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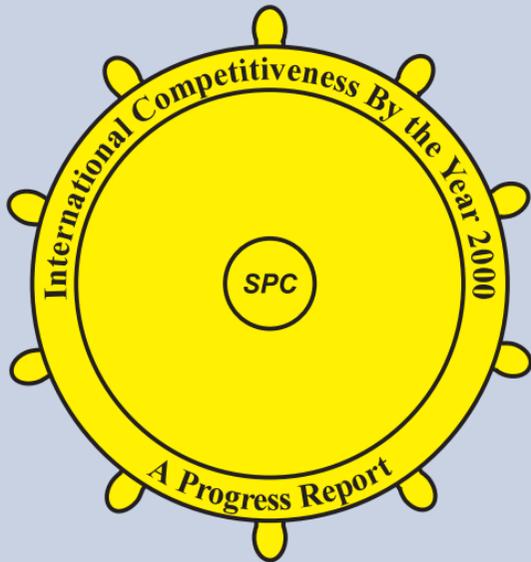
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Design and Production Of ANZAC Frigates For The RAN And RNZN: Progress Towards International Competitiveness

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ABSTRACT

ANZAC, the acronym of the Australian and New Zealand Army Corps, is the name given to a new class of ten frigates under construction for the Royal Australian and Royal New Zealand Navies. The prime contract was awarded in November 1989, and a separate design sub-contract was awarded concurrently. HMAS ANZAC, the first of eight ships for the Royal Australian Navy (RAN), was delivered in March 1996. HMNZS Te Kaha, the first of two ships for the Royal New Zealand Navy (RNZN), is to be delivered in March 1997.

The paper describes the collaborative process, involving the Australian Department of Defence, the New Zealand Ministry of Defence, and Defence Industry in Australia, New Zealand and overseas, for the design and production of the ships. The need to maximize the level of Australian and New Zealand industrial involvement, led to a process of international competition between prospective suppliers, and significant configuration changes from the contract design baseline. Delivery of the first ship was extended to accommodate the revised approach, and in the event only five months additional time proved necessary. Although formal acceptance of HMAS ANZAC is not due until the completion of operational test and evaluation, the contractor's sea trials have successfully demonstrated the performance exceeding the requirements and the expectations of the RAN.

The paper also describes the growing maturity of Australia's naval shipbuilding industry. It suggests some lessons learned from the project, and identifies issues important for the further development and sustainability of the industry. It advocates the need for agreed methodologies to evaluate the productivity of the various elements of the shipbuilding process, and to help ensure the establishment and maintenance of world competitive costs and quality.

NOMENCLATURE

AMECON	Australian Marine Engineering Consolidated	PC	Prime Contract(or)
AMT	Australian Marine Technologies Pty. Ltd.	PT&E	Production Test and Evaluation
ANZAC	Australian and New Zealand Army Corps	RAN	Royal Australian Navy
ANZII	Australian and New Zealand Industry Involvement	RAST	Recovery Assist Secure and Traverse System
ANZIP	Australian and New Zealand Industry Program	RFT	Request For Tender
ASSC	ANZAC Ship Support Centre	RNZN	Royal New Zealand Navy
ASTEC	Australian Science, Technology and Engineering Council	SEL	Standardized Equipment List
BAFO	Best and Final Offer	SPS	Ship Performance Specification
BAINS	Basis for Acceptance Into Naval Service	SWBS	Ship Work Breakdown Structure
B+V	Blohm+Voss GmbH	TDS	Transfield Defence Systems
BVA	Blohm+Voss Australia Pty. Ltd.	TSC	Technical Subject Code
C ³ I	Command, Control, Communications and Intelligence	USN	United States Navy
CDAMS	Contract Definition and Monitoring System	VLS	Vertical Launch (Missile) System
CER	Australian and New Zealand Closer Economic Relations	WDS	Williamstown Development Site
CFI	Contractor Furnished Information		
CGT	Compensated Gross Tonnage		
CIPFS	Critical Item Product Function Specification		
C+M	Control and Monitoring System		
C/SCS	Cost/Schedule Control System		
CST	Contractor's Sea Trials		
CSTOR	Combat System Tactical Operational Requirement		
CSTT	Combat System Tactical Trainer		
DDC	Documentation Development Contract(s)		
DDG	Charles F. Adams Class Destroyer		
DOR	Detailed Operational Requirement		
DSC	Design Sub-Contract		
DT&E	Development Test and Evaluation		
FFG	Oliver Hazard Perry Class Frigate		
GFE	Government Furnished Equipment		
HMAS	Her Majesty's Australian Ship		
HMNZS	Her Majesty's New Zealand Ship		
ILS	Integrated Logistic Support		
IMS	Index of Materials and Services		
ISO	Industrial Supplies Office		
ITP	Integrated Test Package		
MEKO	Multi-Purpose Combination Frigate		
MOU	Memorandum Of Understanding		
NSRP	National Shipbuilding Research Program		
OA	Operational Availability		
OT&E	Operational Test and Evaluation		

INTRODUCTION

In the lead up to World War I, Australia's navy was established by purchasing warships from the United Kingdom, and by building in Australia to UK designs. Warships built during and after World War II were also to British designs until, in the early 1960's, an order was placed in the U.S. for guided missile destroyers (DDGs).

Jeremy [1] described attempts during the late 1960's and early 1970's to establish an Australian warship design capability. However, a planned Fast Combat Support Ship, and a Light Destroyer that grew to over 4200 tons, were each assessed as more expensive than overseas procurement, and plans for local build were cancelled. This experience led to a defense policy that naval acquisition should proceed on the basis of minimum technical risk and be based on an established design.

During the late 1970's and early 1980's, the Royal Australian Navy (RAN) purchased four USN FFG-7 Class frigates built by Todd Shipyards in Seattle. Two more FFG's were also ordered from Williamstown Naval Dockyard under the Australian Frigate Project.

Proposals for submarine and combat system designs based on "proven designs" were called for in 1983. The RAN became strong advocates of building its warships in Australia, and the government agreed the expected benefits would only be fully realised if the design was optimised for Australian production, and all ships of the class were locally built. It was assessed that Australian construction costs might be slightly higher than the costs of overseas procurement, but enhanced in-country support capability would more than offset this incremental cost.

The submarine construction project reduced competition to two shortlisted contenders, and the Kockums/Rockwell proposal became the basis of a contract in 1986. The design selected had a submerged displacement of more than double the largest submarine Kockums had

ever built, and a highly advanced combat system. The construction of the Collins Class submarines involved significant departures from a proven design.

In 1984, in parallel with the submarine project, the New Destroyer Project was established with the aim of selecting a design for local production. Dechaineux and Jurgens [2] described the acquisition strategy and development of the ANZAC Ship Project up to Contract Award. In the interests of risk reduction, and given early schedule pressure, a strategy was decided to seek an "existing design", defined as a ship under contract for construction at that time. As for the submarines, it was envisaged that the new ships would be commercially built, and the Navy would not stay in the shipbuilding business.

During the 1990's, the naval shipbuilding industry in Australia has been revitalized. HMAS ANZAC, the first of ten new frigates was successfully delivered to the RAN by Transfield Defence Systems (TDS) on 28 March 1996.

The second ANZAC Ship, HMNZS Te Kaha, is scheduled to be delivered in Australia to the Royal New Zealand Navy (RNZN) in March 1997. Follow ships are planned to be delivered at twelve month intervals in a building program that will continue until the year 2004. With a current total project cost of approximately A\$ 6.059 billion (December 1996 prices and exchange rates), the ANZAC Ship Project is the largest acquisition project undertaken by the Australian Department of Defence.

Other current major naval shipbuilding projects for the RAN include the construction in Australia of submarines, minehunters and hydrographic ships. HMAS Collins, the first of six large conventional submarines was delivered by the Australian Submarine Corporation (ASC) to the RAN in July 1996. Coastal Minehunters to a design similar to the Gaeta Class developed by Intermarine of Italy are under construction by Australian Defence Industries (ADI). A contract for the design and construction of two Hydrographic Ships was also awarded in 1996 to NQEA Australia.

A factor which is critical to the future of Australia's naval shipbuilding industry is the sustainability of demand. The current new construction program for the RAN represents a peak in domestic demand, and cannot sustain the industry in the long term. Export market opportunities are seen as vital for the industry to survive and grow. To achieve success in export markets, it is essential for Australia's naval shipbuilding industry to be internationally competitive. This pre-supposes an understanding of what it means to be internationally competitive, and the parameters by which international competitiveness in naval shipbuilding is measured.

