SUBMARINE REFITTING IN AUSTRALIA

by

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170

INTRODUCTION

The introduction of "Oberon" Class Submarines into service in the Royal Australian Navy in 1967 heralded a new era in the involvement of the Cockatoo Island Dockyard with submarines in Australia.

The support requirements of the new submarines resulted in the construction of new facilities and the introduction of modern management and production techniques. Since the start of the first refit, in 1971, the refit and support of the submarines has been the principal role of the dockyard.

This paper outlines the progress achieved and the experience gained during the first series of refits. A description is given of the current programme of modernisation of submarine weapon systems which will place Australia's submarines amongst the best equipped conventional submarines in the world.

HISTORICAL BACKGROUND

Australia's first submarines were of the British 'E' Class. *AE1* and *AE2* had a surface displacement of 660 tons, were 181 feet in length and had an armament of four, 18 inch torpedo tubes. The 'E' class were the first submarines to mount broadside torpedo tubes.

The Australian Boats were built by Vickers Limited at Barrow-in-Furness and commissioned in February, 1914. They arrived in Sydney in May, 1914 and shortly thereafter, on 6th June, 1914, both boats docked in the Fitzroy Dock at Cockatoo Island, starting a long association with submarines for the Dockyard.

This first association was, however, to be short lived. *AE1* disappeared without trace off New Britain on 14th September, 1914 and *AE2* was sunk in the Sea of Marmora on 30th April, 1915.

Australia's next submarines were the six surviving 'J' class submarines, built under the Emergency War programme in 1916 and presented to Australia in 1919. These quite large submarines of 1,210 tons surface displacement were unique, being the only British submarines ever fitted with triple screws and on completion they were the fastest submarines afloat, with a surface speed of 19 knots and a submerged speed of 9½ knots.

The six boats, *J1, J2, J3, J4, J5,* and *J7* arrived in Sydney in June, 1919. In somewhat poor condition on arrival, they were taken in hand for refit at Garden Island and Cockatoo Island. The first boats to complete their refits sailed in 1920 to Geelong, Victoria, where a submarine base was established.

The 'J' Boats were to see little service apart from a visit to Tasmania and local exercises, and by 1922 they had been paid off. They were sold for scrap between 1924 and 1929.

The next attempt to start a R.A.N. submarine arm began in 1925 with the ordering from Vickers of two 'O' class submarines, slightly modified to to RAN requirements. *Oxley* and *Otway* were of similar size to the 'J' class and were to the first British post war submarine class design. Completed in 1927, they arrived in Australia in November, 1928, after an eventful voyage marred by serious engine problems.

Again, the dockyard association with submarines was to be short, both boats paid off at the end of 1929, and were handed over to the Royal Navy in 1931.

They were to be the last RAN submarines for 35 years, apart from the brief commission of the Dutch submarine *K9*, in 1943-44.

Between 1949 and 1969, the Royal Navy maintained the 4th Submarine Squadron in Australian waters, based in Sydney. In that twenty year period, ten submarines spent periods of time with the squadron, three 'A' class and seven 'T' class. During the early part of the period the submarines regularly docked in Australia, although main refits were carried out elsewhere.

In 1960, HMS *Tabard* began the first of five 'T' class refits at Cockatoo Island. *Tabard* was refitted twice, *Trump* twice and *Taciturn* once. During the refits, which lasted for about 14 months, all work associated with the refits was carried out at Cockatoo, except for work on radio, sonar, torpedo control systems, gyro compasses, masts and main batteries which were undertaken by Garden Island. The removal and replacement of most of these items was undertaken at Cockatoo.

The specialised facilities available at Cockatoo for these refits were minimal; hence the decision by Australia, in 1963, to purchase a squadron of 'Oberon' class submarines, was to prompt a new era in Cockatoo Island Dockyard and a major role for the yard in the refit and modernisation of the Australian Squadron.

The four submarines initially ordered, *Oxley, Otway, Ovens* and *Onslow* entered service between March, 1967 and December, 1969. Two further submarines *Orion* and *Otama* were ordered in 1970. They entered service in 1978 and together with the earlier boats constitute the First Australian Submarine Squadron, based at HMAS *Platypus* in Sydney. All six boats were built in Greenock, Scotland by Scotts Shipbuilding and Engineering Co. Ltd.

4/....

THE 'OBERON' CLASS SUBMARINE

The 'Oberon' class submarine is a long range diesel electric patrol submarine and is a development of the 'Porpoise' class, which were the first British patrol submarines to be built after the Second World War. The Royal Navy acquired seven 'Porpoise' class and 13 'Oberons' - Canada three 'Oberons', Chile two and Brazil three. Including the Australian boats, a total of 27 'Oberons' have been built.

The Submarines have a surface displacement (full buoyancy) of 2196 tons, and a submerged displacement of 2417 tons. They are 295 feet 3 inches long overall, and have a beam of 26 feet 6 inches. They are propelled by electric motors of 6,000 SHP, and electric power is provided by two generators powered by Admiralty Standard Range diesels of 3,600 BHP.

The submarines have eight torpedo tubes - six 21 inch forward and two 23 inch aft (which are not used in the RAN boats). Accommodation is provided for a crew of 68. Air conditioning is provided for habitability and electronic equipment cooling.

The submarines are constructed with a double hull, the external hull containing main ballast tanks and external fuel tanks. The internal hull, the pressure hull, is divided into five watertight compartments.

The battery is divided into two sections and is charged by the main diesel generators. It is provided with systems for cooling, agitation and ventilation.

The submarine's external casing, and the fin (which houses periscopes, radar and radio masts, and the snort induction and exhaust masts) are largely constructed of glass reinforced plastic.

The submarine is controlled by one rudder and four hydroplanes, two forward and two aft. These are operated hydraulically and controlled by a One Man Control system which incorporates an automatic pilot and can control course and depth.

REFITTING FACILITIES

The 'T' class submarines were refitted with such facilities as were available at Cockatoo Island at the time - and bearing in mind the limited life

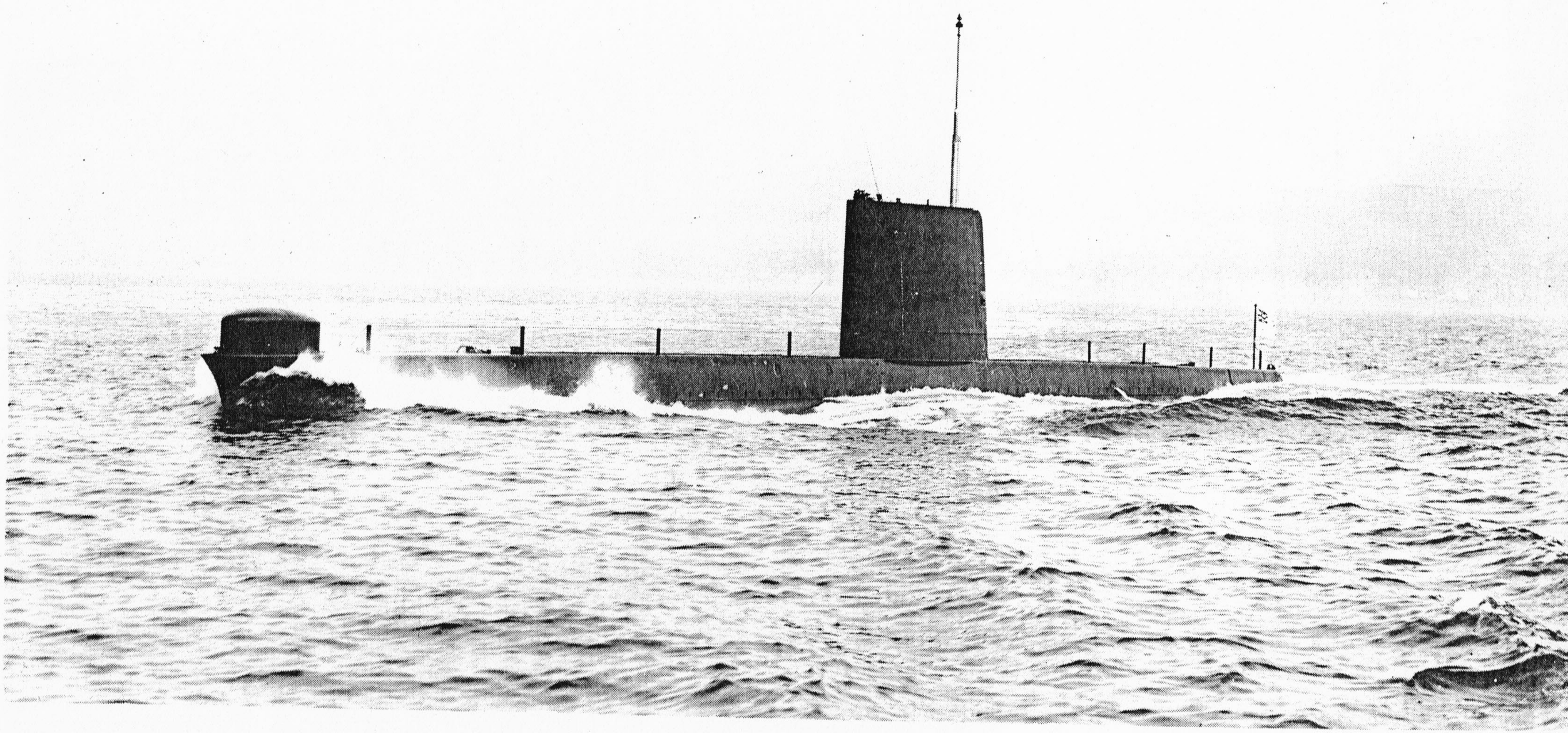


Figure I - R.A.N. 'Oberon' Class Submarine expectancy of the 'T' class submarines and their comparative simplicity, this situation could be tolerated.

The 'O' class submarines however were to start their refit programme in 1971, and from that date a continuous workload could be expected for their remaining service in the R.A.N. The workload, will, in fact extend to the end of the century, given normal operational life expectancy. There was a need therefore to update the facilities to provide adequate means of refitting the much more sophisticated systems in the 'O' boats.

Accordingly, the Department of the Navy and the lessee company (then Cockatoo Docks and Engineering Co. Pty. Ltd.) jointly commissioned the P.E. Consulting Group (Aust.) Pty. Ltd. to carry out a survey of the physical resources of the dockyard and to make recommendations for those modifications needed to enable it to fulfil its role in support of the new submarines.

This survey was completed during 1966, using as its basis terms of reference prepared after a technical mission to the United Kingdom. During the latter stages of the study, a further visit was made to the U.K. and Canada to confirm the suitability of the arrangements proposed.

The modernisation of the dockyard and the provision of facilities as embodied in the final report was extensive, and made the more so by the particular conditions affecting the task of refitting submarines in Australia.

In the United Kingdom and Canada, much use is made of the services of equipment suppliers, or specialised naval facilities in other locations, for the refit of submarine equipment, rather than undertaking the work in the refitting dockyard. In Australia, from the outset, it was intended that as much as possible of the work should be done in the one location - a policy made necessary by our relative isolation from the source of supply of most of the submarine equipment, and the lack of suitable facilities in Australia.

It was proposed that some work would be undertaken in existing facilities at other places. For example, a battery shop existed at Garden Island, as did optical facilities for submarine periscopes, and

6/....

this work has remained in these locations. It is likely, however, that some work of this nature may be moved to Cockatoo in the future.

The proposals made by the Consultants were converted into detailed plans by the Commonwealth Department of Works, and following Government approval to proceed, were implemented between 1968 and 1971. The timescale was rather tight, and the dockyard was very busy at the time with a substantial programme of new construction and naval surface ship refits. A carefully planned schedule was necessary to avoid major disruption to this programme and to meet the anticipated start for the first refit of HMAS *Oxley* in March, 1971.

In the event, the completion of the facilities ran slightly behind programme, overlapping the first refit, and was to provide one of the many challenges to the dockyard management during that refit.

Most of the Consultants' recommendations were implemented. It is unfortunate, however, that one of the major items, the reconstruction of the Fitzroy Wharf as the main submarine wharf fell victim to financial economy. This wharf remains central to the basic logic of the facilities, and to this day the dockyard management persists in the hope that it will be restored to the programme in due course to enable the facilities to be used in the manner originally contemplated.

Nevertheless, it reflects great credit on all those involved in the original study, and on those who turned it into reality, that the facilities have proved to be excellent for the purpose, and after the experience of eight years of use, there is very little that would be changed.

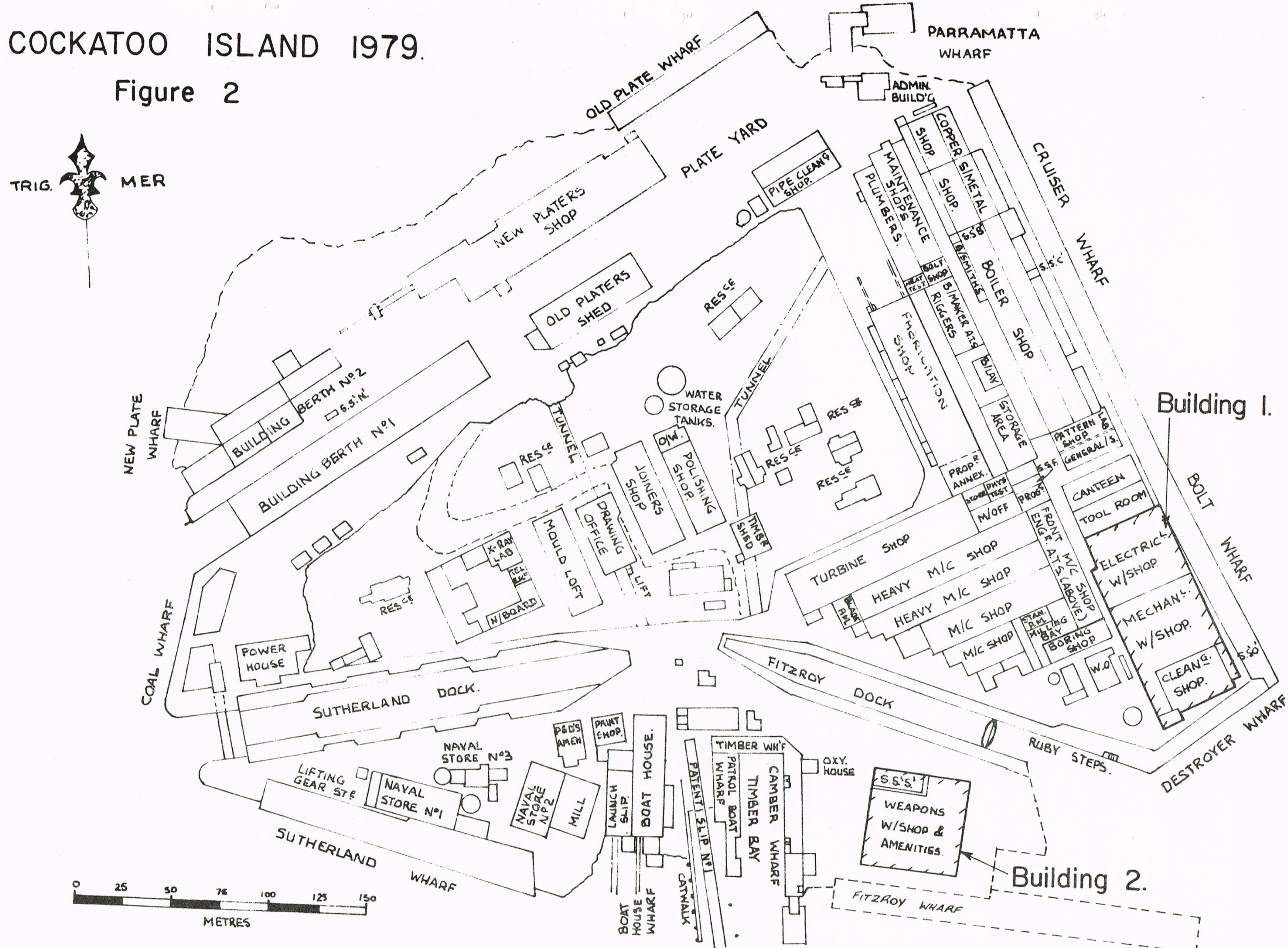
The principal heart of the new facilities was located in two buildings (shown as Building No. 1 and No. 2 on Figure 2) in the south-east corner of the island. The construction of Building No. 1, in particular, necessitated the relocation of existing facilities in the area before work could start. Building No. 2 was to occupy the site of two disused shipbuilding berths.