This paper describes the policy of the Australian Government for the development of a self-reliant defense capability, the objectives of government and industry in undertaking the design and construction of ten ANZAC frigates in Australia, the means by which the program has been implemented, and the resulting achievements. The paper also reviews some of the issues associated with the measurement of international competitiveness in naval shipbuilding, and the application of "benchmarking" to demonstrate "value for money" in defense procurement.

BACKGROUND TO PROJECT DEVELOPMENT

Cahill and Bunch [3] documented a comparative study of foreign naval acquisition, design and construction policy and practices, against the established U.S. acquisition process. The comparative study

involved Canada, the U.K., France, Germany, Italy and Japan. Each of the countries described have ongoing projects involving the indigenous design of surface combatants, although in the case of Japan, the development of the Kongo Class Aegis destroyers was developed with design input from the USN DDG-51 Class destroyer program.

By comparison, the policy and practices adopted by the Australian Department of Defence have, in the past, related to the acquisition and modification of ship designs from overseas countries. The ANZAC Ship Project was based upon the selection of an "existing design" for construction in Australia, and was not conceived as a developmental project. Consequently, none of the models described by Cahill and Bunch accurately represent the acquisition process adopted by the Australian and New Zealand Governments for the ANZAC Ships.

In a paper presented to the 1990 Ship Production Symposium, Dechaineux and Jurgens [2] described the strategy adopted by the Commonwealth of Australia, in a joint project with the Crown of New Zealand, for the acquisition of ten ANZAC frigates. The paper described the ANZAC Ship Project from its inception, through the competitive selection of two alternative existing designs, the short listing of Australian shipbuilders as potential prime contractors, and the teaming arrangements between designers and builders to respond to a Documentation Development Contract (DDC) in parallel with a Request For Tender (RFT). During this process, the Dutch shipbuilding company Royal Schelde offered the "M" Frigate via a consortium called Australian Warship Systems. Blohm+Voss Australia Pty. Ltd. (BVA), a subsidiary of the German shipbuilding company Blohm+Voss AG (B+V), offered the MEKO 200 ANZ frigate design in partnership with Australian Marine Engineering Consolidated Limited (AMECON), now called Transfield Defence Systems (TDS).

Following tender evaluation, a round of Best and Final Offers (BAFO), and source selection, a prime contract was negotiated with TDS and signed on 10 November 1989 for the design and construction of ten ANZAC frigates. On the previous day, in anticipation of the prime contract award, a design sub-contract (DSC) was signed between TDS and BVA, now called Australian Marine Technologies (AMT), for the provision of the design licence and technical services for the MEKO 200 ANZ frigate design.

Steel for the first ANZAC frigate was cut on 27 March 1992, and the ship was launched on 16 September 1994. Contractor's Sea Trials were conducted in January and February 1996 and the ship was delivered to the RAN on 28 March 1996. The commissioning of HMAS ANZAC took place on 18 May 1996. Following a period of Operational Test and Evaluation (OT&E), it is expected that HMAS ANZAC will be formally accepted into naval service in mid to late 1997. It is also expected that ANZAC Ship 02 will be delivered to the RNZN in early to mid 1997, and commissioned as HMNZS Te Kaha.

PROJECT OBJECTIVES

Australian Government Objectives

According to West [4], the objectives of the Australian Government in proceeding with the ANZAC Ship Project included:

- ships for the Navy (maritime force structure considerations),
- furtherance of government industry policy (rationalization), and
- assisting New Zealand in a collaborative venture.

Ships for the Navy - Maritime Force Structure Considerations. A review of maritime force structure in 1985/86 established requirements for three generic capability levels of “Tier One” destroyers and frigates, of “Tier Two” patrol frigates, and of “Tier Three” patrol vessels, and it was decided the first need was for the patrol frigate class. The Government objectives for the ANZAC Ship Project, were defined as part of a defence review by Dibb [5], then the Director of Joint Intelligence. The review was conducted within the framework of Government policy which required self-reliance, a coherent defense strategy and an enhanced defense capability. Dibb advocated the need for a light patrol frigate to complement an essential core force of 8 to 9 destroyers (currently comprising 3 DDGs and 6 FFGs).

Furtherance of Government Industry Policy. Defense policy for industry provided a second major Government objective. In his report, Dibb [5] commented on the need for private sector involvement in defense purchasing and identified shipbuilding and repair as the next priority for reform.

As a consequence of a revised Defense policy for industry, the former government-owned Williamstown Naval Dockyard was sold in February 1988 to a consortium of three Australian engineering companies, known as the Australian Marine Engineering Corporation (AMEC). The sale included the task of completing two FFG-7 Class frigates under the Australian Frigate Project.

The company was subsequently renamed Australian Marine Engineering Consolidated Limited (AMECON) following a successful takeover of the three companies in 1988 by the Transfield Group, one of Australia’s largest privately owned companies.

Defense policy for industry also includes maximizing the level of Australian and New Zealand Industry Involvement (ANZII) in defense purchasing, including naval ship acquisition projects. This policy provided a major objective for both the ANZAC Ship and Collins Submarine Projects, which were seen as opportunities to revitalise Australia’s shipbuilding and heavy engineering industries.

Assisting New Zealand in a collaborative venture. Regional collaboration in defense is a priority of the Australian Government, and this policy extends to defense acquisition projects. The ANZAC Ship Project is the most ambitious collaborative project undertaken to date. In addition to promoting cooperation, joint acquisition projects offer potential economies of scale.

New Zealand Government Objectives

New Zealand’s objectives in collaborating with Australia on the ANZAC Ship Project also included maritime force structure considerations, and the furtherance of government industry policy. Concurrent with Australia’s need for frigates, New Zealand had a requirement to replace two Leander Class ships in the mid 1990s, and a further two after the turn of the century; effectively the replacement of the New Zealand fleet.

To formalize the collaboration between the Governments of Australia and New Zealand for the ANZAC Ship Project, an MOU was signed on 6 March 1987. Under the MOU, a supplementary agreement called the “Agreement between Australia and New Zealand concerning collaboration in the Acquisition of Surface Combatants for the RAN and RNZN” (also called the Treaty) was signed on 14 December 1989. The Treaty covers the major issues, including the management of the Joint Project, payment arrangements, industry participation, integrated logistic support, rights under the prime contract,

and optional ships (11 and 12).

Under the ANZAC Ship Treaty, and consistent with another Government to Government Treaty relating to Closer Economic Relations (CER), the Australian and New Zealand defense ministers agreed to treat the industries of Australia and New Zealand as a common industrial base for the purpose of defense procurements and to treat the other’s industry as it treats its own.

Industry Objectives

According to conventional business principles, the objectives of industry are simple: to stay in business and to provide a good return on the capital invested. In the early days of the ANZAC Ship Project, the prime contractor defined its objectives as being: to become an internationally viable shipbuilding and marine engineering company, to successfully complete the Australian Frigate Project; to win and successfully complete the ANZAC Ship Project; and to win export contracts for Australia, which would involve developing a full design capability.

The ANZAC Ship Project has given the prime contractor an opportunity to become a significant player in the domestic and international defense industry. This vision includes a commitment to create a sustainable “world-class” naval shipbuilding capability, and to develop the Australian and New Zealand industrial capability.

PROJECT IMPLEMENTATION

Program Management Overview

The scope of the project includes the acquisition of ten ANZAC ships and three shore facilities, as the major deliverables. Of the ten ships ordered, eight are for the RAN and two (ships 02 and 04) are for the RNZN. The contract includes an option for a further two ships for New Zealand (ships 11 and 12). The three shore facilities comprise the ANZAC Ship Support Centre (ASSC) located at Williamstown, and two Combat System Tactical Trainers; one located at HMAS Watson in Australia and one located at HMNZS Tamaki in New Zealand. The project also involves the development of an integrated logistic support (ILS) package, including training.

Consequently, the range of capabilities required to fulfil the scope of the project includes expertise in project management, systems engineering, software engineering, and integrated logistic support, in addition to naval ship design and construction skills.

An overview of the top level management arrangements for the project is provided in Figure 1.

Contract Management

Contracting Arrangements. The prime contract between the Commonwealth of Australia and the builder takes the form of a fixed priced contract worth \$A 4.206 billion (in December 1996 prices), which includes price variation for escalation and is in multiple currencies.

A feature of the contracting strategy was to minimize the number of items supplied as Government Furnished Equipment (GFE) to only those items which could not be supplied cost-effectively by the prime contractor, such as the missile launcher, gun and cryptographic equipment. In accordance with the project objectives, the prime contract requires a high level of Australian and New Zealand Industry Involvement (ANZII). The prime contract also requires the

establishment by the prime contractor of a Cost/Schedule Control System, and a Quality System to ISO 9001.

The prime contractor has overall responsibility for project implementation. This includes the design of the ships and shore facilities, procurement of systems, equipment and materials, construction of ships and shore facilities, set-to-work, test and

evaluation, and provision of an initial ILS package. In specialist areas, selected responsibilities, together with the relevant contractual provisions, flow down in “back-to-back” arrangements to sub-contractors.

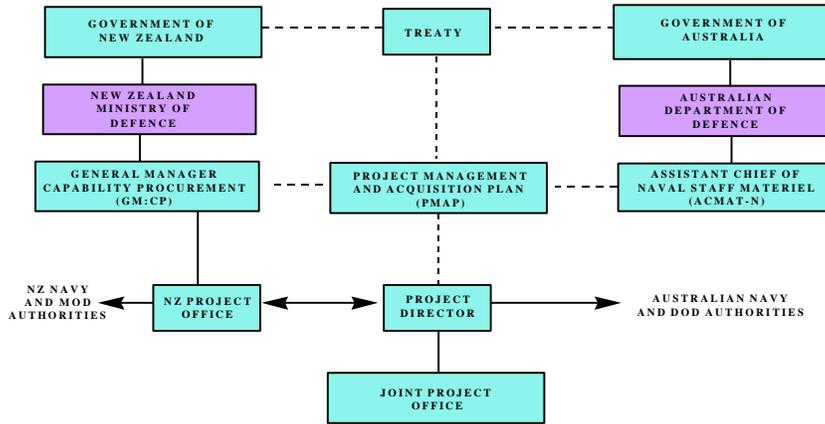


Figure 1. Top Level Management Arrangements

The principal sub-contractors include:

- Australian Marine Technologies Pty. Ltd. for ship design;
- CelsiusTech Australia Pty. Ltd. for Command and Control system design and integration;
- Computer Sciences Corporation Australia for Combat System simulation software development;
- Scientific Management Associates Pty. Ltd. for ILS management, including training;
- Siemens Industries Limited for Electrical Systems supply and system integration; and
- Stanilite (now a part of Australian Defence Industries Pty. Ltd.) for Communications Systems supply and system integration.

Cost/Schedule Control System. The prime contract includes a requirement for a Cost Schedule Control System (C/SCS) to be established by the prime contractor as an internal project management tool. The system implemented by the prime contractor was subject to formal review and audit by the Department of Defence. Formal accreditation was granted on 25 October 1993. Under the prime

contract, the project authority does not have access to cost data held in the system.

Contract Definition and Monitoring System. The prime contract is a fixed price contract and financial progress is reported against priced planning and work packages rather than costs incurred. For this purpose, a Contract Definition and Monitoring System (CDAMS) has been implemented, which uses the same Work Breakdown Structure as the C/SCS, but substitutes pricing data for budgeted and actual costs. The system was revised in 1993. Elements for escalation and exchange rate control remain, but CDAMS now monitors progress payments based on C/SCS earned value claims.

Schedule. In accordance with the schedule shown in Figure 2, ships are planned to be delivered at about annual intervals from 1996 to 2004.

Australian and New Zealand Industry Program. The Australian and New Zealand Industry Program (ANZIP) for the ANZAC Ship Project has been developed in accordance with defense industry policy to maximise Australian and New Zealand Industry Involvement (ANZII). For supplies delivered under the ANZAC Ship Project, the prime contractor is committed to achieve a level of ANZ Content equal to 73% of the total contract price. A further 8% of the contract price is to be met through Defense Offsets. There is no contract specified work for the project.

Operational Requirements. McLean and Ball [6] discussed the strategic issues and the operational requirements for the ANZAC ships. In terms of documentation, the ANZAC Ship Project

developed from a brief capability statement. Whilst there is currently no endorsed Detailed Operational Requirement (DOR) for the project, the following technical documents collectively define the requirements:

- Combat System Tactical Operational Requirement,
- Ship Performance Specification, and
- Basis for Acceptance Into Naval Service.

Contract Design Baseline. West [4], the RAN's Chief of Naval Material in 1989, stated that:

"The ANZAC Ships are to be built to an existing design with minimum modification to meet the required characteristics, and with maximum Australian and New Zealand content within the bounds of practicality, cost and design integrity."

The selected MEKO 200 ANZ design was based on the existing MEKO 200 PN design, under construction at that time for the Portuguese Navy. The contract for the first MEKO 200 PN had been awarded to a consortium of German shipbuilders on 20 November 1986. Construction of the lead ship, Vasco Da Gama, progressed with the keel being laid on 1 February 1989, launching on 26 June 1989 and commissioning on 18 January 1991.

During the Design Development Contract that preceded the competitive tendering phase, a number of major engineering changes were incorporated in the configuration of the MEKO 200 ANZ design to better suit the requirements of the RAN and RNZN. The changes affected the propulsion system, ship systems, communications systems, combat system and aviation systems integration. Other significant engineering changes were required to meet RAN requirements for the ship's thermal, acoustic, vibration and shock environment.

The Contract Design, the meaning of which is given by the RAN's Chief of Naval Staff [7], or "Allocated Baseline" was defined at contract award as a result of the Documentation Development Contract (DDC) and Best And Final Offer (BAFO) process, and covered the ship as a total system, including the systems and equipment proposed as an integral part of the tenderer's offer. The design baseline was defined by the contract specification, and supported by drawings, and engineering analyses prepared to demonstrate, at least by calculation, the performance of the ship and its principal systems. The design

baseline, and the analysis involved in its development, provided the basis of the ship designer's warranty on performance.

Specifications for the Ship and its Combat System. The ANZAC Ship Specification forms a part of both the prime contract and the design sub-contract. The specification was developed to specify the characteristics and performance to be achieved by the vessel, and to define in detail all of the requirements necessary for the production design, construction and costing of the vessel to meet the characteristics and performance requirements.

In format, the specification is divided into groups, sub-groups and elements using the RAN's Technical Subject Code (TSC) system which is similar to the USN Ship Work Breakdown Structure (SWBS). The content of those technical groups dealing with Ship Systems was developed along the lines of the "General Specification for ships of the USN." For the groups, sub-groups and elements dealing with the Combat System, a specification format in accordance with MIL-STD-490A System/Segment Specification was developed, which follows the method of defining functional chains.

During the project development phase, the Commonwealth required the competing tenderer's to prepare Critical Item Product Function Specifications (CIPFS), providing a detailed description of the technical characteristics of a system/equipment considered to be critical to ship performance. In particular, they were to include statements as to the extent to which the system/equipment met generic RAN requirements.

The Ship Specification was originally intended to be "equipment non-specific". However, in the interests of standardization across the Class, a list of the major systems and equipment called the Standardized Equipment List (SEL) was introduced. The SEL formed the basis of the Shock Qualification List, which sought to confirm the performance of the nominated systems and equipment against the requirements for shock and vibration, and complemented the drawings, documents and engineering analyses delivered during the project development phase.

Modification to the Project Acquisition Strategy

At the time of contract award, it seemed to many of those involved that the MEKO 200 ANZ design baseline was clearly established, and that the ship as specified