Building No. 1

Building No. 1 is a large two storey building some 295 feet by 145 feet, constructed of a reinforced concrete framework with brick infill in the walls. On the ground floor it houses the principal mechanical and

COCKATOO ISLAND 1979.

Figure 2



electrical workshops together with sub-station and conversion machinery spaces. The second floor has amenities for 1,000 workmen, and plant rooms.

The facilities in this building include:-

- The Dirty Transit Store - this space is the first stop for equipment removed from the submarine, it has a stripping and cleaning bay.

- The Mechanical Assembly Shop - a fitting shop well served with craneage and local workshops and stores.

- The Telemotor and HP Air Room - this is a clean room which is air conditioned and supplied with filtered air to class 10,000.

- Functional Test Rooms - equipped with all the liquid and electrical services found in submarines to enable full functional, noise and vibration trials to be carried out on submarine equipment.

- The Electrical Production Shop and the Electrical Assembly Shop - complete with cleaning bays, machine tools and test facilities. This is the one area of the facilities which has proved to be rather too small for its intended purpose, and in recent years, some relocation of machinery and extension into adjoining spaces has been necessary.

- An Electroplating Shop - principally to serve the needs of the electrical workshops.

All the spaces are well finished internally, brightly lit and provided with the necessary air, electrical and firefighting services. A central, inbuilt, vacuum cleaning system serves the whole of the ground floor.

Building No. 2

Building No. 2 is principally devoted to weapons and electronics; however it also contains those facilities planned to complement the proposed Fitzroy Wharf, which has not eventuated. It contains:-

- Secure Transit Stores and Lay-Apart Stores.

- Stripping and Cleaning Areas - with ultrasonic cleaning facilities for electronic equipment.

- An Electronics Workshop.
- Testrooms for Sonar and Torpedo Fire Control Systems - these rooms contain rigs to allow complete functional testing of these systems.
- A Sonar Directing Gear Workshop.
- A Battery Connector Shop.
- A Clean Transit Store - for holding refitted equipment prior to re-installation on board.
- A Radio and Radar Workshop.
- An Instrument Workshop.
- Accommodation for stand-by ships' crew, including sleeping and mess spaces for officers, senior and junior sailors.
- Offices and amenities for dockyard staff.

This building is some 164 feet by 166 feet and is of similar construction to Building No. 1. Most of the workshops are air conditioned and all necessary services are provided.

Other facilities provided during the modernisation include a pipe cleaning shop, the re-location and modernisation of other shops, and the provision of services at the Bolt and Destroyer Wharves (see Figure 2). In 1974, a specially designed slave dock was built at Cockatoo for use by the submarines. The design and construction of this dock was described in detail in a paper given to the Australian Branch of the RINA in 1975 (Reference 3).

More recently, a further stage of the overall modernisation of Cockatoo has been completed with the full rehabilitation of the Bolt and Destroyer Wharves. This work entailed the structural repair of the wharves, the provision of more complete air, water and electrical services, and two new wharf cranes. All these services and cranes were specifically designed to suit the requirements of what is known as 'two-stream' refitting - as had the facilities in Buildings 1 and 2.

Two stream refitting occurs when the overlap between refits is sufficient to result in virtually a continuous refitting programme with two submarines in hand. From 1971 to 1978 the programme was essentially single stream.

9/....

Figure 3 - Mechanical Assembly Shop

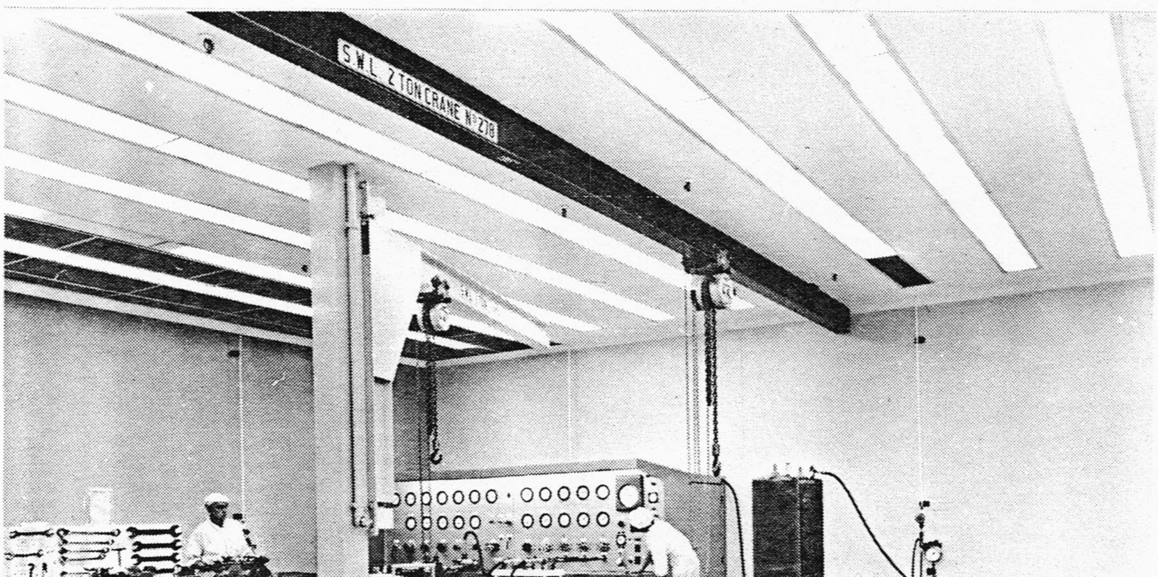


Figure 4 - H.P. Air and Hydraulic Workshop

THE SUBMARINE REFIT CYCLE

Australia's submarines operate on a five year cycle. This means that the normal operating period between refits is five years. The 'Oberon' class submarine was originally intended to operate on a three year cycle - this was extended to four years, and subsequently to the present period of five years. HMAS *Onslow* was the first RAN submarine to operate for five years before refit, and she covered some 112,000 miles on operations during that period.

The five year operational period is broken by three intermediate dockings (of approximately 3 weeks) and one survey docking (of approximately 6 weeks). The survey docking, which is carried out at approximately three-fifths cycle, involves a more rigorous examination of the hull and systems subject to full diving pressure than is normal during an intermediate docking, and is intended to confirm the safety of the submarine to complete the five years of service.

The four refits completed to date (1979) have each taken approximately two years to complete, and the presently planned refit time for the next series of refits is about two years. This time is largely governed by the substantial updating programme which has been planned for each refit. However, it also happens to suit the dockyard workload conveniently, and in the context of a five year cycle means that in its normal life each submarine will have three refits. For the first four submarines the second refit is more in the nature of a half life modernisation. The bar chart in Figure 5 outlines the history of the refit programme to date.

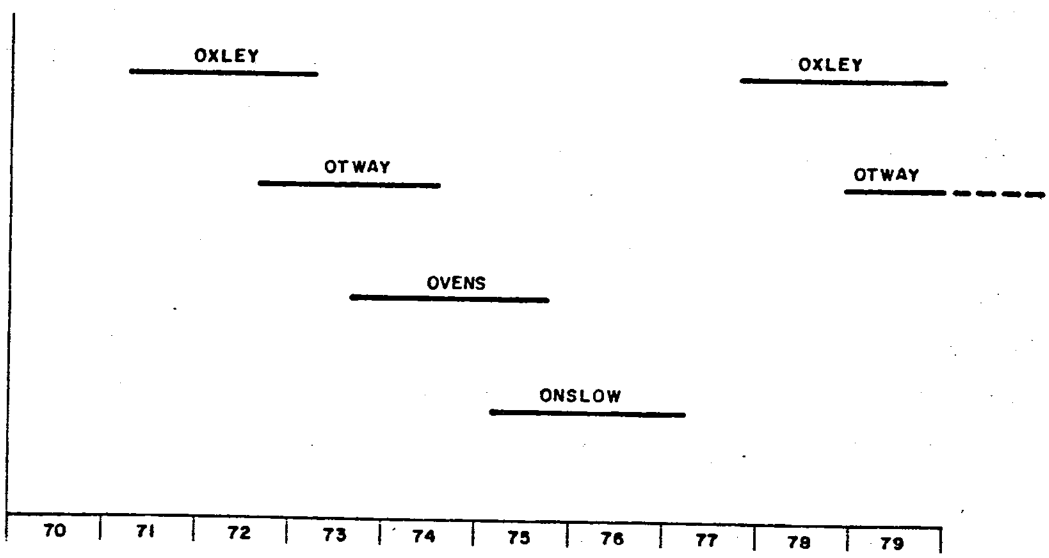


Figure 5 - R.A.N. 'O' Class Refit History

THE DOCKYARD ORGANISATION

Cockatoo Island Dockyard is owned by the Commonwealth of Australia and leased to Vickers Cockatoo Dockyard Pty. Limited (a subsidiary of Vickers Australia Limited) who operate the dockyard under the terms of a Trading Agreement. This company has operated the dockyard since 1933 (it was previously known as Cockatoo Docks and Engineering Co. Pty. Ltd.), the lease having been last renewed in 1972.

Orders for submarine refits are placed directly by the Department of Defence (Navy Office), the conditions of the order being determined both by its conditions of contract and the Trading Agreement. The Department is represented locally by the General Overseer and Superintendent of Inspection East Australia Area (who is also the Company's landlord as Chairman of the Cockatoo Island Lease Supervisory Committee). He is represented on the island by the resident Principal Naval Overseer (a Commander RAN). The PNO has a uniformed staff of 6 including his direct assistant in submarine matters, the Submarine Project Officer (a Lieut. Commander RAN) and the Quality Assurance Representative (A Lieutenant RAN). He also has a civilian staff of 23 headed by professional engineers and naval architects.

For a major part of the refit period, the responsibility for safety and security of the boat is passed to the Company. Nevertheless, the operators, the First Australian Submarine Squadron are represented throughout the refit by a small nucleus of standby officers and sailors, who increase in number towards the end of the refit as they gradually accept systems and equipment for custody and maintenance during the trials phase of the refit. Their formal line of communication with the Company is through the General Overseer and his staff.

Whilst the submarine refitting programme represents a major portion of the workload of the dockyard, it is involved in a wide range of other activities in the shipbuilding and ship repair field, and in general engineering. For this reason, few of the dockyard's resources are devoted solely to submarine refitting.

The high content of shared skills and resources amongst the tasks rules out a project oriented management structure. Such an organisation would make it virtually impossible to retain the flexibility in the allocation of resources which is essential for the efficient operation of the dockyard. The organisation structure of the dockyard was designed therefore to maximise this flexibility by retaining strictly functional departments. Thus, all trade labour and plant are concentrated in the Production Division and most technical support services such as design, draughting, planning and estimating within the Technical Division. Within each there is full authority to allocate resources to projects in accordance with their fluctuating needs.

It is recognised nevertheless that a major project such as a submarine refit requires dedicated supervision on a full-time basis. A Submarine Superintendent fulfils this role within the Production Division and a project office operates within the Technical Division.

To provide means for a total project review and co-ordination, the submarines have a Contract Manager, responsible directly to the Managing Director. His duties include day-to-day liaison with the RAN, attention to contractual matters, ensuring that information flows smoothly and constant monitoring of progress, both financial and physical.

PRE-REFIT ACTIVITIES

Advance planning for each refit starts twelve months before the scheduled start date. The work undertaken in this period is vital for a successful start for the refit. The principal milestones for the year are:-

At start date minus 12 months	- Start identifying spares requirements for refit work.
At start date minus 11 months	- Start placing demands for spares requirements from the Naval Supply system.
	- Receive order from Navy for preliminary work (advance funding available).
At start date minus 6 months	- Receive main Work Package.
	- Receive main order for refit.
	- Start preparing Work Packs for alterations and additions and modifications.

12/....

At start date minus 6 months (Cont'd)	- Start preparation of Quality Plan.
	- Start ordering materials for A's and A's and Mods.
	- Start preparation of Master Refit Network.
	- Start preparation of Work Orders.
At start date minus 4 months	- Submit cost list and first estimate
At start date minus 1 month	- Submit Agreed Key Date Programme.
	- Confirm final Work Package.
	- Commence issue of Work Orders.
	- Issue first Work Schedules.
As appropriate, prior to start date	- Pre-refit Conference

THE WORK PACKAGE

The scope of the work to be carried out by the dockyard in each refit is defined in the Work Package. This document calls up applicable scheduled maintenance items, known defects, and approved Alterations and Additions and Class Modifications.

The starting point for the work package is the Submarine Planned Maintenance Schedule. This lays down ships staff, base staff and dockyard maintenance routines for all submarine systems and equipments. The RAN schedules are a development of those for the Royal Navy 'O' Class submarines.