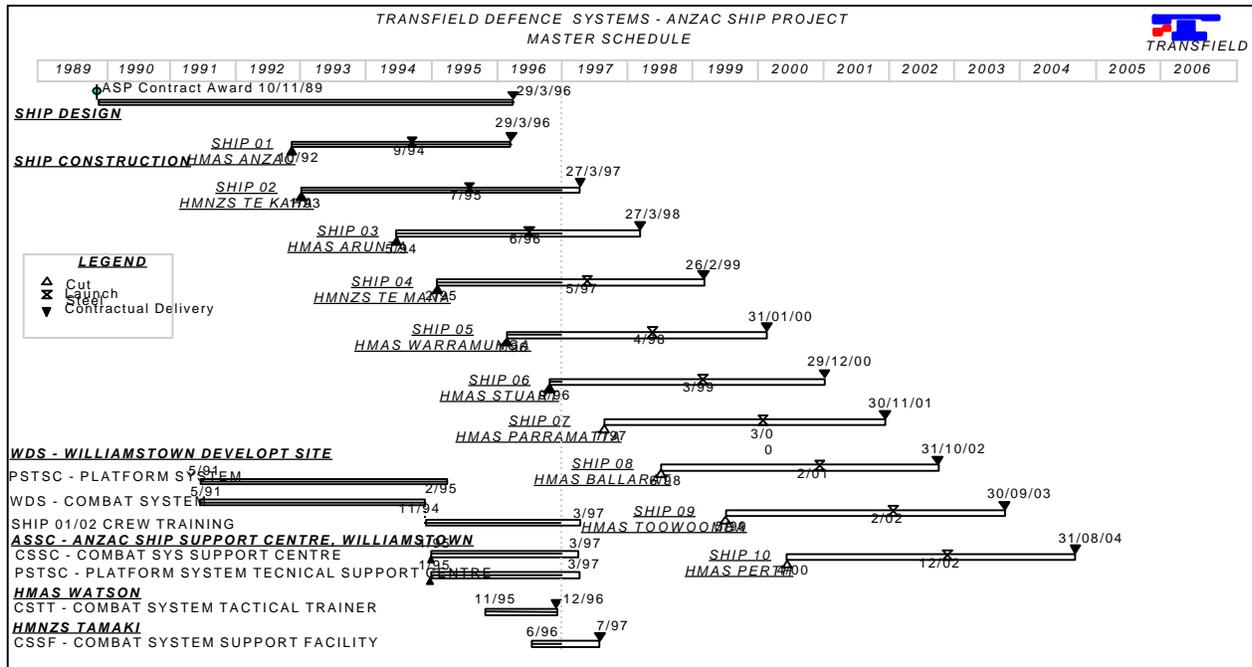


Figure 2. Project Master Schedule

could proceed on a clearly defined and low risk path to detail design and construction. The designer was confident that the warranted performance would be obtained, and the principal concerns were that the contract delivery schedule allowed little time to establish the high level of ANZ Industry Involvement (ANZII) that was required.

The procurement of major systems and equipment, especially long lead items, was a priority. For reasons of risk-management, the requirements of the prime contract were flowed down to potential suppliers. This included provisions relating to ANZII. In some cases, prospective suppliers considered themselves sufficiently well placed, either to not accept the ANZII requirements, or on becoming fully aware of the requirements, to increase prices accordingly. As a consequence of these actions, the prime contractor was faced with no alternative, in order to meet the contracted obligations for ANZII and also to control costs, but to competitively tender almost all of the equipments including those on the SEL. This strategy was supported by a clause negotiated into the ANZAC Ship Specification prior to contract award which stated:

“The Contractor shall have the right to propose alternatives to any of the Sub-contractors and equipments in the Standardized Equipment List (SEL). Changes shall be proposed pursuant to Clause 49 of the Contract. The Project Authority’s approval for such proposed changes shall not be unreasonably withheld.”

It was recognized that while this strategy would assist in meeting the objectives of high ANZII and cost control, it would have a negative impact on both schedule and the “low risk” aims of the project. However, after analysis of all of these factors, the client was prepared to accept that the advantages of this strategy far outweighed the impacts

and agreed that the prime contractor proceed on this basis. Despite an overall impact on the engineering design schedule of about 13 months in contractual terms, which averaged around 11 months in practice, the client was prepared to accept a delay of 5 months to the delivery of Ship 01 and a delay of 1 month for Ship 02.

In dealing with configuration changes proposed by the prime contractor, the Commonwealth adopted a flexible approach which is discussed by Malpas [8]. This shifted the emphasis from the original strategy of building “an existing design with a minimum of changes”, to the maintenance of “function and performance.” Under these circumstances, the ANZAC Ship Specification, based as it was on the existing MEKO 200 PN design, proved to contain a level of detail which was inappropriate to either the prime contractor, or the Commonwealth.

Consequences of the modified strategy were delays in the availability of Contractor Furnished Information (CFI) for systems and equipment pending source selection, resulting in delays in ship design development, and the need to prepare sub-contract amendment proposals to advise the technical and commercial implications of the configuration changes.

The many changes in configuration clearly had the potential to impact on the performance warranted by the designer. There were periods between contract award and delivery of Ship 01 when the risk of not meeting the requirements was carried by the prime contractor and the system supplier. In the event, the design integration was satisfactory and the designer’s warranty on ship performance maintained.

MEKO Naval Ship Design Philosophy

The MEKO design philosophy has been widely documented

elsewhere, and it is not the purpose of this paper to review the detailed characteristics of the MEKO 200 ANZ. The principal features of MEKO vessels have been described by Sadler [9], and Ehrenberg and Schmidt [10].

According to Dunbar [11], the acronym MEKO translates as “Multi-Purpose Combination”, and the design concept includes:

- “modularity, with the use of a variety of standard size modules and pallets for the installation of weapon and electronic systems;
- standardization, with the development of standard structural, electrical/electronic and ship system interfaces for the integration of standard sized weapons and electronics modules; and
- survivability, with the individual ship section independence of ventilation, seawater, firefighting, electrical power distribution and data transfer systems.”

The design philosophy is one in which a naval ship is regarded as an “integrated system.” This total system is broken down into functional systems and sub-systems in accordance with a four digit coded hierarchy known as the Index of Materials and Services (IMS).

In accordance with the MEKO philosophy, there is also a pre-defined breakdown of the ship into modules for the hull structure, superstructure, and outfit. The hull structure is divided into six modules M1 to M6, and the superstructure is also divided into six modules A1 to A6. Each of the hull structure modules is further sub-divided into structural units and sub-units, as shown in Figure 3.

The outfit modules/functional units include:

- 2D Radar container,
- 127 mm Gun Container,
- Communication Control 1 Container,
- Communication Control 2 Container,
- Communication Control 3 Container,
- Command and Control Equipment Container,
- Communications Transmitter,
- Sonar,
- Target Indicating Radar,
- Ventilation Modules - 9 off,
- Operations Room Pallet, and
- RAST Equipment Pallet.

For the Mk 41 VLS launcher, whilst not designed as a MEKO functional unit, the system-ship integration facilitates installation as for other MEKO functional units.

Design features of the MEKO 200 ANZ. Pine [12] described the specific features of the MEKO 200 ANZ and concluded that:

“the ANZAC Ship design offers four innovations to the designers of the 21st Century Surface Combatant:

- *Firstly, the modular/functional unit design concept which allows flexibility in equipment selection throughout the life of the ship. It also provides improved survivability with its*

fully independent ship sections and allows a distribution of resources during the ship build phase.

- *Secondly, the automated Control and Monitoring System offers many advantages in supporting the Propulsion, Electrical, Damage Control and Auxiliary systems.*
- *Thirdly, the system redundancy installed throughout the ship.*
- *Finally, the independency offered by the Combat System software.”*

The Control and Monitoring (C+M) System is described by Cruickshank [13]. The basis for the design was the MEKO 200 PN. The graphic pictures were modified to reflect the configuration of the systems on board the MEKO 200 ANZ, and the measuring points list was also modified. Functional descriptions were prepared for the Propulsion System, the Electric Plant, and the Damage Control and Auxiliaries. These three documents described how the various ship systems were intended to be operated via the C+M System in sufficient detail for the system supplier to proceed with the design of the system software. At this stage, the supplier changed the technological basis of the system, from the NAUTOS 2 system used on the MEKO 200 PN, to the NAUTOS 4 system which used the S5 industrial based plc system used on the MEKO 200 HN. Following criticism of the graphics system, the graphics technology was also subsequently changed to a “Windows-based” system.

The approach adopted for managing environmental engineering issues involving acoustics, vibration, and shock is discussed by Smallwood [14]. As a general rule, system suppliers are responsible for the selection and supply of suitable shock/vibration mounts.

The management of Electro-Magnetic Interference/Compatibility (EMI/EMC) issues proved complex, due to the procurement of systems and equipment to several different standards, which could not be directly related.

Design Changes. Malpas [8] documented the characteristics of the MEKO 200 ANZ design, and described some of the configuration changes incorporated during the design process, which included:

- Propellers,
- Ships Boats,
- Hangar Gantry Crane,
- Paint Scheme,
- 5” Gun,
- Flight Deck Firefighting,
- Control and Monitoring System, and
- Administrative Local Area Network.

Other significant configuration changes, in terms of engineering integration, included:

Platform:

- Cross-Connection and Diesel Gearboxes,
- Fluid Couplings,
- Propulsion Shafting,

- Fin Stabilisers,
- Fuel and Lube Oil Purifiers,
- Combustion Air System and Uptakes for the Propulsion and Generator Diesels,
- Gas Turbine Engine Control Module,
- Steering Gear,
- Fire Pumps,
- Salvage Pumps,
- Hangar Door,
- Anchor Windlass,
- Anchor and Mooring Capstans,
- Vacuum Sewage Treatment Units,
- Batteries,
- Commissary and Laundry Equipment,
- Ballistic Protection,
- Cathodic Protection, and
- Security Containers.

Navigation and Communications:

- Ship's Navigation Data System,
- GPS Receiver, and
- Communications Electronic Surveillance Measures.

Combat System:

- Combat System Local Area Network,
- Target Indicating Radar,
- Electronic Surveillance Measures,

- Identification Friend or Foe System,
- Closed-Circuit Television System,
- Helicopter Visual Landing Aids, and
- Towed Array Sonar System.

The scope of the above design changes, when considered together with the configuration changes incorporated prior to contract award, represented a substantial engineering impact on the existing MEKO 200 PN design.

Production of MEKO Frigates in Germany

Experience in the design and construction of first-of-class vessels has shown that build time and cost are related, and efforts are aimed to minimise the elapsed time from contract award to delivery, which includes the lead time for engineering, design, and procurement. The MEKO design philosophy of modular construction, facilitates the parallel design and production of weapons, sensor, electronics and outfit modules (functional units and pallets), and assists in the reduction of the build time.

Figure 4 (from [15]) shows a typical comparison of the time frame between contract award and commissioning for a conventional frigate, versus a MEKO frigate. For the design and construction of the MEKO 200PN, an elapsed time of approximately 50 months from contract award to delivery was achieved. By comparison, for the design and construction of an F123 destroyer, an elapsed time of 62 months from contract award to delivery was

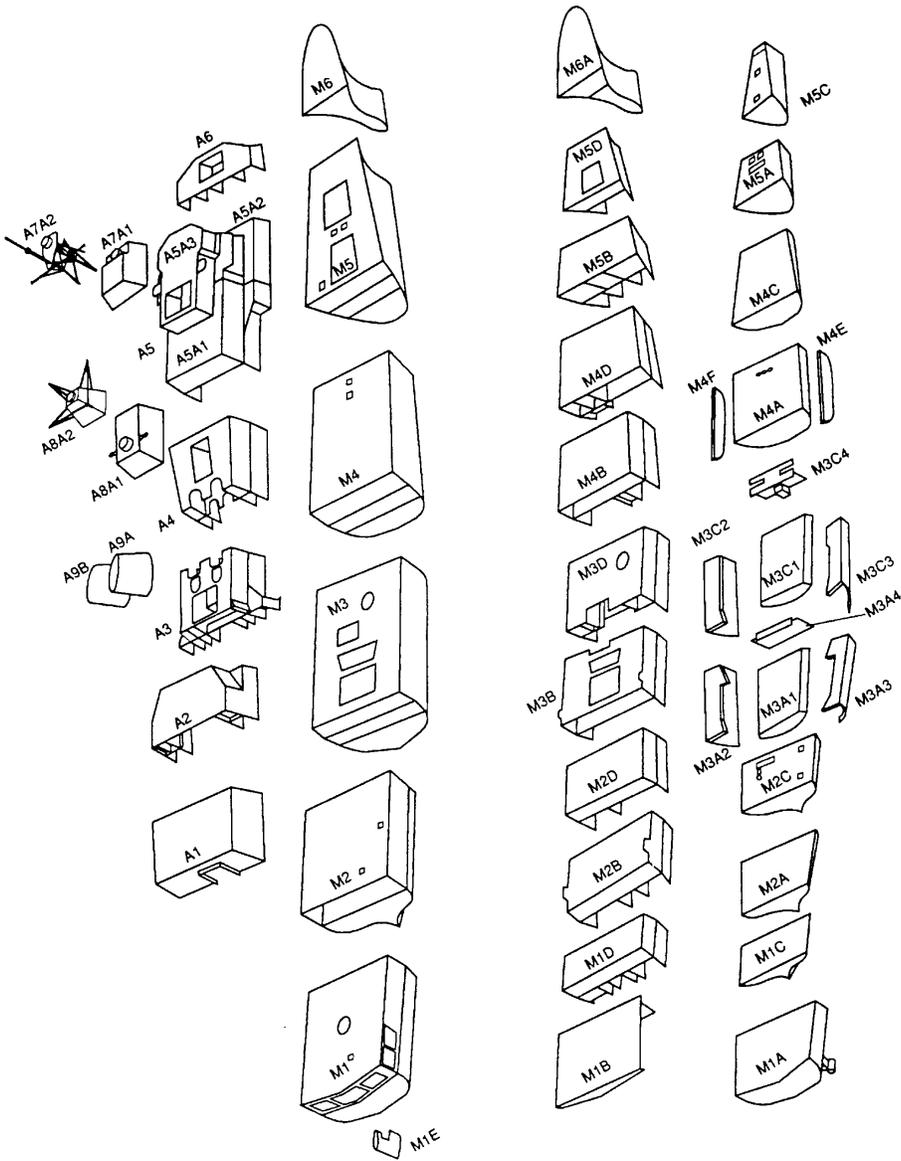


Figure 3. Modular Construction of the MEKO 200 ANZ

achieved.

The build strategy developed for the production of steelwork is consistent with the Hull Block Construction Method [16]. The fairness of structural modules gives an indication of good dimensional control during fabrication, and line heating is used as a technique to remove distortion.

The ship design process ensures a high level of outfit planning and integration with steelwork production, and is further enhanced by

the advantages offered by the MEKO system of outfit modules. In the construction of first-of-class vessels, the achievement of high levels of outfitting prior to the erection of hull and superstructure modules on the berth is an objective, but one which is dependent upon the timely availability of design information, and any additional costs incurred for earlier delivery of equipment.

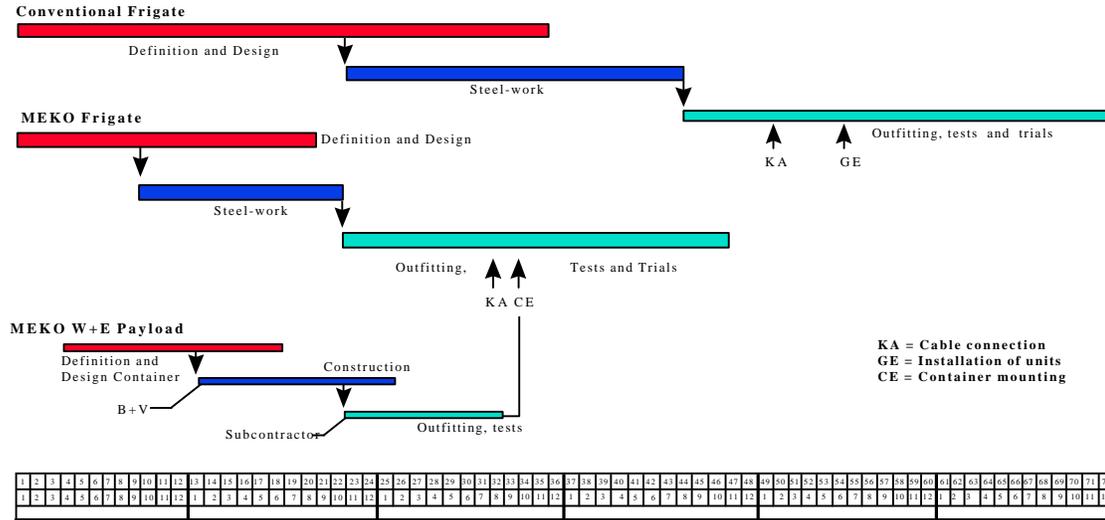


Figure 4. Time Frame Between a Contract Coming in to Force and Commissioning

Change Process - Comparisons	
Williamstown Dockyard	Transfield Defence Systems
23 Unions	3 Unions
30 Awards	1 Award
390 Classifications	2 Classifications
Demarcation Endemic	Demarcation Free
180 Allowances	Nil Allowances
Various Types of Leave	Standard Leave
Recruitment Geared to Programme Peaks	Recruitment Geared to Programme Troughs
Idle Time	No Idle Time
Industrial Lost Time 10%	Industrial Lost Time 0.1%
Productivity Extremely Low	Productivity Increased by 600-700%
2,400 Employees	1,200 Employees
Paid According To Classification	Paid According to level of Skill
Award is multi-skilled, demarcation free and fully flexible. Based on the concept of employees completing whole tasks as long as it is safe, legal, sensible and the employee is competent. That is the simple basis of multi-skilling.	

Table I

Production of ANZAC Ships in Australia

Transformation in Naval Shipbuilding Culture at Williamstown. The transformation effected at Williamstown from being a government-owned Naval Dockyard to a privately-owned industrial enterprise specialising in defense systems, has required a significant change in the culture of the organisation. Table I (from Horder [17]) provides a summary comparison of the changes that were accomplished during the transformation.