For the earlier refits, the work package was a relatively slim document which made reference to the refit items in the PMS, as well as listing the approved A's and A's and Class Mods. It was prepared by the Ship's Staff with assistance from the Base staff. At best, it was an imperfect document. Essential work was sometimes ommitted, the precise scope of work was generally unclear, and frequently it listed A's and A's and Modifications for which there was little real prospect of information and materials being available to suit the refit programme.

In recognition of these deficiencies, and in order to seek the most cost effective use of resources during refit, the Work Package became subject to scrutiny by a joint Navy/Company committee known as the Work Content Committee.

The activities of this committee were somewhat sporadic for a number of years. Events were however, to bring it to new prominence. The first refit of HMAS *Onslow* (the fourth to be undertaken) was to start at a time of particular financial stringency, and in an endeavour to reduce the total cost of the refit the Work Content was reduced by rather arbitrary means, giving priority for refit to those items which principally affected safety. This approach created many problems for that refit - it ignored the experience which had been gathered over the previous three refits, created many problems during trials and completion, and in the long run did not achieve significant economies.

Towards the end of this refit it was clearly apparent to all that the time was right for a major review of the Work Package, not only to assess the appropriateness or otherwise of the work called up, but to incorporate in it the experience of the first four refits, with the aim of producing a Standard Work Package - in effect a refit 'bible'. There was also to be a gap in the programme of refits of about 12 months which would provide a breathing space in which the work could be completed.

The Work Content Committee was tasked with the job, and for some nine months, staff from Navy Office, the Submarine Base, GOSIEAA and the Dockyard laboured to produce the new document.

The work was completed just in time for the start of the second refit of HMAS *Oxley* and for the first time there was available a comprehensive document which:-

(a) Defined the extent of systems and equipments to be removed from the boat during refit.

(b) Included a definitive statement of the repair procedures to be undertaken, making reference to applicable specifications and drawings.

(c) Nominated for routine replacement those items which experience had dictated would need replacement regardless of survey.

(d) Nominated approved procedures.

(e) Nominated, as before, approved A's and A's and Modifications.

In this regard, the Work Content Committee, as part of the preliminary activities prior to refit, reviews items proposed for inclusion and may recommend deferment of non-mandatory items if doubt exists as to the timely availability of information, materials or equipment.

This new Work Package (which comprises some 1253 pages) forms the basis for the Work Orders issued within the Dockyard. It is significant that its format is directly related to the dockyard's system of Work Authorisation and costing. This ensures a minimum of effort to translate the customer's requirements into work instructions. The improvement which has been achieved is best illustrated by comparison of similar sections of the Work Order for the first and second refits of HMAS *Otway*. These are included as figures 6 and 7.

In addition to the reasons quoted above, there were other pressing reasons for a more precisely defined work package. These related to the requirements of a new Company system, introduced to an Australian Dockyard for the first time for the 'O' class Submarines - Quality Control.

QUALITY CONTROL

In 1967 the Navy advised the Company that, in view of the increased complexity and tighter specification requirements for modern submarines, they would be required to establish a Quality Control System for submarine refits. At that time there was no Australian Specification for Quality Control, however in 1968 a document appeared - NQA7101A "General Requirements of a Contractors Quality Control Organisation". Planning began on the basis of this specification and in 1970 approval was given for the establishment of the necessary organisation.

For many years past, Cockatoo Dockyard had been used to working with Naval Overseers, who, in addition to providing the customer with a form of assurance that work had been completed successfully, gave extensive technical support to the company, often beyond that strictly called for. It was

15/....

HMAS OTWAY MAIN REFIT 1972-73

EQUIPMENT: CYLINDER HEADS.

EDP Nº: 158

P.M. SCHED. REF.: E408 **INSPECTION:** P.O.C.

COST HEADING	WORK DESCRIPTION
1580A	Remove, dismantle, decarbonise, flush, descale, crack detect and survey cylinder heads & compression cocks. Shop pressure test with hot water to 60 p.s.i. for 3 hours. Decarbonise, clean & polish inlet & exhaust valves. Crack detect cylinder head studs & check elongation. Renew valves with bent or scored spindles or with more than 0.0625" clearance between valve head and the explosion face of the cylinder head when the valve is in the closed position. If with a new valve, the clearnace exceeds 0.050" the cylinder head is to be reclaimed by fitting valve seat inserts in accordance with BR.3601, Repair Instruction No. 11. Repair defective cylinder head studs and nuts. Renew cylinder head joints and rubber rings on water ferrules. Grind valves to seats & machine pitted valves. Replace cylinder heads. Tighten nuts in order 1,4,2,5,3,6 using torque spanner set at 590 lbs/ft. Refit & test compression cocks. <u>NOTE</u>: In order to reclaim worn cylinder heads, valve seat inserts with a hardness range of 40-47 (Rockwell) Ad.Ref.No. 954-958004 for inlet valves and 954-958005 for exhaust valves are to be used by shrinking into the heads using 'cardice' after the heads have been machined in accordance with drawing 81/078/12B. Adhere to shrink fit diameter. When grinding seat and valve, grade 360 carborundum powder is to be used and changed frequently. Cylinder heads are to be crack detected on the expansion face before and after fitting valve seat inserts. See Engine Mod 273 for details of modification to water orifice and clearing of water spaces which is to be carried out concurrently if not already done.
1587L	Carry out OCM 628:- Replace existing exhaust valves with stellite faced exhaust valves.

Figure 6

VICKERS COCKATOO DOCKYARD PTY. LTD.
H.M.A.S. "OTWAY" - 2nd MAIN REFIT 1979-81.

RE65 CB | JOB No 3068 OTWY

MASTER INDEX No:- 158 & 169
P.M. SCHEDULE No:- E408, E421

Work Description PART. 1.

W.O. No | CYLINDER HEADS & VALVE GEAR

NOTE: USING REFIT INSTRUCTIONS E408 & E421 (ref in brackets)

The following work to be carried out on W/O No 1511P:-

1. Disconnect, identify & remove:
   a. Rocker gear covers, cylinder heads, valve gear & push rods, I.A.W. BR3601, Chap. 4, Para. 6, Operations (I) to (II).
   b. Radius arms & radius arm brackets I.A.W. Refit Instruction E421 (ref 4.1).
   c. Cylinder head holding down studs & nuts.

   NOTES:
   1. Bumping clearances are to be taken prior to removing the cylinder heads from the engine.
   2. As soon as possible after lifting the cylinder heads the spigot sealing faces are to be protected from damage by security a suitable plywood disc covering the spigot and flame plate. This disc is to be kept in position at all times during transportation, survey & repair, except when access to the spigot or flame plate valve seats is required.
2. Blank all open ended pipes & other openings remaining in ship.

1582C
1. Remove & identify the valve gear, valves spring, spring plates & collets I.A.W. BR3601, Chap. 4, Para. 6, Operation 12 & 13 & Para. 7, Operation 1 & 2
2. Dismantle & identify the valve gear, radius arms & radius arm brackets I.A.W. Refit Instruction E421 (ref 4.2).
3. Remove from head, dismantle & identify indicator valve components.
4. Decarbonise, degrease & dry the cylinder heads I.A.W. Refit Instruction E408 (ref 4.3.1).
5. Decarbonise, clean & polish each valve. Clean the valve springs, spring plates & collets.
6. Clean the valve gear components, prove clear all oilways.
7. Clean rocker gear covers.
8. Decarbonise & clean indicator valve components.
9. Remove core plugs & hydroblast the heads I.A.W. Refit Instruction E408 (ref 4.3.1(d)).
10. Crack detect the following I.A.W. Refit Instruction E408 (ref 4.3.1(g)):
    a. Cylinder heads.
    b. Cylinder head holding down bolts.
11. Crack detect the following I.A.W. Refit Instructions E421 (ref 4.3):
    a. Valve lever brackets.
    b. Valve & valve lever tappets.
    c. Thrust & fulcrum pins.
    d. Push rods.
    e. Radius arms & radius arm brackets.
12. Dimensionally check the cylinder head, valve stem & valve guides I.A.W. Refit Instruction E408 (ref 4.3.2 & Plate 1).
13. Test valve springs for free length & compression I.A.W. BR3601, Chap. 5, Page 5.23, Item 81/074/36 & Drg 163P-4133-048.

VICKERS COCKATOO DOCKYARD PTY. LTD.
H.M.A.S. "OTWAY" - 2nd MAIN REFIT 1979-81.

RE65 CB | JOB No 3068 OTWY

MASTER INDEX No:- 158 & 169
P.M. SCHEDULE No:- E408, E421

Work Description PART. 1.

W.O. No | CYLINDER HEADS & VALVE GEAR

1582C CONTD.
14. Dimensionally check the following valve gear components I.A.W. BR3601, Chap. 5, Pages 5.6 & 5.7 & Refit Instructions E421 (ref 4.3(d) & Plate 1):
    a. Fulcrum pin & brush.
    b. Fulcrum pin & thrust bush.
    c. Radius arm roller & bush.
    d. Radius arm fulcrum pin & bush.
    e. Roller shell.
15. Check tappet springs for compression & free length I.A.W. BR3601 Chap. 5, Page 5.23, Item 81/074/66 & Drg 163P-4133-072.
16. Survey for additional work (excluding items renewed on W/O No 1583D)

1583D
Repair as follows:-

1. General
   a. Renew items for all components I.A.W. APPENDIX A/158 PART 1.
   b. Deburr all components & dress all threads.
   c. Protect, preserve & blank all open ends for storage.
2. Cylinder Heads & Valves
   a. Renew items.
   b. Lap explosion joint spigots.
   c. Machine valves & valve seats & lap together.

   NOTES:
   1. Valve seat inserts should be fitted when the clearance between the crown of a new valve & the explosion face exceeds 0.040" or when the width of the valve seat exceeds 0.240".
   2. Where a cylinder head has previously been fitted with one or more seat inserts, on the next occasion when an original (i.e. no insert) seat requires reclamation by insert, then all original seats should be so reclaimed.
   3. Where a cylinder head still in the original seat condition requires only one insert, the remaining seats are to remain in the original condition. However, if two or more inserts are required then all four seats are to be reclaimed.
3. Valve Gear, Radius Arms, Brackets
   a. Renew items.
   b. Prove clear all oilways.
4. Indicator valves
   a. Renew items.
   b. Lap valve to seat.
   c. Assemble & shop test to 1800p.s.i. using clean air.
5. Rocker Gear Covers
   a. Renew items.
   b. Replasticise covers.
   c. Rechrome cover sleeves.
   d. Rechrome hand nuts.
6. Closing up dimensional inspection required & readings recorded.
7. Reassemble cylinder heads & valve gear I.A.W. BR3601, Chap. 4, Article 13 & carry out shop test on water spaces to 60p.s.i. using hot fresh water.

VICKERS COCKATOO DOCKYARD PTY. LTD.
H.M.A.S. "OTWAY" - 2nd MAIN REFIT 1979-81.

RE65 CB | JOB No 306 OTW

MASTER INDEX No:- 158 & 169
P.M. SCHEDULE No:- E408, E421

Work Description PART. 1.

W.O. No | CYLINDER HEADS & VALVE GEAR

1583D CONTD.
NOTES:
1. If required, valve seat inserts are to be fitted I.A.W. BR3601 Repair Instruction No. II.
2. Cylinder heads, with damaged joint spigot - for slight spigot damage, the spigot may be dressed or machined within the dimensions 0.186"/0.188" without corrective action on the steel seating ring. Should this 0.002" tolerance be insufficient to provide a clean joint face, reduction in height of the spigot up to 0.030" is allowed. Should this be necessary the steel seating ring thickness must be reduced by the same amount, & the ring & head kept together as a pair. Any further reduction in spigot height should be catered for by: (a) Machining the explosion face & outer face in increments of 0.030" I.A.W. BR3601, Chap. 4, Para 10 and (b) Machining the spigot by such an amount as to regain the design spigot height of 0.186"/0.188".
3. Replace onboard & connect the following on W/O No 1514B I.A.W. Refit Instruction Nos E408 (ref 5 & 6) & E421 (ref 6):
   a. Cylinder head holding down studs & nuts.
   b. Radius arms & radius arm brackets.
   c. Cylinder heads, valve gear, push rods & rocker gear covers.
4. Carry out Contractors Inspection on W/O No 1514B.
5. For further information regarding Inspection, Tests & Trials for this equipment see W/O No 1515C.

REFERENCES: MOD Ship Letter 15/119/DPT13 of Sept. 1969 Enclosure to N.O. Letter 1218/51/552 of 30.1.70.
HANDBOOK: BR3601
REFIT INSTRUCTIONS: E408 & E421
SPARE GEAR APPENDIX: A/158
P.I.L.: DID/4/4 ADREF 001-995732
DRAWINGS: 163P-4140-C88 to 096, 098, 099 & 101; 163P-4133-001 to 092 incl. 163P-4133-115 & 117 to 123 incl.
FURTHER REFERENCES: I.A.W. REFIT INSTRUCTIONS E408 & E421 (ART. 1)

Figure 7

recognised that it would take time for a change in this role to take effect, a new organisation could not be established and effectively accepted overnight. Hence a gradual build up was planned in the Company's responsibility for Quality Control, starting with about a 40% coverage on the first refit and reaching 100% by the fourth refit, with the Naval Overseers assuming a Quality Assurance role by means of audit.

In setting up a Quality Control system, the dockyard was fortunate to be able to draw extensively on the experience of the Vickers Shipbuilding Group of Barrow-in-Furness, England, builders of Royal Navy nuclear submarines.

The story of the first years of Cockatoo Dockyard's Quality Control are told in reference 4.

The specification NQA7101A has now been superseded by the Australian Standards AS1821, 1822 and 1823. "Suppliers Quality Control Systems". AS1822 defines what is known as a Level 2 system, which is directed towards manufacture, assembly and test and is reasonably adaptable for naval refit work.

This standard, only part of a slim book, is a wide ranging requirement which impinges upon almost all of an organisation's activities - from the structure of the organisation itself, through review and audit, planning, work instructions, records, corrective action, documentation and documentation change control, inspection equipment and methods, supplies and services, manufacturing control, control of non-conforming supplies, handling and storage, and verification of conformance with specification.

The Company's interpretation of this Standard, as it should be applied to any particular refit is described in a document known as a Quality Plan. At present produced for each particular project, standard Quality Plans for Submarine Refits, Survey and Intermediate dockings are being prepared as the dockyard's systems and procedures are brought fully into line with the requirements of AS1822.

The Quality Plan lists applicable quality documents (Procedure specifications and information sheets and forms) and makes reference to two other significant documents relating to the control of work, the Master Index and the Inspection Plan.

16/....

A requirement of Quality Control is that there be a system whereby all parts of the submarine can be identified, in order that their history can be traced through all production processes. Unfortunately, there was no such requirement when the submarines were built. With an incomplete data bank on the submarines, drawings which only partly represented the true state of the submarine, parts identification lists for only some of the equipments, the problem was massive. Using a basic numbering system which appeared on the early Planned Maintenance Schedules (known as the EDP number) as a basis, a very complete Master index of all the various parts of the submarine has been prepared, which lists several hundred thousand items. The numbering system provides the means of unique identification and is directly related to the Work Breakdown Structure used for costing purposes, and to the Q.C. documentation system.

In order to provide the required records of inspection status throughout the refit process, a substantial number of inspections and tests are applied. The applicability of these tests to the various parts is defined in the Inspection Plan. It indicates for each component of the main equipments and systems the applicable inspections, documents and the department responsible for completing them. They include surveys, pipe processing records, pressure test records, NDT results, calibration certificates, opening and closing dimensional inspection records, shop and ship trial records.

The role of these various inspections in the refit process will become more evident in later sections. Selected pages of the Master Index Inspection plans are reproduced as figures 8 and 9.

The final phase of the Quality Control process, the tests and trials, is the responsibility of a branch of the Quality Control department, the Dockyard Test Organisation (DTO). The role of this useful and effective organisation is described later.

REFIT PLANNING

Network Analysis has been in use for major project planning at Cockatoo Dockyard for some fifteen years. Preparation of the refit network for the first of the 'O' Class Submarines began about two years before the refit start date. It was developed using the experience of the 'T' Class refits as a basis, together with a considerable quantity of planning information

DRG. ITEM Nº	DESCRIPTION	P.L./ADREF Nº	P.L. LINE Nº	CATALOGUE Nº	Nº OFF	DRAWING Nº	E.D.P.
	3" VALVE NO.4 MASTER BLOW LB 61	001-999887			1	163P-0111-061	203/034
S3006/100	THROUGH VALVE BODY	001-998999	217		1	"	001
S3006/102	COVER	"	219		1	"	002
S3006/108	STUFFING BOX GLAND	"	225		1	"	003
S3006/103	SPINDLE	"	220		1	"	004
S3006/109	S.L. VALVE	"	226		1	"	005
S3716	HANDWHEEL	001-999007	P.011		1	163P-0111-001 P.7.10	006
S3006/112	NAMEPLATE	001-998999	228		1	163P-0111-061	007
S3867	COVER JOINT	"	240				008
S3006/111	SOFT PACKING						009
S3006/113	WASHER 1 1/2" O.D. x 13/16" I.D.	001-998999	229		1	163P-0111-061	010
S596	3/4" BSF COVER STUDS	"	230		8		011
S361	5/8" BSF GLAND STUDS	"	231		2		012
S411	3/4" BSF COVER NUTS	"	232		8		013
S4148	5/8" BSF GLAND NUTS	"	233		2		014
S4121	3/4" BSF NYLOC SPINDLE NUT	"	234		1		015
S2855	NO.2 B.A. INDICATOR SCREWS	"	235		2		016
S2592	3/16" INDICATOR TAPER PIN	"	236		1		017
S3006/107	INDICATOR RING	"	224		1		018
S3348	1/8" SPLIT PIN	"	237		1		019
S3287	SEALING RING 'O' TYPE	"	238		1		020
S3297	SEALING RING 'O' TYPE	"	239		1		021

Figure 8 – Master Index

H.P. AIR SYSTEM

DRAWING No 164A-4801-001 | P.I.L. ADREF No 001-951231 | E.D.P. ITEM No 202

DRAWING No		COMPONENT No
HP 123	CAPSULA AUTO VALVE FOR AIR OPERATED GROUP EXHAUST VALVE	2/143
HP 124	SCHRADER MIDGET SPOOL VALVE FOR AIR OPERATED GROUP EXHAUST VALVE	2/144
HP 124	" " " " " " " "	2/145
HP 127	RELIEF VALVE FOR D.C.B.A. CHARGING SYSTEM (FORWARD)	2/146
HP 127	" " " " " " (AFT)	2/147
HP 140	7/16" S.D.N.R. VALVE - COMPRESSOR DISCHARGE PORT	2/148
HP 140	7/16" S.D.N.R. VALVE - COMPRESSOR DISCHARGE STARBOARD	2/149
HP 142	COMBINED CHARGING VALVE AND GAUGE ASSEMBLY	2/150
HP 142	" " " " "	2/151
HP 143	B.I.B.S. REDUCING VALVE	2/152
HP 144	" RELIEF VALVE	2/153
HP 148	QUICK ACTING STOP VALVE - BLOW TO CRANE SEAL PORT	2/154
HP 148	" " " - " " STARBOARD	2/155
HP 151	REDUCING VALVE - BLOW TO CRANE SEAL	2/156
	SURPLUS AIR VALVE - H.P. AIR SEPARATOR COLUMN, STARBOARD	2/157
	SURPLUS AIR VALVE - H.P. AIR SEPARATOR COLUMN, PORT	2/158
HP 9	7/16" STOP VALVE - H.P. AIR TO AFTER HYDROPLANE CONTROL	2/159
HP 9	7/16" STOP VALVE - BLOW TO 'O' TANK AND INTERNAL OIL FUEL TANK	2/160
	BRANCH TEE DISTANCE AND PROTECTION PIECES, CAST BENDS, HOSE CONNECTIONS, ADAPTORS ETC.	5
	BULKHEAD AND DECK PIECES, STUD COUPLINGS, INTERNAL AND EXTERNAL FITTINGS	6
HP 105	FLEXIBLE PIPE FROM H.P. AIR COMPRESSOR 2 OFF	7/1
HP 114	3/8" FLEXIBLE PIPE (TELEMOTOR PUMP DELIVERY SILENCERS) 2 OFF	7/2
HP 132	FLEXIBLE PIPE (1/8" BORE WITH 1/8" B.S.P. CONNECTIONS)	7/3
	PRESSURE GAUGES	11
	17"DIAMETER BOTTLE - NO.1 BOTTLE GROUP - PORT FORWARD	14/1
	" " " " " " PORT	14/2
	" " " " " " PORT AFT.	14/3
	" " " " " " STARBOARD FORWARD	14/4
	" " " " " " STARBOARD	14/5
	" " " " " " STARBOARD	14/6
	" " " " " " STARBOARD	14/7
	" " " " " " STARBOARD	14/8
	" " " " " " STARBOARD AFT.	14/9
	" " " NO.2 " " PORT FORWARD	14/10
	" " " " " " PORT	14/11
	" " " " " " PORT	14/12
	" " " " " " PORT	14/13
	" " " " " " PORT	14/14
	" " " " " " PORT	14/15
	" " " " " " PORT	14/16
	" " " " " " PORT AFT.	14/17
	" " " NO.3 " " PORT FORWARD	14/18
	" " " " " " PORT	14/19
	" " " " " " PORT	14/20
	" " " " " " PORT	14/21
	" " " " " " PORT AFT.	14/22
	" " " " " " STARBOARD FORWARD	14/23
	" " " " " " STARBOARD	14/24
	" " " " " " STARBOARD	14/25
	" " " " " " STARBOARD	14/26

SHIP/JOB No OTWAY/3068 | INSPECTION PLAN FOR ITEM No 202

010	014	013	013/1	014	052R	012P	012	OSC	WO	COMPONENT No
QC	QC		QC				QC		PLM	2/143
QC	QC		QC				QC		PLM	2/144
QC	QC		QC				QC		PLM	2/145
QC	QC		SC				SC	SUP	PLM	2/146
QC	QC		QC				QC		PLM	2/147
QC	QC		QC				QC		PLM	2/148
QC	QC		QC				QC		PLM	2/149
QC	QC		QC				QC		PLM	2/150
QC	QC		QC				QC		PLM	2/151
QC	QC		QC				QC		PLM	2/152
QC	QC		QC				QC		PLM	2/153
QC	QC		QC				QC		PLM	2/154
QC	QC		QC				QC		PLM	2/155
QC	QC		SC				SC	SUP	PLM	2/156
QC	QC		QC				QC		PLM	2/157
QC	QC		QC				QC		PLM	2/158
QC	QC		QC				QC		PLM	2/159
QC	QC		QC				QC		PLM	2/160
QC	QC				*	QC			PLM	5
QC	QC				*	QC			PLM	6
QC	QC	QC					QC		PLM	7/1
QC	QC	QC					QC		PLM	7/2
QC	QC	QC					QC		PLM	7/3
QC	QC	For pressure gauge inspection plans see E.D.P.Item							068	11
QC	QC	SC		SC				SUP	PLM	14/1
QC	QC	SC		SC				SUP	PLM	14/2
QC	QC	SC		SC				SUP	PLM	14/3
QC	QC	SC		SC				SUP	PLM	14/4
QC	QC	SC		SC				SUP	PLM	14/5
QC	QC	SC		SC				SUP	PLM	14/6
QC	QC	SC		SC				SUP	PLM	14/7
QC	QC	SC		SC				SUP	PLM	14/8
QC	QC	SC		SC				SUP	PLM	14/9
QC	QC	SC		SC				SUP	PLM	14/10
QC	QC	SC		SC				SUP	PLM	14/11
QC	QC	SC		SC				SUP	PLM	14/12
QC	QC	SC		SC				SUP	PLM	14/13
QC	QC	SC		SC				SUP	PLM	14/14
QC	QC	SC		SC				SUP	PLM	14/15
QC	QC	SC		SC				SUP	PLM	14/16
QC	QC	SC		SC				SUP	PLM	14/17
QC	QC	SC		SC				SUP	PLM	14/18
QC	QC	SC		SC				SUP	PLM	14/19
QC	QC	SC		SC				SUP	PLM	14/20
QC	QC	SC		SC				SUP	PLM	14/21
QC	QC	SC		SC				SUP	PLM	14/22
QC	QC	SC		SC				SUP	PLM	14/23
QC	QC	SC		SC				SUP	PLM	14/24
QC	QC	SC		SC				SUP	PLM	14/25
QC	QC	SC		SC				SUP	PLM	14/26

NOTE: Spaces marked * are left vacant to indicate that N.D.T. may be called for if needed.

Figure 9 - Inspection Plan

gathered from the Royal Dockyards in the U.K. who had been refitting 'O' Class Submarines. The enormous network which grew over those two years (some 8,000 activities) was to prove very difficult to control. As the problems encountered with the first refit grew, arising from late completion of the facilities, severe shortages of spares, problems with the supply of information, and lack of defined refit standards, the refit network became unmanageable and ceased to be of any real assistance.

The network for the second refit was heavily slashed, to some 3,000 activities, and it too was not entirely satisfactory as it was too broad to adequately reflect the complex interrelationship of tasks in a submarine refit.

By the end of the third refit sufficient experience had been gained by the planners and what has since become a standard refit network began to emerge. Today, the dockyard has on file standard networks for refits, survey and intermediate dockings of submarines which complement the standard work packages for these tasks. The advance planning task prior to refit start is now much simpler, as the standard network can be read from the computer file and adapted to suit the particular project contemplated. The main work required is to incorporate the A's and A's and class modifications approved for the refit. The refit network now comprises some 6,000 activities.

A submarine refit comprises many individual jobs which are closely interrelated, particularly during the on-board phases of the work. The real world of the dockyard presents a constantly changing picture of labour, materials and information availability which requires a flexibility in the planning approach, particularly as the submarines draw on resources common to all other dockyard activities.

Recognising the need for an improved planning system for the future, in 1975 Vickers Cockatoo Dockyard began the development of a computer based planning system, tailored to the dockyard's operating environment. This system is being set-to-work at present, and is a multi-project planning system which uses ICL PERT as the principal scheduling system, within a framework of computer programmes written by the Company.

The system operates on the Company's ICL 2904 computer, with on-line facilities.

The system consists principally of the following components:-

- Work Breakdown Structure
- Project Plans
- Overall Dockyard Programme
- Work Schedules
- Work Orders
- Feed-back Procedures
- Reporting structure

The Work Breakdown Structure (WBS) is the coding system by which tasks or groups of tasks are identified for planning, costing and reporting purposes. It links the tasks with the project, and relates them to the documentation which defines and authorises the work. The Cockatoo structure has four levels.

- Level 1 - the job number, unique for each customer order.
- Level 2 - the main cost number, a standard numbering code which identifies the type of equipment or system on which work is being done. For general use the dockyard has adopted the U.S. Ship Work Breakdown Structure (SWBS) which has been extended by the company to cover other general engineering tasks undertaken in the dockyard. For the submarines however, the EDP number previously mentioned fulfils this purpose, as it is so firmly entrenched throughout other dockyard systems that to replace it would not be cost effective. It can be related to the SWBS.
- Level 3 - a sub-cost number which is optional, and not used for submarines at this stage.
- Level 4 - the Work Order number, which identifies the packages of work comprising the total project. For submarines these numbers are a functional breakdown of the EDP number and can be seen in figures 6 and 7 identifying the various stages of the work in the submarine work order. The principal breakdown at

19/....

this level is as follows:-

Function 1 - Removal from submarine

2 - Strip, clean and survey

3 - Repair and shop test

4 - Replace on Board

5 - Onboard Inspection and Trial

6 - Alterations and Additions

7 - Class Modifications

There are about 1,300 level 4 cost items for a submarine refit. As each of these items may accumulate costs relating to more than one activity in the refit network, there is, in fact, a level 5 in the WBS, which is an activity uniqueness identifier.

The project plans may range from a refit size network to a single activity bar chart for the manufacture of a small component. All are treated as network activities by the computer system for resource analysis processing within the overall dockyard programme.

On a broader level, the computer also provides facilities for long term forward labour loading, some ten years ahead. On-line access is available for updating these programmes and work order generation through a VDU and termiprinter facility in the planning department.

From the master programme the computer generates monthly work schedules for the individual resources (principally labour) by department.

Use is also made, where appropriate of barcharts and other means of programme presentation where they are of particular benefit.

Any computer based planning system demands a disciplined reporting process if it is to be kept adequately up-to-date and produce useful schedules without a rush "last minute" re-scheduling. Labour costs, which are recorded daily on each workman's time docket, are first input to the labour costing system, from which charges against each work order number are transferred automatically to the planning system.

For physical progress, the reporting system is centred on the planning department. Many systems have been considered for automatic feedback from the work face, but the complexity of the activities and the rigorous approach demanded by networks has meant that review and assessment by planners themselves has proved to be the most reliable method. For submarine refits, a progress review is made monthly and the network updated accordingly.