The successful resolution of the major issues associated with the above changes occurred during the tendering process for the ANZAC ships, prior to the award of the prime contract. At that time, the new owners of the shipyard were engaged in the construction of FFG-7 Class ships under the Australian Frigate Project.

Procurement. The objective to maximize the level of Australian and New Zealand Industry Involvement (ANZII) was a significant driver behind the strategy adopted for the procurement of systems, equipment and material. Using competition to gain commercial leverage, Requests For Tender (RFTs) were issued progressively in priority order based on an assessment of the procurement lead time and the criticality of engineering information to support the design process.

To support the procurement strategy, purchase specifications

defining the technical requirements and the scope of supply/work, were prepared in terms that were sufficiently generic to allow a number of suppliers to bid. The purchase specifications also needed to contain sufficient information to allow prospective Australian and New Zealand suppliers to compete, some of whom were unfamiliar with the requirements typical of naval shipbuilding projects, including performance, shipboard integration, and environmental qualification for acoustic, vibration, shock and EMI/EMC performance.

Some prospective suppliers were also unfamiliar with the type and volume of documentation and information required to support naval shipbuilding projects, including product/system specifications, interface specifications (system-system and system-ship), drawings and detailed engineering data.

In many instances, the required performance of the ship as a total system, and the physical constraints of shipboard integration, such as available space and weight and physical interfaces to other systems and the ship, were needed as input parameters to the purchase specification. This led to a complex and iterative dialogue between the supplier, the prime contractor, and the designer, who was at "arms length" from the supplier.

The contracting structure that resulted from this procurement process, was quite different to that developed for the construction of the existing MEKO 200 PN design.

From the original project strategy, it was envisaged that the required level of ANZII would be achieved mainly by the manufacture and/or assembly in Australia or New Zealand of the systems and equipment within the MEKO 200 ANZ design baseline, as nominated in the SEL, in order to maintain configuration "form, fit, and function." Most of these items were of European origin. In the event, ANZII was achieved by the substitution of alternative systems and equipment. ANZII obligations upon sub-contractors resulted in arrangements between overseas suppliers and local manufacturers, such that a substantial package of work was performed in Australia and New Zealand.

An organization known as the Industrial Supplies Office (ISO), with offices in each Australian State and Territory, aimed at facilitating the replacement of imported products with locally manufactured items, played an important role in supporting the procurement process.

Early in the procurement process, the allocation of responsibility for the preparation of purchase specifications was an issue between the prime contractor and the ship designer, aggravated by contradictions within the design sub-contract. These contradictions can perhaps be explained by the modification in project strategy outlined earlier, and the procurement strategy whereby generic purchase specifications needed to be developed by the purchaser, rather than detailed specifications being developed by the selected supplier.

System Integration. Following the award of procurement sub-contracts, system integration was able to progress. In terms of engineering documentation, this activity involved the preparation by the supplier of product or system specifications, and interface specifications for system-system and system-ship integration.

The preparation of system and interface specifications is an iterative process between the supplier(s), prime contractor, the combat systems integration sub-contractor, and the ship design sub-contractor. The finalization of the documents, involving the incorporation of comments, and the implementation of configuration changes to ensure proper system integration, was in some cases protracted. These documents formed attachments to the original procurement sub-contract.

As a consequence of the modification in the project acquisition strategy referred to earlier, its impact upon risk management generally, and the need to maintain the design sub-contractor's general warranty on performance, a difficult situation developed over time because neither the original procurement sub-contracts nor the system and interface specifications had been finalized and formally "signed-off" by the design sub-contractor to accept responsibility for overall compliance with the ANZAC Ship Specification. Consequently, there was some doubt as to the basis upon which the design sub-contractor's warranty on performance could be supported. This issue also had implications subsequently for the preparation of test procedures required for the Production Test and Evaluation Program, which needed to be based on the purchase specifications.

To support the system integration activity, the prime contractor took responsibility for the design and construction of the Williamstown Development Site (WDS) as a land-based test site for the engineering development and integration of the Control and Monitoring System and the Combat System. The design and construction of the WDS was on the project's critical path, and was separate from the design sub-contract. To the extent that the design of the WDS was dependent upon the design of the ship, this became an area of some difficulty, since the schedules for the availability of design drawings were not related.

Specialist support was obtained for the following system integration roles:

- Command and Control System Integrator,
- Combat System Simulation,
- Communications Systems Integrator,
- Navigation Systems Integrator, and
- Control and Monitoring System Integrator.

Ship Production (Build Strategy)

The build strategy developed for the construction of the ANZAC frigates centred around the geographic distribution of work. For the first and second ships, all modules were fabricated and erected in Williamstown. For the third and possibly subsequent ships, hull modules M4 and M5 are being fabricated in Newcastle, and all superstructure modules A1 to A6 are being fabricated at Whangarei in New Zealand. Modules constructed off-site are shipped to Williamstown by barge.

The shipyard underwent an extensive modernization program during the late 1970's and early 1980's, in preparation for the construction of FFG-7 frigates. The modernization included the construction of a new dual berth slipway, new cranes, installation of an automated plate preservation line, numerically-controlled cutting equipment, a module blast and painting facility, an extension to the pipe fabrication shop, new outfit workshops, an outfitting pier, material storage warehouse, and administration offices.

For the construction of ANZAC frigates, a new module hall has been built, and two multi-wheeled transporters have been purchased, each capable of moving modules weighing over 200 tonnes from the module hall to the slipway. Attention has also been given to improved access to ships on the slipway, and to providing a healthy shipboard environment that is clean and safe.

The ship production process for the ANZAC frigates, superimposed upon the physical layout of the shipyard, is illustrated in

Figure 5. The Hull Block Construction Method is evident in the construction of modules. Outfit planning is increasing the level of outfit components installed in modules “On Block”. The revised paint specification introduced as a design change on Ship 01 was originally developed for the construction of FFG-7 frigates under the Australian Frigate Project, and incorporates the basic philosophy of the Zone Painting Method. Consequently, progress has been achieved on several fronts towards the goal of Integrated Hull Construction, Outfitting and Painting [16].

Limiting the impact on the delivery schedule for Ship 01 to five months, given the additional lead time averaging about eleven months required for procurement, and design development on the part of suppliers and the design sub-contractor, required a range of measures to be taken. This included the use of “preliminary” information in a number of areas, particularly for hull construction and the electrical system installation.

Test and Evaluation Program. The structure of the Test and Evaluation Program is divided into:

- Development Test and Evaluation (DT&E),
- Production Test and Evaluation (PT&E), and
- Operational Test and Evaluation, (OT&E).

DT&E is a prime contractor responsibility, but the scope of this

test activity for the ANZAC Ship Project is limited. OT&E is a Commonwealth responsibility conducted by the customer navy subsequent to ship delivery and prior to acceptance into naval service. The major testing activity in support of ship construction is PT&E.

Production Test and Evaluation (PT&E) includes the following Categories:

- Category 0 - Design & Eng. Development Tests,
- Category 1 - Factory Tests,
- Category 2 - Environmental Tests,
- Category 3 - System Development Tests,
- Category 4 - Shipyard Tests, and
- Category 5 - Sea Tests.

Pre-Construction Testing: Pre-construction testing comprises Categories 0-3 testing.

Construction Testing: comprises all Category 4 and 5 testing. All construction testing (except Stage 1 of Category 4 tests), is incorporated into an Integrated Test Package (ITP) after first ship validation of all Category 4 and 5 tests has been completed. The ITP consists of the test matrix, test sequence network, test procedures, and test index.