This monthly review provides the basis for a project monitoring system which culminates in the monthly report which is made to the Navy. Following the analysis of the refit network on the basis of reported progress, the planning department prepares a progress report which is circulated to senior management. This "raw data" report provides the catalyst for an internal review of progress and an assessment of any logic changes which may be necessary to maintain programme. A final network review after these changes provides the basis for the next issue of work schedules.

Progress is reported to the Navy by means of a Key Date Programme, the format of which is shown in figure 10.

During the later stages of the refit, the tests and trials programme becomes the principal control document. Based upon a Trials sub-network, this programme is reviewed and updated on a weekly, and finally day-to-day basis. Detailed co-ordination of this programme is a responsibility of the Dockyard Test Organisation.

Of course, no matter how detailed the planning, a major task like a submarine refit cannot succeed without a well co-ordinated supply of information and materials.

TECHNICAL INFORMATION

The dockyard holds over 100,000 drawings of the submarines, their systems and equipment. The accuracy and completeness of this information has presented many problems, particularly during the earlier refits. "As Fitted" drawings should more correctly have been termed "As might have been fitted", and detailed information on components and parts of equipment was often lacking. This presented particular problems in determining standards for acceptance for parts, as many of the original working drawings were untoleranced.

21/....

VICKERS COCKATOO DOCYARD PTY.LTD.

KEY DATE PROGRAMME

PROJECT: HMAS

REPORT Nº 6 SHT.1.OF 2. DATE 14 . 8 . 78

STATUS KEY

✓ ✓ KEY DATE ACHIEVED AHEAD OF TIME
✓ KEY DATE ACHIEVED ON TIME
× KEY DATE MISSED
× × KEY DATE NOT EXPECTED ON TIME
✓ × KEY DATE ACHIEVED LATE

KEY DATE	STATUS	SCHEDULED DATE (SEE NOTE)	CALENDAR MONTH 1978 J F M A M J J A S O N D / 1979 J F M A M J J A S O N D / 1980 J F	RESCHEDULED WEEK COMMENCING	ACHIEVED DATE	REMARKS
START DATE	✓	16 JAN 78			16.1.78.	NOTE: Dates given are week commencement dates for: (a) Scheduled achievement. (b) Latest achievement.
COMMENCE REMOVE BATTERY	✓	6 FEB 78			6.2.78.	
IN DRY DOCK	✓	20 FEB 78			24.2.78.	
STBD 100 KW MACHINE REMOVED	✓×	27 MAR 78 15 MAY 78			10.4.78.	See comments para 5 Covering Letter 2nd Report.
HULL BLASTING COMPLETED	✓	24 APR 78 5 JUN 78			26.4.78.	Minor portions only to be completed as convenient.
COMPLETE STRIP BOW TUBES	✓✓	22 MAY 78 5 JUN 78			17.5.78.	
H.P. AIR BOTTLES REMOVED	✓	12 JUN 78 7 AUG 78			16.6.78.	
BOW TUBES & FITTINGS SURVEYED	✓×	17 JUL 78 14 AUG 78			12.8.78.	
ENGINE RUNNING COMPONENTS SURVEYED	✓	7 AUG 78 25 AUG 78			11.8.78.	
PRESSURE HULL WELDING COMPLETED IN CONTROL ROOM	××	14 AUG 78 4 OCT 78		28.8.79.		Progress delayed by lack of suitable welding rods.
ENGINE FRAMES LOWERED		28 AUG 78 16 OCT 78				
NO: 3 H.P. AIR BOTTLE GROUP REPLACED		11 SEP 78 25 OCT 78				
COMPLETE STRUCTURE A & A 63		18 SEP 78 25 OCT 78				
ADVANCE INSTALLATION INSPECTION SWUP		18 OCT 78 4 DEC 78				

Figure 10

VICKERS COCKATOO DOCKYARD PTY. LIMITED.
WORKS INSPECTION DEPARTMENT

DIMENSIONAL INSPECTION RECORDS

ISSUE No	OPENING DATE / SIGNATURE	CLOSING DATE SIGNATURE	SHIP H.M.A.S/M. OXLEY
DATE	No OF HOURS RUN SINCE LAST REFIT	1 179 ...	JOB NO. 5043 0152P 0153A

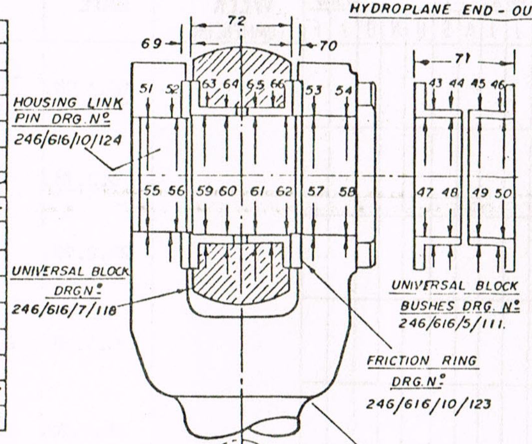
HYDROPLANE END - OUTBOARD.

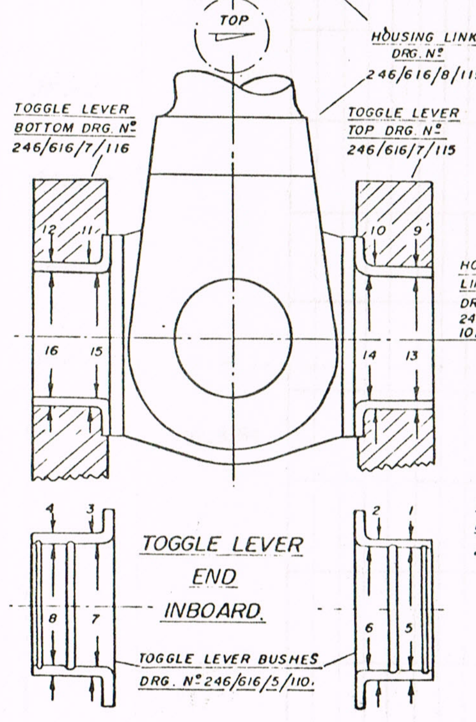
LINK PIN & LINK HOUSINGS - OUTBOARD.

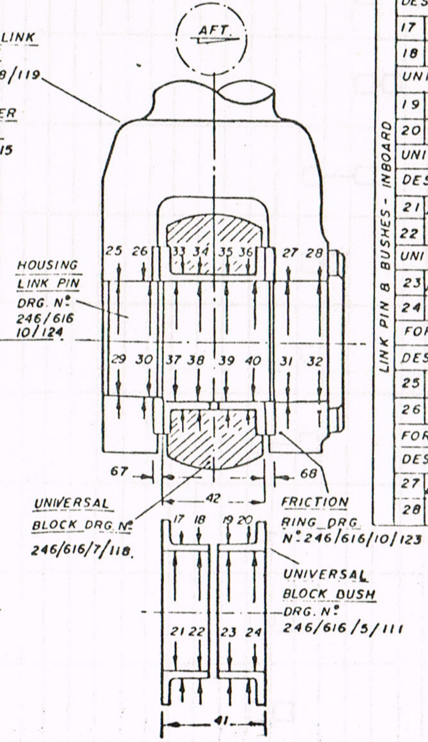
FORK BORE - FREE END.				
DESIGN 4.2020 - 4.2000				
51	4.207	.207	.2060	.210
52	.209	.208	.2075	.209
FORK BORE - FIXED END.				
DESIGN 4.2520 - 4.2500				
53	4.252	.2525	.252	.2525
54	.252	.2530	.2525	.2525
LINK PIN O.D. FREE END				
DESIGN 4.2005 - 4.1995				
55	4.200	.200	.200	.200
56	.200	.200	.200	.200
LINK PIN O.D. FIXED END				
DESIGN 4.2505 - 4.2495				
57	4.249	.249	.249	.249
58	.249	.249	.249	.249

TOGGLE LEVER BUSHES - INBOARD

TOGGLE LEVER BUSH - TOP. O.D.				
DESIGN 5.1005 - 4.9994				
1	5.1015	.1015	.1015	.1015
2	.1015	.1015	.1015	.1015
TOGGLE LEVER BUSH - BOTT O.D.				
3	5.1015	.1015	.1015	.1015
4	.1015	.1015	.1015	.1015
TOGGLE LEVER BUSH - TOP - BORE				
DESIGN 4.5022 - 4.5000				
A. 5	.443	.443	.443	.443
6	.443	.443	.443	.443
TOGGLE LEVER BUSH - BOTT. BORE				
7	.443	.4435	.443	.4435
8	.443	.4435	.4435	.4430
BUSH - HOUSING - TOP - BORE				
DESIGN 5.1022 - 5.1000				
9	5.1015	.1015	.1015	.1015
10	.1015	.1015	.1015	.1015
BUSH HOUSING - BOTT - BORE				
11	5.1015	.1015	.1015	.1015
12	.1015	.1015	.1015	.1015
UNI - BLOCK TRUNNION - TOP				
DESIGN 4.4983 - 4.4967.				
A. 13	.440	.440	.440	.440
14	.4405	.441	.4405	.441
UNI - BLOCK - TRUNNION - BOTT				
15	.440	.4405	.437	.4365
16	.4405	.4405	.437	.4365







LINK PIN CENTRE & BUSH HOUSING OUTBOARD

LINK PIN O.D. CENTRE BOTTOM				
DESIGN 4.2485 - 4.2470				
59	2495	.2495	.2495	.2495
60	.2495	.2495	.2495	.2495
LINK PIN O.D. CENTRE TOP				
61	.2495	.2495	.2495	.2495
62	.2495	.2495	.2491	.2495
LINK PIN BUSH - HOUSING BOT BORE				
DESIGN 4.7522 - 4.7500				
63	Bushes in			
64	Place			
LINK PIN BUSH HOUSING TOP BORE				
65	Bushes in			
66	Place			

LINK PIN BUSHES O.D. & BORE - OUTBOARD

UNI. BLOCK BUSH - BOTT - O.D.				
DESIGN 4.7505 - 4.7494				
43	Bushes in			
44	Place			
UNI - BLOCK BUSH - TOP - O.D.				
45	Bushes in			
46	Place			
UNI - BLOCK BUSH - BOTT - BORE				
DESIGN - 4.2520 - 4.2500				
47	2525	.2515	.2505	.251 A.
48	.2530	.2520	.2505	.251
UNI - BLOCK BUSH - TOP - BORE				
49	2525	.2520	.252	.252
50	.2525	.2525	.252	.252

LINK PIN & BUSHES - INBOARD

UNI BLOCK BUSH - FOR'D O.D.				
DESIGN 4.7505 - 4.7494				
17	Not			
18	Available			
UNI - BLOCK BUSH - AFT. O.D.				
19	Not			
20	Available			
UNI - BLOCK BUSH - FOR'D BORE				
DESIGN 4.2520 - 4.2500				
21	4.2510	.2515	.2515	.2515
22	.2505	.2505	.251	.2505
UNI - BLOCK BUSH - AFT BORE				
23	4.251	.2515	.2515	.2515
24	.251	.2515	.2515	.2510
FORK BORE - FREE END				
DESIGN 4.2020 - 4.2000				
25	4.207	.207	.2065	.2065
26	.207	.207	.205	.2055
FORK BORE - FIXED END				
DESIGN 4.2520 4.2500				
27	4.252	.252	.252	.252
28	.252	.252	.252	.252

DIST A/C UNI-BLOCK BUSHES				
DESIGN 3.8 NOM.				
41	3.809	3.816	3.812	3.817
DIST BETWEEN FRICTION RINGS				
DESIGN				
42				
DIST A/C UNI - BLOCK BUSHES				
43				
DIST BETWEEN FRICTION RINGS				
44				

FRICTION RINGS

INBOARD - AFT. THICKNESS				
DESIGN 0.175				
67	.174	.174	.174	.174
INBOARD - FORD - THICKNESS				
68				
OUTBOARD - BOTTOM THICKNESS				
69				
OUTBOARD - TOP - THICKNESS				
70				

LINK PIN & BUSHES - INBOARD

LINK PIN O.D. - FREE END.				
DESIGN 4.2005 - 4.1995				
29	4.2005	.2005	.2005	.2005
A. 30	.2010	.2010	.2010	.2010
LINK PIN. O.D. FIXED END.				
DESIGN 4.2505 - 4.2495				
A. 31	.2495	.2495	.2495	.2495
32	.2495	.2495	.2495	.2495
LINK PIN BUSH HOUSING - F. BORE				
DESIGN 4.7522 - 4.7500				
33	Bushes in			
34	Place			
LINK PIN BUSH HOUSING - A - BORE				
35	Bushes in			
36	Place			
LINK PIN O.D. CENTRE FOR'D				
DESIGN 4.2485 - 4.2470				
37	4.2495	.2495	.2495	.2495
38	.2495	.2495	.2495	.2495
LINK PIN O.D. CENTRE AFT.				
39	4.2495	.2495	.2495	.2495
40	.2495	.2495	.2495	.2495

UNIT	FOR'D HYDROPLANES.
ITEM	HOUSING LINK ARMS - STARBD.
DIR / 015 / 24	SHT 1 of 1

EPS 23/5/75

Figure 11

The selection of tolerances for valve components for example, which had to be made without any knowledge of the tolerances used in manufacture, resulted in a high proportion of new spares supplied from Naval stores being rejected by Company Quality Control on receipt.

Many fittings and pipes in the boats had no identification which could be related to drawings, a problem which is still being progressively overcome by use of the Master Index, and the permanent identification of the items during refit.

In one case, the reluctance of an equipment manufacturer to supply sufficient technical information to enable it to be refitted in Australia (it is normally returned to him for refit in the U.K.), resulted in a change to an alternative item.

In other cases, it has been necessary for the dockyard to prepare procedures and specifications to meet the refit, and quality control requirements. The need for adequate specification of dimensional tolerances in particular resulted in the preparation of a comprehensive set of dimensional inspection record sheets (some 2,300 are used during a refit). A sample is reproduced in figure 11.

The design work associated with Alterations and Additions and Modifications is undertaken by Navy Office, Canberra. Many of the early items originated from the U.K., but now most are peculiar to the RAN submarines. Navy Office provides the dockyard with a statement of work and guidance drawings. A lead drawing office is responsible for the preparation of a comprehensive work pack, which is issued to the yard in accordance with a programme prepared by the planning department.

In theory, no A and A or modification should be included in the refit work package if there is any doubt that the necessary information or material will be available to suit the refit programme. In reality, it is occasionally necessary to seek deferment of items during the course of the refit due to lack of information or material.

MATERIAL SUPPLY - PROCUREMENT OF SPARES

As a matter of basic principle, it is intended that the bulk of spares and materials required for a refit be supplied through the Navy supply system, the dockyard only buying directly a minimum of materials and consumables.

22/....

When the first submarines were purchased, the stores and spares were procured on the basis of stocks held by the Royal Navy in support of their own 'O' Class boats. Unfortunately, it was some time before the implications of the different approach to the Australian refits on the spares supply situation were fully realised.

As previously mentioned, much equipment from RN boats in refit is returned to the manufacturers for refit. With the Australian equipment being refitted in the dockyard, major problems were soon experienced with the supply of spares, which were to have a very disruptive effect on the first refits. Moreover, our unexpected requirements could not easily be satisfied by demands on the RN supply system, which did not hold stocks of the parts we needed. The restoration of adequate supply by purchase from the manufacturers took some time, and was in due course to present further problems in Quality Control.

Extraordinary measures were necessary during the refits to obtain spares, manufacture them wholly, or repair or re-use the old parts. Local manufacture was not always possible due to lack of manufacturing drawings or insufficient stocks of materials to the correct specifications, for which, frequently, there were no locally made equivalents.

These frustrating problems placed a great load on the Navy and Company supply systems, and resulted in the establishment of procedures for very close liaison on these matters to ensure that the very best action possible is taken to overcome the problems.

The demanding of spares during the first four refits tended to rely heavily on the assessment of requirements as a result of equipment survey during the refit. As a result, supply problems arose late, with little time available for alternative action, and consequent disruption to production. Disruption of this kind can be very costly, particularly in such a sequence governed task.

At the time of the review of the Work Package, the opportunity was taken to include in it automatic authorisation of the replacement of those items which were known from the experience of the first four refits would be necessary.

Arrangements were also made for stocks of regularly used spares and materials to be held on the Dockyard, in a special store, known as the

Defence Store. These items, whilst convenient to the workforce, and thus readily available, had not in fact been issued to the Company, and remained on the Naval Stores ledgers and available to the operational boats if required. This store, which is manned and operated by the Company, has proved of considerable benefit and its holding is being progressively expanded.

Unfortunately, the revision of the Work Package and its intended improvements to parts supply, overlapped the early stages of the second refit of HMAS *Oxley*, with the result that the benefits expected were not achieved. Moreover, as this refit was the first second refit of an RAN boat, surveys of the now older equipment resulted in new stores requirements which again could not be satisfied fast enough by the system to avoid substantial programme disruption.

A major effort has been made to correct the situation for HMAS *Otway* and subsequent refits.

As part of the preparatory work for the refits, an Appendix to the Work Order is prepared, which is a Spare Parts Schedule. This schedule is in two parts. Part 1 lists those items which are authorised for replacement by the Work Order. These are demanded in advance of the refit for holding in the Defence Store on the Dockyard. Part 2 lists those items which experience has indicated are likely to be required as a result of survey. They are demanded in advance for issue to suit the refit programme. Items required as a result of survey, not listed in this schedule are demanded in the usual way during the course of the refit.

A sample page of this schedule, which lists some 5,320 line items is included as figure 12. This schedule is used as a means of monitoring supply progress, in conjunction with a computer listing of required dates to suit the refit plan (known as the RAPS - repair as per survey schedule). Items which are not expected to meet the required deliveries are listed in a "stoppers" list. This is reviewed monthly by a special committee of Naval Stores and Company staff and it is used as an action list for hastening or alternative procurement action.

As part of its expansion of computer applications, the company is transferring the Naval Stores procurement system to the computer, using the Master Index as a basic data file. At present it is principally used as a procurement ledger, however, it will eventually be able to

24/....

SPARE GEAR APPENDIX — H.M.A.S. "OTWAY"

PAGE No. 1 of 2

PARENT EQUIPMENT:- CYLINDER HEADS AND VALVE GEAR

APPENDIX:- A/158 **PART. 1.** P.I.L. No 996732 E.D.P. No 158 & 169

DESCRIPTION	STORES IDENTIFICATION				PROCUREMENT DATA				DELIVERY DATA						REMARKS
	P.I.L. ENTRY	GROUP	CAT/ADREF NO.	JOB NO.	BACK REF. NO.	QTY.	DATE	STORE	REQ'D	GIVEN	REC'D	QTY.	VOUCHER NO.	SHOP	
JOINT WASHER	749	5310	99 423 3363		30211/5	32	23/1/79	CO24	19/2/79					MASH	
JOINT WASHER	751	5310	99 423 3354		7	32	"	"	"					"	
JOINT WASHER	753	5310	99 423 2652		9	32	"	"	"					"	
WASHER	765	5310	66 083 8685		30214/7	64	"	"	"					"	
WASHER	768	5310	99 941 8610		10	128	"	"	"					"	
WASHER	771	5310	99 873 7348		13	128	"	"	"					"	
PIN	773	5315	99 942 0426		15F	128	"	"	"					"	
JOINT WASHER	775	5310	99 423 3364		30216/1	32	"	"	"					"	
WASHER	780	5310	99 873 9348		6	128	23/1/79	CO24	"					"	
SEAL	783	2815	66 077 4533		30185/1	64	22/1/79	"	"					"	
JOINT	784	5330	66 082 4296		2	32	"	"	"					"	
WASHER	798	5310	66 083 4032		12	32	"	"	"					"	
CIRCLIP	801	5365	66 079 3713		14	32	"	"	"					"	
CIRCLIP	804	5365	66 061 6829		30156/2	64	"	"	"					"	
CIRCLIP	806	5365	66 079 3713		4	32	"	"	"					"	
WASHER	815	5310	66 083 4032		9	32	"	"	"					"	
DEFLECTOR	826	5365	66 077 4535		30188/4	128	"	"	"					"	
CIRCLIP	829	5365	66 079 3712		7	128	"	"	"					"	
WASHER	839				SEE REMARKS	32			"					"	SHOP COMMITTMENT I.A.W AMEND'T No. 17
PIN, SPLIT	840	5315	9? 942 0426		30155/15F	32	22/1/79	CO24	"					"	

Figure 12 – Spare Parts Schedule

VICKERS COCKATOO
DOCKYARD PTY LTD

LIST OF STOPPERS AS AT 11/04/79
FOR OXLEY REFITS

FORM SU66 V20 PAGE 17
RUN 1600 AT 22:16 ON 11/04/79

MCN STOPPER CLASS	CATALOGUE	SHORT NAME	QTY	PIL LINE REFERENCE	DATE	REC'D	DEPOT FOR REP'D	VCD P.S.	ALTERNATE ACTION	REMARKS
0418 PERISCOPE EQUIPMENT TYPE TN4										
0418-001	6145-99-521-8363	CABLE ELECTRIC	20MR	10913/01	04JAN79	18JAN79	418 WL	418-355		* ANTIC DEL APRIL
0418-001	6145-99-521-8363	CABLE ELECTRIC 413/3	10MR	10913/01	29SEP78	04OCT78	418 WL	418-355		* ANTIC DEL APRIL
0456 AUX POWER SWBRD PANEL & CONTROL FRAME										
0456-001	6625-66-078-9037	FREQUENCY METERS 456-20-3	2EA	10853/01	29AUG78	13SEP78	51 WL	456-356		* 1 REC'D 19-12-78 BAL ANTIC DEL MAY
0572 ELECTROMAGNETIC LOG										
0572-001	6130-99-999-1190	RECTIFIER SELENIUM 572-3-1	1EA	10050/01	29JUL77	01DEC77	51 WL		438-1	NO DELIVERY DETAILS NO LONGER AV. IN UK SM-M INVEST ALT USED IN UK
0602 MAIN GENERATORS PORT&STBD										
0602-001	8030-66-059-9373	SEALING COMPOUND	20TU	90/01	08FEB79	22FEB79	27 FL			ANTIC DEL MAY/JUNE
0702 AERIAL OUTFIT AWJ										
0702-001	5985-99-447-1732	ROD AERIAL TELESCO-PIC 702-1	1EA	10905/01	13SEP78	21SEP78	94 WL	702-215		ANTIC DELIVERY MAY
0752 SONAR 2007										
0752-019	5935-99-112-4667	SOCKET SIDE ENTRY 50 WAY	1EA	10708/01	27JUL78	26AUG78	94 WL	752-158		ICOI 4-4-79 Recd 11-4-79
0752-020	5935-99-112-4668	SOCKET SIDE ENTRY 50 WAY	1EA	10718/01	27JUL78	26AUG78	94 WL	752-158		ICOI 4-4-76 Recd 11-4-79.
0752-021	5935-99-112-6198	SOCKET SIDE ENTRY	1EA	10719/01	27JUL78	26AUG78	94 WL	752-158		ANTIC DELIVERY APRIL

Figure 13 - Stoppers List

generate pre-refit demands automatically with VDU access on-line for subsequent file search and demand preparation.

The RAPS schedule will be automatically updated by the planning system each time the submarine network is reviewed on the planning master file, ensuring that the computer generated "stoppers" lists (figure 13) represent the latest programme requirements. The Naval Supply System, as it is known, will also be able to store information in EBASAL (Equipment Breakdown and Support Assessment List) format, now being used as a basis for stores provisioning for RAN new construction.

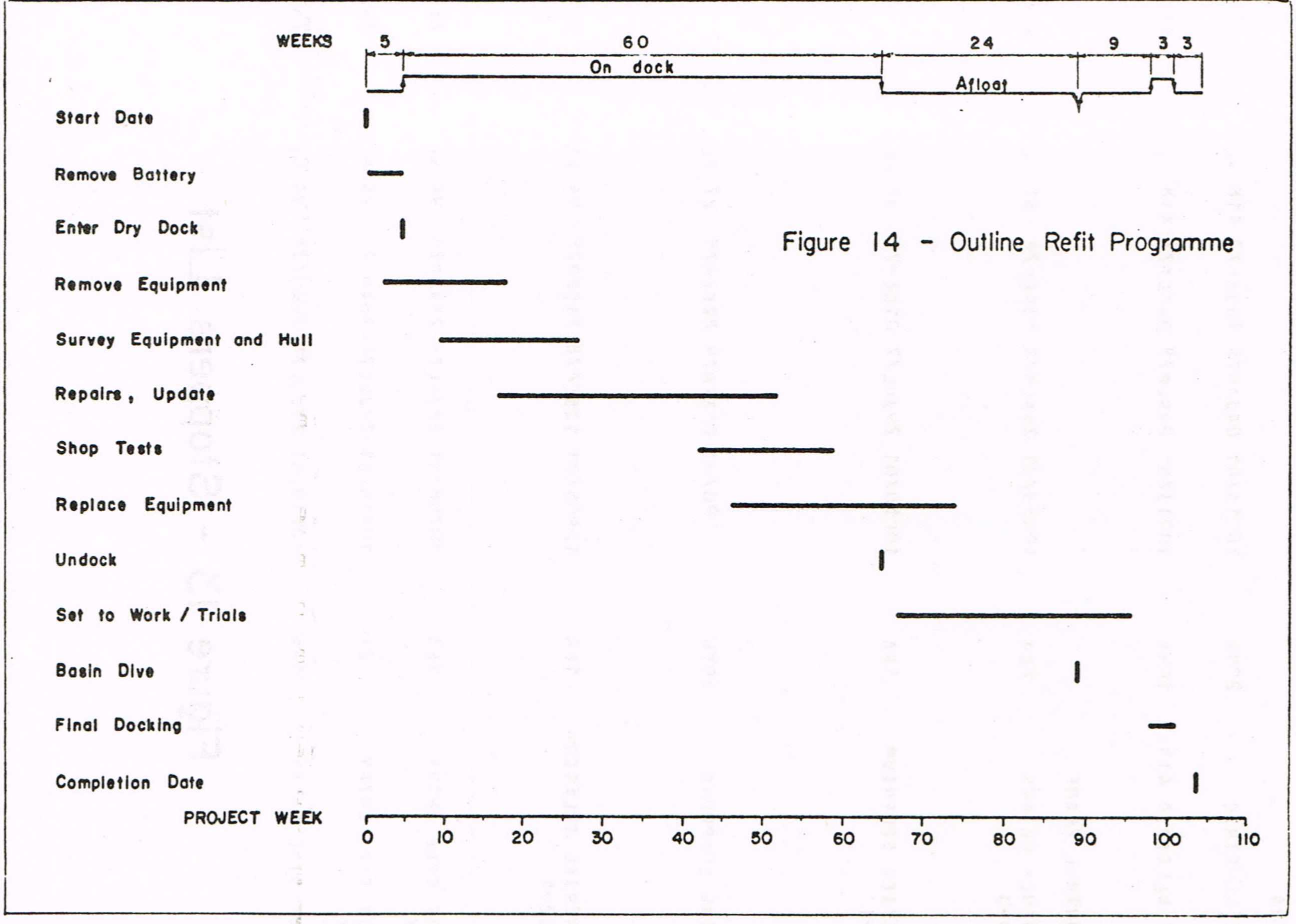


Figure 14 - Outline Refit Programme

THE REFIT PROCESS

The principal phases of a submarine refit of 104 weeks are shown in figure 14.

At refit start date, the submarine is taken in hand in a de-stored and de-fuelled condition. The first few weeks are concentrated towards the principal target of battery removal. The 'O' class submarine battery comprises 448 cells with a total weight of some 224 tons and is stowed within two battery tanks which are below the main accommodation area. To gain access, all furniture and furnishings and minor bulkheads in the accommodation space are removed. The battery is then removed through the accommodation space and conning tower hatches.

During this early part of the refit weapons, radio and radar electronics are removed from the boat, together with as much machinery as possible. This tends to be somewhat limited at this stage, as most submarine systems are kept in service until the boat is docked.

After about five weeks in refit, the submarine is placed on the slave dock, where it will remain for about sixty weeks. At this time, the responsibility for safety and security passes to the Company. The following weeks see intense effort in stripping the boat of equipment and systems, work which will be largely complete in six months.

All electrical and mechanical machinery is removed from the boat with the exception of the main motors and main generator bedplates and main frames. All equipment is taken from the submarine through existing hatches - no access openings are cut in the pressure hulls.

All minor bulkheads, ships side linings and deck coverings are removed, all ladders, gratings and floor plates, furniture and stowages, together with about 70% of ventilation trunking and 60% of pipework. Some piping systems are almost entirely removed.

It is apparent that it is not long before the submarine is totally devoid of its own services, and temporary systems are installed, including a temporary firemain, a fire alarm system, a 32 V A.C. temporary lighting system and the boat is supplied with cooled and dehumidified air from air-conditioning units mounted on the slave dock. The air conditioning not only improves habitability on board during Sydney's humid summer, but helps to preserve systems and equipment remaining on board.