Test Stages Construction Testing (i.e. Category 4 and 5 testing) is further divided into seven stages:

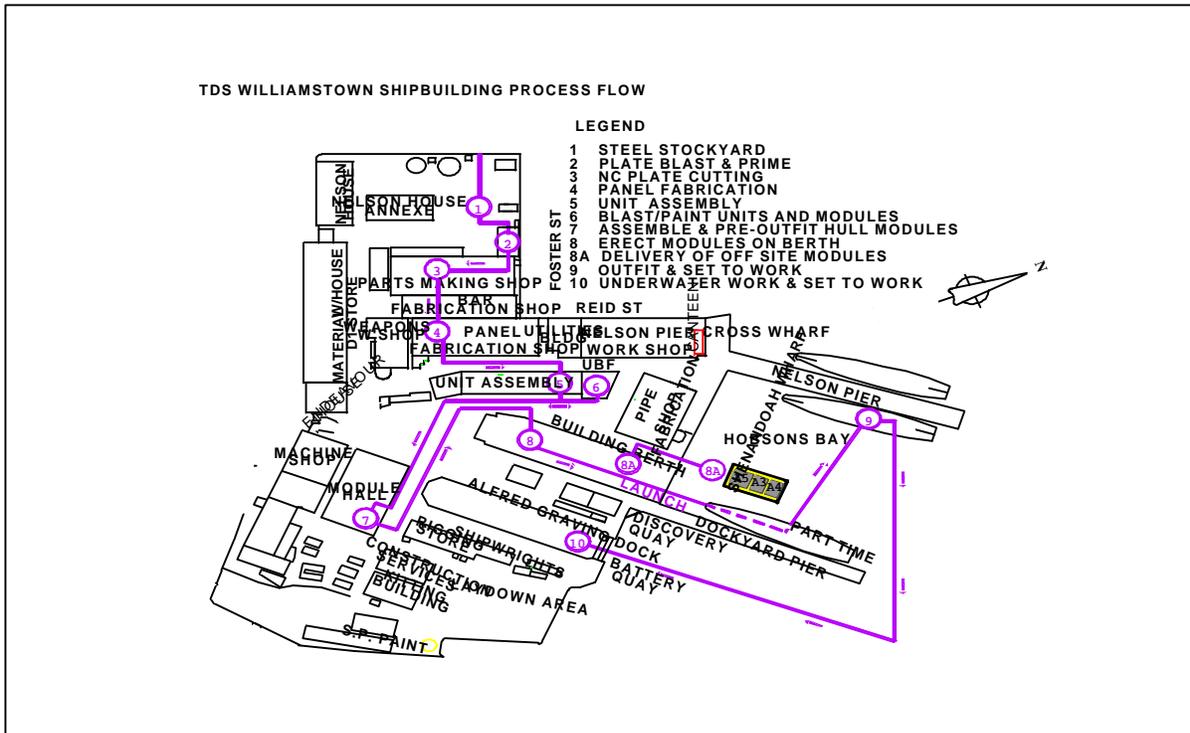


Figure 5. Ship Production Process for the ANZAC frigates.

- Stage 1 - Quality Control Inspections/Tests,
- Stage 2 - Installation Inspection and Tests,
- Stage 3 - Equipment/Module Level Tests,
- Stage 4 - Intrasystem Level Tests,

- Stage 5 - Intersystem Level Tests,
- Stage 6 - Special Tests, and
- Stage 7 - Sea Trials.

By the end of 1995, with the extent of changes incorporated in Ship 01, the original low risk strategy of an 'existing design' could scarcely be considered valid. Much rested on the outcome of Contractor's Sea Trials (CSTs) to provide proof of performance.

The Category 5 Contractors's Sea Trials activity was conducted during January and February 1996, and successfully demonstrated that the performance of Ship 01 exceeded both the requirements and the expectations of the RAN.

ANZ Industry Program.

In order to meet the commitment to ANZII under the prime contract, involving 73% ANZ Content and an 8% Defense Offsets obligation, overseas suppliers were encouraged to establish facilities in Australia or New Zealand, or to establish partnerships with local companies, to manufacture products required for the project.

As shown in Figure 6, the commitments to ANZII are on target. More than half of the obligation under the prime contract for ANZ Content has been spent within Australian and New Zealand industry, and a competent and capable local supplier base has been established. Business Victoria, a Department of the State Government of Victoria, reported that:

"The project has expanded local industry capabilities across a broad range of disciplines. It has brought together a network of over 1,300 suppliers throughout Australia and New Zealand.

Many of the companies are producing products they have not produced before - from advanced software programs for ship systems, to valves, ventilation ducting, pumps, refrigeration units, furniture, recovery boats, engines, electric driers, switchgear and specialist castings."

Integrated Logistic Support.

The prime contract for the ANZAC frigates includes a comprehensive requirement for Integrated Logistic Support (ILS) necessary to ensure that the ships are effectively operated, maintained and supported throughout the life of the ANZAC Class. The elements of the ILS package include maintenance planning, supply support, documentation, manpower, training, technical documentation, facilities, storage and transportation, support and test equipment, and computing support.

An innovation for the ANZAC frigates is the introduction of an ILS performance warranty. The prime contractor has guaranteed an Operational Availability of 80% for a period of 10 ship years. This covers an elapsed period of 4 years from delivery for Ship 01, 3 years for Ship 02, 2 years for Ship 03, and 1 year for Ship 04.

The ANZAC Ship Support Centre (ASSC) has been established at Williamstown to support the development and integration testing of both the platform Control and Monitoring System and the Combat System, and to train navy personnel. The ASSC will be used to provide ongoing training, and to support system maintenance and development to incorporate technological changes. It offers the RAN the important capability to provide parent navy support, and to contribute to the Australian Government's aim for a self-reliant defense capability, rather than depending on an overseas navy, as has been the case in the past.

PRIME CONTRACT REQUIRES 73% ANZ CONTENT + 8% OFFSETS.

AS OF DECEMBER 1996 THE PRIME CONTRACTOR HAS COMMITTED \$A 2,413M AGAINST A PLANNED \$A 2,372M OF ANZIP IN SUB-CONTRACTS.

THE TREATY GUARANTEES NZ \$ 585M OF NEW ZEALAND INDUSTRY INVOLVEMENT.

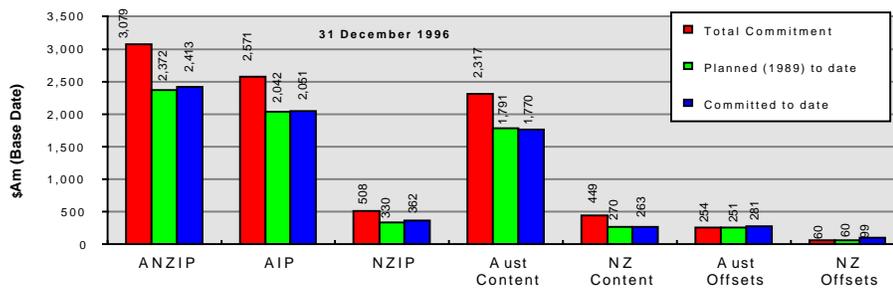


Figure 6. Australian and New Zealand Industry Involvement

PROGRESS TOWARDS INTERNATIONAL COMPETITIVENESS

International competitiveness in naval shipbuilding is considered to be dependent upon several factors; the principal ones being the technology incorporated in the product, the cost of the product, and the delivery time. In the context of the ANZAC Ship Project, Horder [17] claimed it necessary to achieve productivity levels comparable with Germany by Ship 03, which is planned to be delivered in 1998. In 1995, White [18] claimed that international competitiveness had been achieved in productivity, quality and cost, but gave no quantitative evidence to substantiate the claim.

A report entitled "Best Practice in Action" [19] was prepared under the Australian Best Practice Demonstration Program, sponsored by the Australian Manufacturing Council and the Department of Industrial Relations. It presents a collection of the executive summaries of case studies developed on 42 projects. Details of the case studies, including one which relates to the prime contractor for the ANZAC Ship Project, have been published in a book entitled "The Best Practice Experience" [20]. A book by Rimmer et al [21] entitled "Reinventing Competitiveness - Achieving best practice in Australia" also draws on the case study material and other literature. "Best Practice in Action" [19] describes best practice as: "*a comprehensive and integrated cooperative approach to the continuous improvement of all facets of an organisation's operations. The projects are grouped under the particular characteristics in which they excelled, which included:*

- **Leadership/Vision** - *shared vision and strategic plan, commitment and leadership of the Chief Executive Officer;*
- **Industrial Relations Reform** - *co-operative industrial relations;*
- **Focus on People Issues** - *commitment to continuous improvement and learning, innovative human resource management, integration of environmental management practices;*
- **Work Organisation** - *flatter organisational structures, pursuit of innovation in technology, processes and products;*
- **External Links** - *focus on customers, closer relations with suppliers, development of networks; and*

- **Benchmarking** - *development of performance measurement systems and benchmarking."*

In September 1994, the Australian Science, Technology and Engineering Council (ASTEC) commenced a study called "Matching Science and Technology to Future Needs: 2010" to investigate what Australia's future science and technology needs are likely to be by the year 2010. The study has two major components: the "Overview" and the "Partnerships". The Overview component involves the identification of ASTEC's key issues in 2010 looking at Australia's social, economic and environmental needs. The Partnership component of the study involves a more in-depth analysis of the key issues facing Australia in a number of areas. Five Partnerships have been established, one of which is the ASTEC Shipping Partnership. In its report [22], the Shipping Partnership recommended that a suitable set of benchmarking measures be identified, so that a basis for comparisons of international competitiveness and continual improvement can be established for the Australian shipbuilding industry.