ON BOARD WORK

Soon after it is placed on the dock, the submarine is completely grit-blasted externally and in tanks. Following initial preservation, the hull is subject to an extensive survey, which includes a large number of ultrasonic thickness tests on the pressure hull. These tests are intended to record structural wastage and locate any plate laminations. So far the submarines have remained in excellent structural condition and this is no doubt largely due to the extensive preservation of the hull which is undertaken each refit after grit-blasting.

To facilitate the hull survey and preservation, the permanent ballast (some 150 tons comprising about 7500 ingots) is removed, re-preserved and replaced in the keel and external tanks.

External and internal tanks are surveyed and pressure tested.

Internally, about 5% of the cork thermal insulation inside the pressure hull is removed to enable the structure to be surveyed, and all surfaces internally are re-painted.

Systems remaining on board are examined internally, removed for repair if necessary and blanked to prevent any accumulation of foreign matter. Electric cables are surveyed for continuity and insulation resistance. Usually, it will be found necessary to replace about 5%, including all cables which run outside the pressure hull.

The Main Motors, the principal items of machinery which remain on board, are surveyed, cleaned and repaired (if necessary) in situ. Main engine main frames and bed plates are surveyed and the alignment of the bearing housings is checked. The alignment of bulkhead glands, thrust blocks, stern tubes and 'A' brackets is also checked.

Similar work is undertaken on torpedo tubes, hydroplane and steering gear and mast bearings. During this docking period, before equipment starts to reappear from the shops, any structural work associated with alterations and additions is completed.

Shop Work

All items removed from the boat, whether directed to electrical, electronic, mechanical or hull shops are subjected to essentially the same routine. The first task is to strip, identify and clean the equipment. Mechanical and electrical equipment and pipes are cleaned by chemical treatment. Electronic components are usually ultrasonically cleaned.

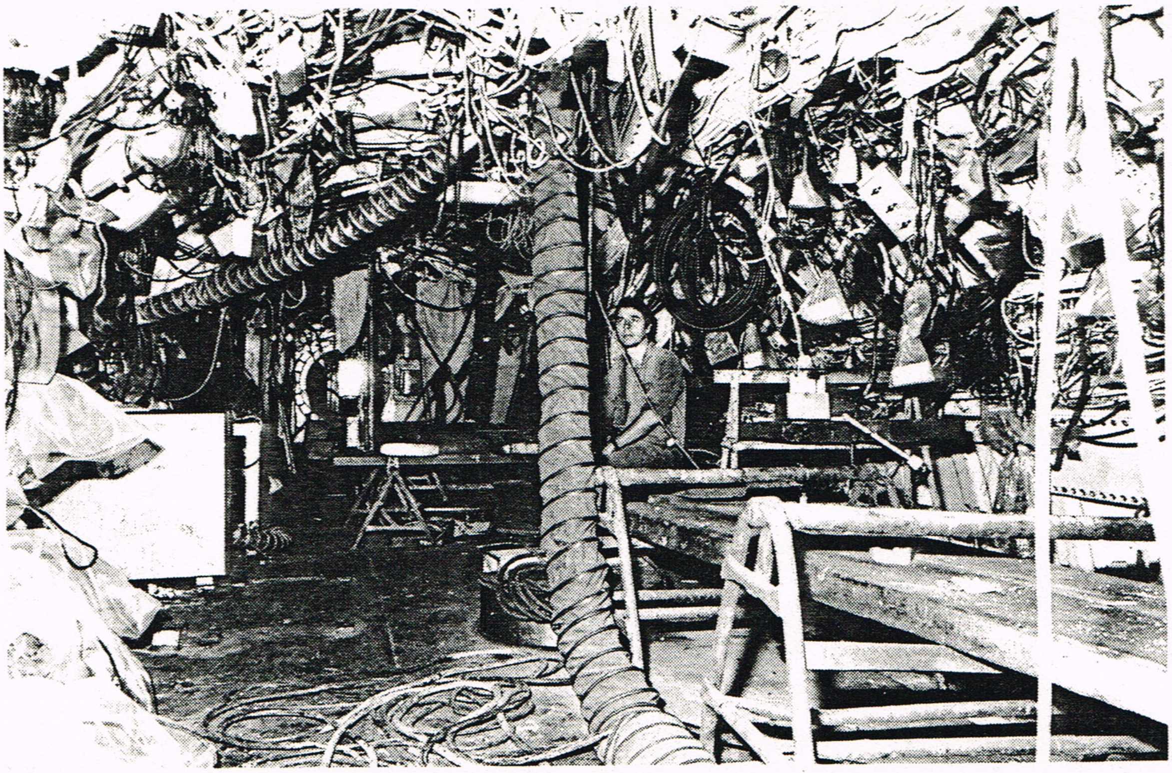


Figure 15 - Stripped Control Room

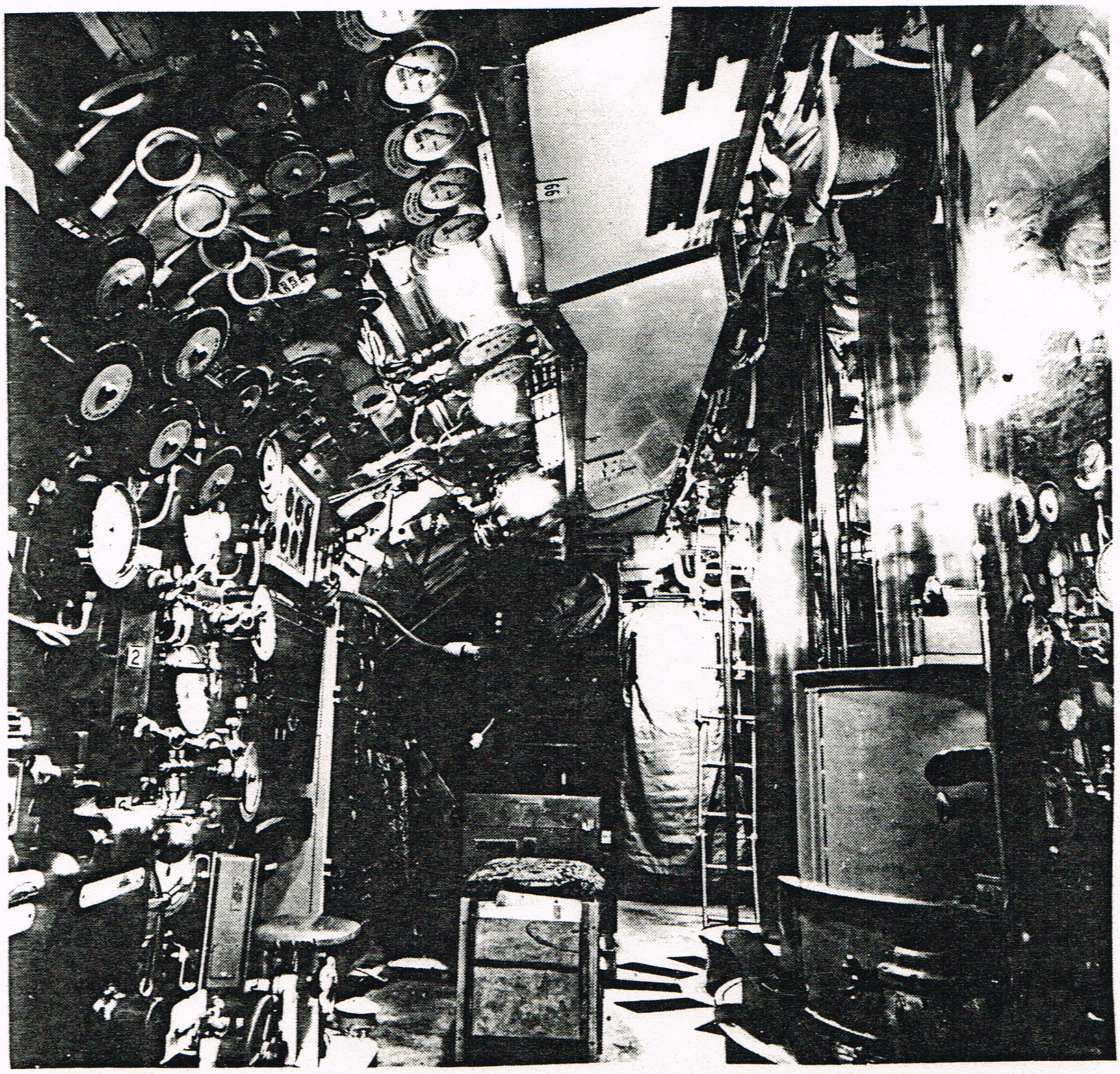


Figure 16 - Completed Control Room

After cleaning, the equipment is inspected, dimensionally, where appropriate and for each item a survey report is prepared. After the first four refits, the format of the survey report was updated in the light of experience to reduce the time required for survey. Some 4020 Survey Reports are prepared, comprising 1830 mechanical, 1190 hull, 620 electrical, 130 weapons electrical and 250 weapons mechanical. On completion, they are forwarded by Q.C. to the planning department for issue as an amendment to the Work Order and authority for repair to proceed.

The repair standard sought is "as new" performance and reliability, but this often means as new appearance as well, as it is usually necessary to completely repaint equipment as part of the repair process. Whilst this may seem occasionally to be somewhat "cosmetic" - it results in a much more acceptable final finish to the submarine.

On completion of repair, as much equipment as practicable is subject to a shop test. All pipes and valves are pressure tested in the shop prior to release by Q.C. Electric motors and their associated control equipment are tested under load before they rejoin their mechanical components.

Completed mechanical equipments are tested in the functional test rooms before they leave the shop. These rooms are provided with all power and fluid services as required, and a full load functional test can be carried out. These test rooms are designed to be suitable for noise tests and in addition, a programme is in hand to fit vibration analysis blocks to machinery to enable progressive records to be obtained in service as an aid to fault detection and maintenance and the first set of readings is obtained in the test room.

Torpedo firing valves and equipment are also set-to-work and tested in torpedo firing test rig.

Equipment is not permitted to leave the workshops without Quality Control clearance, either following successful test, or approval of concession if the necessary standards cannot be achieved. In some cases, repair of equipment can be delayed by lack of spares, necessitating re-use of existing parts if equipment is to be available in time to meet the on-board programme. On these occasions, equipment may be released to the submarine to enable the programme to proceed, however, the equipment

28/....

must later be either completed on board, returned to the shops or replaced. Quite frequently defective valves have to be replaced to complete systems on board. They are usually painted bright red for identification purposes. Where these items cannot be replaced during the refit period, a concession may be sought for their acceptance as is.

A similar repair routine is adopted for electronic equipment. The weapons test rooms in Building 2 are laid out with duplicates of the systems on board the submarines, enabling all equipment to be tested and set-to-work a part of a complete system in the shop. It can be kept in these test rigs until it is needed on board, again minimising on board setting to work time.

Mechanical and electrical equipment is either held in the clean transit store or returned directly to the submarine for re-installation.

INSPECTIONS, TESTS AND TRIALS

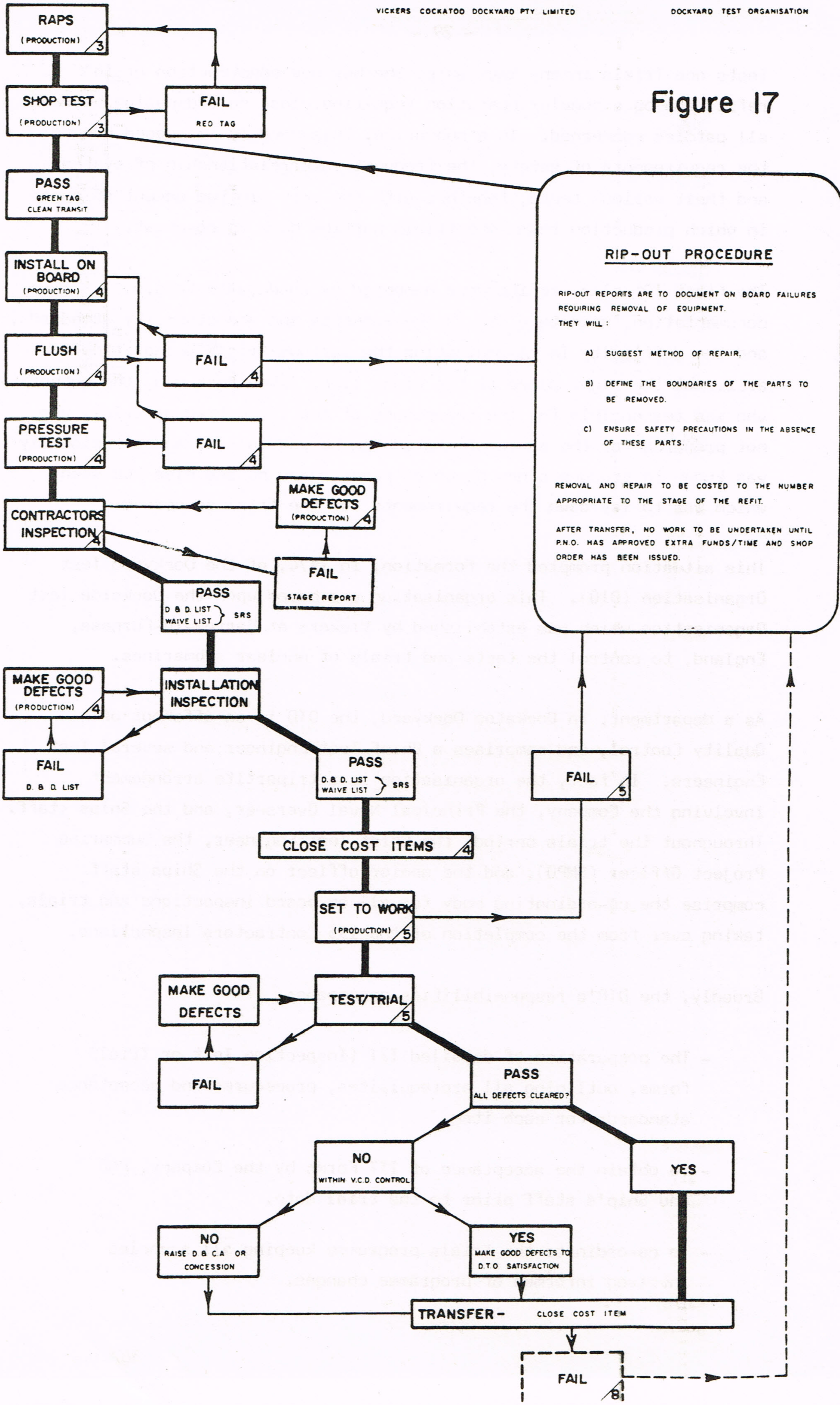
The confined spaces inside the submarine dictate a closely sequence governed programme for the re-installation of equipment on board. Progress with the completion of systems is aimed towards the requirements of undocking, a target which is critical not only to the submarine on the dock, but to the programme for the next submarine which will be approaching docking.