Attempts at comparisons of international competitiveness in naval shipbuilding programs are undoubtedly difficult because of the specialised nature of the work, and government policies which may give preference to work being performed in-country, and not necessarily in the most effective or efficient manner. These and other economic and political factors lead some to conclude that comparisons of international competitiveness are not feasible, practical or worthwhile. However, if such an attempt were to be made, the comparison would need to be between similar activities. For first-of-class ship production, the comparison would need to include the engineering, design, and procurement activities as well as production, test and trials activities over the total time from contract award to delivery. A comparison of first-of-class production man-hours with follow ship production man-hours is considered inappropriate.

A methodology which has been applied to assess the competitiveness of U.S. naval shipbuilders against foreign commercial shipbuilders, was reported by Storch, Clark and Lamb [23]. The paper summarises a study conducted by Storch, A&P Appledore and Lamb [24] for the NSRP, and uses Cost (in US\$) per Compensated Gross Ton (CGT) as a measure of international competitiveness for both commercial and naval vessels.

Efforts to undertake a direct comparison of performance between shipyards in Australia and overseas

have not as yet been practicable. However, there is a general view that Australia is approaching a level of international competitiveness in naval ship construction and that the costs of construction in Australia are no higher than the costs in either Europe or the U.S. Further work is needed to make an accurate assessment of the costs of naval shipbuilding in Australia versus overseas.

FURTHER DEVELOPMENT AND OUTLOOK

In the course of the ANZAC Ship Project, problems have occurred along the way, but these have been resolved. The success of the project to date bodes well for the future of naval shipbuilding in Australia, subject to there being a sufficient and sustainable demand from the domestic and/or regional markets.

Australian defense procurement is based on a policy of seeking open and effective competition as a means to demonstrate that best “value for money” has been obtained for the Australian tax payer. However, the need to ensure competition has helped to create a shipbuilding capacity which exceeds the long term steady-state demand of the Australian Department of Defence. Consequently, further industry re-structuring and rationalisation may be inevitable to reduce capacity.

For future RAN ship acquisition projects, there is a need for long term strategies that provide an opportunity for industry to provide some input to the strategy development.

Following the review by Gabb and Henderson [25, 26] of Australian Department of Defence specification practices, it is likely that future defense procurement will be conducted against a “requirements specification” pitched at the relatively high level of “function and performance,” rather than against a detailed “technical specification” which documents the function, performance and technical characteristics of the “solution” or “product” offered.

The Quality Standard ISO 9001 (1994) also includes clauses relating to design verification and validation which effectively require objective evidence to demonstrate traceability from the “requirements” through to the “design solution.” For compliance with the standard, increased rigour is needed in both the formulation of requirements, and their implementation through the design, construction and testing process.

The procurement of critical/major systems and equipment involves a substantial technical activity, and good communication is necessary between the customer, the prime contractor and the ship designer. An arrangement whereby the major parties involved have visibility of the technical and commercial aspects of the

procurement process could help to ensure adequate lead time for the development of specifications and engineering data, and would do much to overcome the difficulties encountered on the ANZAC Ship Project. To support project development, competitive pre-qualification, short listing, or possible source selection of critical/major systems and equipment could be considered as part of the acquisition strategy. This could be performed by the Commonwealth, or by a joint arrangement also involving the prime contractor and the ship designer.

Proposals for the indigenous design of a future surface combatant to replace Australia’s core force of DDG’s and FFG’s [27] must overcome a bureaucratic aversion to the cost and perceived risk of large scale engineering development and design projects. This is likely to continue to make the competitive selection of an overseas-sourced design an attractive option. Assuming that the defense policy for ANZII continues, consideration regarding its implementation is an important part of the project acquisition strategy.

In the acquisition of future surface combatants, both Defence and Industry should seek to learn from the ANZAC Ship Project. Key issues to be considered are:

- The Australian Government policy of seeking self-reliance in defense places priority on developing and sustaining a naval shipbuilding industry capability, not solely on the acquisition of ships for the Navy.
- The objective of the ANZAC Ship Project acquisition strategy to minimize changes to an overseas-sourced existing design proved to be incompatible with the objective of maximising the level of ANZII within a fixed-price contract.
- An acquisition strategy should recognize “change” as a reality, and plan accordingly. It is expected that such recognition will result in a better definition of the scope of changes required, if an overseas-sourced design is considered for construction in Australia, with an associated streamlining of procedures.
- The need exists for a more robust systems engineering management framework for RAN ship acquisition projects, covering requirements analysis and definition, specification practices and engineering standards, procurement, engineering development, design, production, and test and

evaluation.

- Capability upgrades should be pre-planned and scheduled as an integral part of the change management process, both to serve the purpose of maintaining pace between the product and the level of technological change, and also as a means of sustaining the key engineering skills and capabilities developed through the ship acquisition process.
- “In-service support should be addressed as an integral element of the acquisition process, and also as a means of sustaining the key engineering skills and capabilities developed through the ship acquisition process.

A new policy of Evolutionary Acquisition (EA) is under development by the Australian Department of Defence, intended primarily for application to high technology projects which involve large scale software development and system integration. Henderson and Gabb [28] describe the concepts of EA which have resulted from work done in the US at the Defence Systems Management College, and state that a major reason for the introduction of EA for the procurement of complex systems is because users have great difficulty in specifying many of their detailed needs. Traditional acquisition strategies often fail to take this into account and the stated user requirements remain static after the development contract is signed. Additionally, advances in technology are not easily incorporated into systems when the advances occur during development.

The main thrust of EA is the specification, design, implementation, testing, delivery, operation and maintenance of systems incrementally. Delivery of each incremental release increases the capability of the system until complete. Users have early access to system releases and are encouraged to provide feedback on performance. This is used to shape the system as it evolves into its final form. If this approach is followed in a disciplined manner, a more responsive system should result.

It would seem that Evolutionary Acquisition is seeking to deal with some of the factors which, for the ANZAC frigates, emerged as difficulties during the procurement, design and production phase. The concept, whilst primarily intended for software intensive projects, such as Command, Control, Communications and Intelligence (C³I) systems, might also have application to complex naval ship design and construction projects. In this respect, the provision of margins, either as “Space

and Weight” or “Fit For But Not With,” within the contract design baseline of the ANZAC ships is indicative of planning for future capability enhancement.

Overall, there are many factors to be taken into account and balanced, and the development of an appropriate acquisition strategy represents both an opportunity and a challenge to those involved in planning the design and production of Australia’s next generation of surface combatants.

PROJECT ACHIEVEMENTS

The ANZAC Ship Project has been successful in delivering the first-of-class, HMAS ANZAC, to the RAN. The ship has successfully completed its PT&E program, and the Combat System is fully functional. Formal acceptance into naval service of HMAS ANZAC by the RAN is expected in mid to late 1997, following a period of OT&E. The second ship, HMNZS Te Kaha, is expected to be delivered to the RNZN in March 1997. The Combat System Tactical Trainer at HMAS Watson in Australia has been delivered. The Combat System Tactical Trainer for New Zealand and the ANZAC Ship Support Centre at Williamstown in Australia will be delivered in early 1997. Delivery of these major items is within the budget and the agreed schedules.

The engineering achievements of the ANZAC Ships are described by Welch [29], the RNZN Chief of Naval Staff, in a paper to the 1997 Annual Conference of the Institution of Professional Engineers New Zealand. Factors which have featured in the successful outcome include the development of an increasingly self-reliant industry capability, the transfer of technology, the development of Australian and New Zealand industry involvement, improvement in the performance and competitiveness of the Australian naval shipbuilding industry, and the potential for export market opportunities.

The industrial infrastructure developed to support the ANZAC ship construction activity is also capable of providing through-life support. This capability will be tested when the RAN invites industry to bid to provide ANZAC Class In-Service Support.

The ANZAC Ship Support Centre, together with appropriate commercial support, provide the means by which the RAN can provide the full range of services required of a parent navy. The ASSC and the Combat System Tactical Trainers at HMAS Watson in Sydney and at HMNZS Tamaki in New Zealand, will provide comprehensive navy crew training facilities.

Achievements on the ANZAC Ship Project have been recognized within Australian industry with the announcements in 1996 of two awards, namely: the

Institution of Engineers, Australia "Engineering Excellence Award", and the "Australian Defence Quality and Achievement Award" for Projects over A\$ 20 million.

The task remains to deliver another 9 ships, with the possibility of a major capability upgrade during construction for Ships 07 to 10.

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