Early systems to complete are those associated with the battery, which is shipped shortly prior to undocking. At this time, the responsibility for safety and security of the boat reverts to the ship's staff.

Undocking signals the start of the major portion of the tests and trials programme to completion. Figure 17 is a flow chart of those activities, inspections, tests and trials which lead to the transfer of each equipment and system to the ship's staff during this period.

Installation on board is followed by system flushing (where appropriate) and test, and finally by an Inspection known as a Contractors Inspection, which is intended to satisfy the production departments and Quality Control that the system is fit to pass on the first stage of the formal tests and trials programme, the Installation Inspection.

Figure 17


RAPS
(PRODUCTION)
3
SHOP TEST
(PRODUCTION)
3
FAIL
RED TAG
PASS
GREEN TAG
CLEAN TRANSIT
INSTALL ON BOARD
(PRODUCTION)
4
FLUSH
(PRODUCTION)
4
FAIL
4
PRESSURE TEST
(PRODUCTION)
4
FAIL
4
CONTRACTORS INSPECTION
4
MAKE GOOD DEFECTS
(PRODUCTION)
4
FAIL
STAGE REPORT
PASS
D. B. D. LIST
WAIVE LIST
SRS
MAKE GOOD DEFECTS
(PRODUCTION)
4
INSTALLATION INSPECTION
FAIL
D. B. D. LIST
PASS
D. B. D. LIST
WAIVE LIST
SRS
FAIL
5
CLOSE COST ITEMS
4
SET TO WORK
(PRODUCTION)
5
MAKE GOOD DEFECTS
TEST/TRIAL
5
FAIL
PASS
ALL DEFECTS CLEARED?
NO
WITHIN V.C.D. CONTROL
YES
NO
RAISE D. B. C.A. OR CONCESSION
YES
MAKE GOOD DEFECTS TO D.T.O. SATISFACTION
TRANSFER - CLOSE COST ITEM
FAIL
8
RIP-OUT PROCEDURE
RIP-OUT REPORTS ARE TO DOCUMENT ON BOARD FAILURES REQUIRING REMOVAL OF EQUIPMENT.
THEY WILL:
A) SUGGEST METHOD OF REPAIR.
B) DEFINE THE BOUNDARIES OF THE PARTS TO BE REMOVED.
C) ENSURE SAFETY PRECAUTIONS IN THE ABSENCE OF THESE PARTS.
REMOVAL AND REPAIR TO BE COSTED TO THE NUMBER APPROPRIATE TO THE STAGE OF THE REFIT.
AFTER TRANSFER, NO WORK TO BE UNDERTAKEN UNTIL P.N.O. HAS APPROVED EXTRA FUNDS/TIME AND SHOP ORDER HAS BEEN ISSUED.

Tests and Trials in any Navy ship, whether new construction or in refit, can be a complex operation requiring close co-ordination between all parties concerned. In a submarine, this need is increased due to the requirements of safety, the frequent interrelationship of systems and their various tests, together with the very limited amount of space in which production teams and trials parties have to co-exist.

The first 'O' class refits were hampered by inadequate trials documentation, uncertain trials requirements and acceptability standards, and the difficulty in co-ordinating the various trials authorities to arrive at the right place at the right time. When they did, the authority who was responsible for the acceptance of the inspection or trial, was not prepared for the state of the system he was to see, and occasionally was known to produce a new piece of paper which no one else had seen, which was to lay down the requirements for the trial concerned.

This situation prompted the formation, in 1974, of the Dockyard Test Organisation (DTO). This organisation was based upon the Dockside Test Organisation which was established by Vickers at Barrow-in-Furness, England, to control the tests and trials of nuclear submarines.

As a department, in Cockatoo Dockyard, the DTO is an offshoot of Quality Control, and comprises a Chief Test Engineer and several Test Engineers. In fact, the organisation is a tripartite arrangement involving the Company, the Principal Naval Overseer, and the Ships staff. Throughout the trials period, the Chief Test Engineer, the Submarine Project Officer (SMPO), and the senior officer on the Ships staff comprise the co-ordinating body for all on-board inspections and trials, taking over from the completion of the 195 Contractors Inspections.

Broadly, the DTO's responsibilities encompass:-

- The preparation of detailed ITT (Inspection Test or Trial) forms, outlining all prerequisites, procedures and acceptance standards for each item.

- To obtain the acceptance of ITT Forms by the Company, PNO and Ship's staff prior to the trial date.

- To co-ordinate the trials programme keeping all agencies involved informed of programme changes.

H.M.A.S. OXLEY

JOB/ITEM NO. 3043/0045E

I.T.T. 024/2

SERIAL NO. 1

ANCHOR, CABLE & TOWING ARRANGEMENT - INSTALLATION INSPECTION

TEST GROUP MEMBERS

V.C.D.	P.N.O.	SHIP'S STAFF

OBJECT

a) To show that the anchor, cable and towing arrangements have been installed in accordance with the references, and is in a fit state to proceed with I.T.T. 004/10 - Capstan and Windlass Trial.

b) To raise a defect and deficiency list should this prove necessary.

REFERENCES

a) 163P-1102-002 Hinged Cover over Anchor Recess

b) 163P-1102-003 Lock Bolt for Hinged Cover over Anchor Access

c) 163P-1102-005 Anchor and Cable Arrangement

d) 163P-1102-006 Cable Compressor Assembly and Details

e) 163P-1102-007 Towing Arrangement Pendant Stowage & Lead of Messenger Down Haul.

f) 163P-1102-008 Towing Slip Details

g) BR 1964 (1) Capstan and Windlass, Anchor Gear

PREREQUISITES

a) The Q.C. documentation for equipments within the boundaries of this I.T.T. and as quoted in the Inspection Plan to be available and outstanding deficiencies from the progressive Contractor's Inspection to be acceptable to the P.T.P.

b) Windlass pressure and return on Telemotor Distribution Valve Chest T.S.31 to be shut.

PRECAUTIONS AND LIMITATIONS

All personnel working in the area are to be warned prior to operation of Anchor Gear.

TEST PARAMETERS AND ACCEPTABLE TOLERANCES

None.

CLEANLINESS STATE

Grade 2.

SPECIAL EQUIPMENT, SERVICES, MANPOWER

a) Man power as required to be arranged by the Submarine Hull Co-ordinator.

b) Small selection of hand tools.

c) Ships Staff to provide a "T" spanner for the anchor door cable compressor.

a) PRESENTING AUTHORITY

Submarine Refit Superintendent.

b) RECORDING AUTHORITY

D.T.O.

c) CONDUCTING AUTHORITY

Ship's Staff.

d) TRIALS AUTHORITY

D.T.O.

BOUNDARIES OF INSPECTION

a) Anchor, Anchor Door, Operating and Locking Arrangement, Cable Compressor, Blake and Bottle Screw Slips, Cable Sheaves and Rollers.

b) The Towing Slip, Inboard Pendant and Trough, Outboard Pendant and securing arrangements on Bridge Fin.

DETAILED PROCEDURE

Carry out a Mechanical inspection as follows:-
This inspection need not be detailed, it is aimed at substantiating the Contractors inspection.

MECHANICAL INSPECTION

Visually inspect the equipment listed below for

1) Mountings.
2) Connections, keeps and fastenings.
3) Lagging, insulation, fairing, paint
4) Bonding strips, corrosion pieces.
5) Full range of operation and accessibility
6) Correct tallies and/or indicators.
7) Correct handles/handwheels.
8) Freedom from obstruction and blockages.
9) Correct range.
10) Lubrication.

CHECK LIST

i)	Anchor and shackles	
ii)	Blake and bottle screw slip	
iii)	Anchor door and operating gear	
iv)	Anchor door locking gear	
v)	Cable sheaves and rollers	
vi)	Cable compressor	
vii)	Towing slip	
viii)	Inboard pendant	
ix)	Outboard pendant	
x)	Senhouse slip	

✓ Indicates satisfactory.

X Must be shown as an item on a defect list.

Figure 18

- To conduct inspections, test and trials, involving staff from other departments as required.

- To prepare and accept Waive lists of items not complete prior to inspections, tests and trials.

- To prepare, after inspections, tests and trials, Defect and Deficiency lists and to verify the completion of these items.

- To transfer satisfactorily completed systems and equipments to the custody of ship's staff for operation and maintenance.

- To manage the "Rip-Out" procedure (see figure 17).

Overall, the DTO is responsible for some 162 inspections, tests and trials. It has made a major contribution to the success of submarine trials since it was formed.

ALTERATIONS AND ADDITIONS AND MODIFICATIONS

It is only really practicable to undertake major alterations to submarines systems and equipments during refit. Some modification work may be undertaken during intermediate and survey dockings, or maintenance periods, but alterations and additions are generally so complex that sufficient time is available only during refit. With the relatively long refit cycle, it is sensible for as much updating of the submarines equipment and systems as possible to be undertaken at each refit. This work has therefore been a major part of each refit completed to date, the numbers of A's and A's and modifications completed at each refit are indicated in the table.

	A's and A's	Mods.
FIRST REFIT		
Oxley	*30*	*120*
Otway	*37*	*127*
Ovens	*36*	*155*
Onslow	*26*	*110*
SECOND REFIT		
Oxley	*43*	*136*

This table is somewhat incomplete as it does not adequately reflect the volume of work represented by the tasks undertaken. In fact, the workload of A's and A's and modifications for HMAS *Oxley* second refit represents 4.3 times the amount of work undertaken in the first refit. This is principally due to the introduction of a major series of A's and A's which together comprise the Submarine Weapons Update Programme (SWUP).

THE SUBMARINE WEAPONS UPDATE PROGRAMME (SWUP)

A major part of the current refits is the installation and setting to work of an advanced weapon system which embraces a new generation of fire control and sonar systems, and a new weapon, the U.S. Mk 48 Mod 3 Torpedo. The modernisation provides the capability for the integration at a later date of a submarine launched air flight guided missile (e.g. HARPOON).

The present weapons systems of the RAN submarines date back as far as the 1930's, when the Mk 8 torpedo was first introduced into service with the Royal Navy. The Fire Control systems, TCSS7/9, are analog systems dating from the 1950's, which need a large team of operators, requiring a high degree of training and integration to realise the full potential of the weapon system.

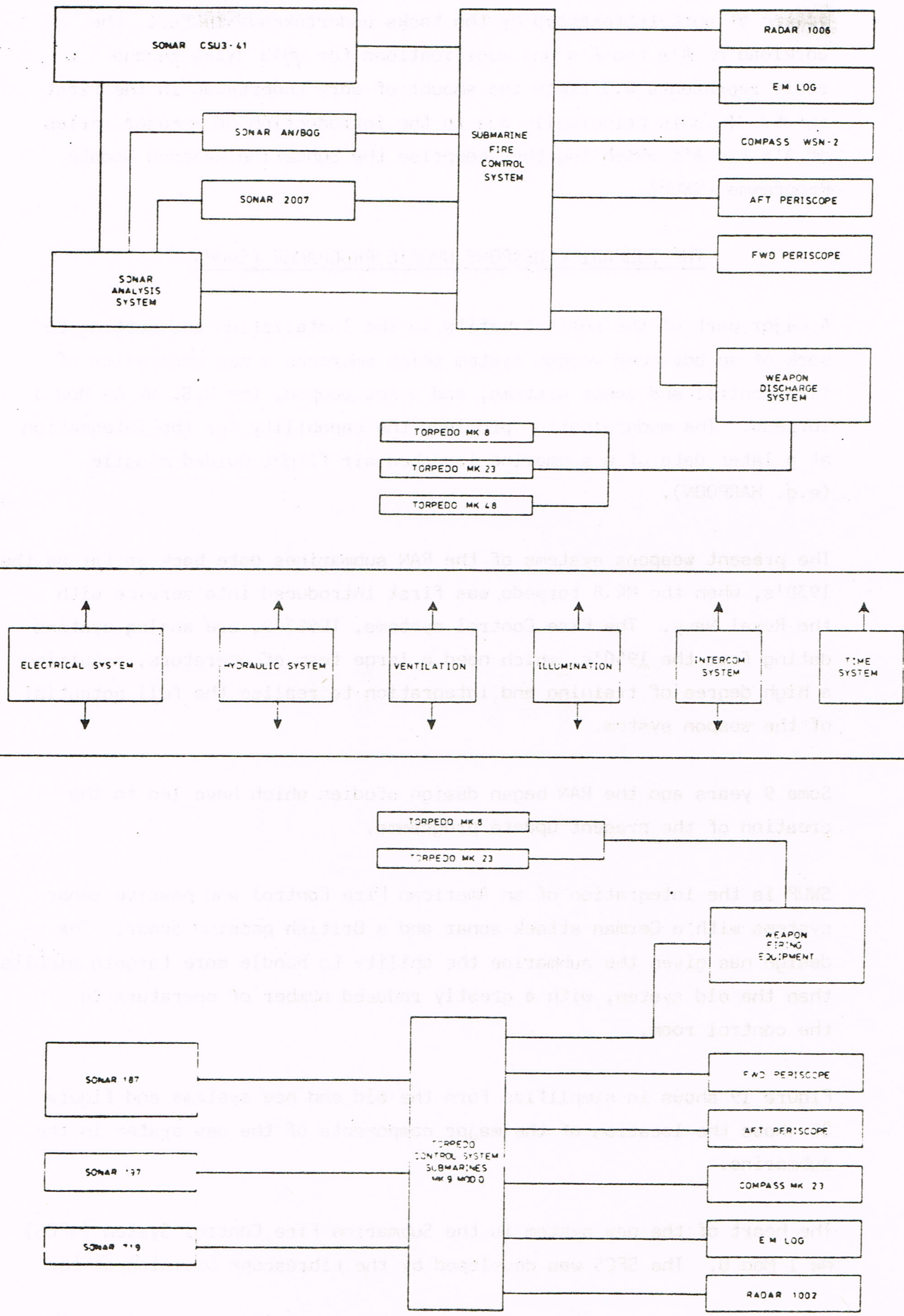
Some 9 years ago the RAN began design studies which have led to the creation of the present update programme.

SWUP is the integration of an American Fire Control and passive sonar systems with a German attack sonar and a British passive sonar. The design has given the submarine the ability to handle more targets simultaneously than the old system, with a greatly reduced number of operators in the control room.

Figure 19 shows in simplified form the old and new systems and figure 20 shows the location of the major components of the new system in the submarine.

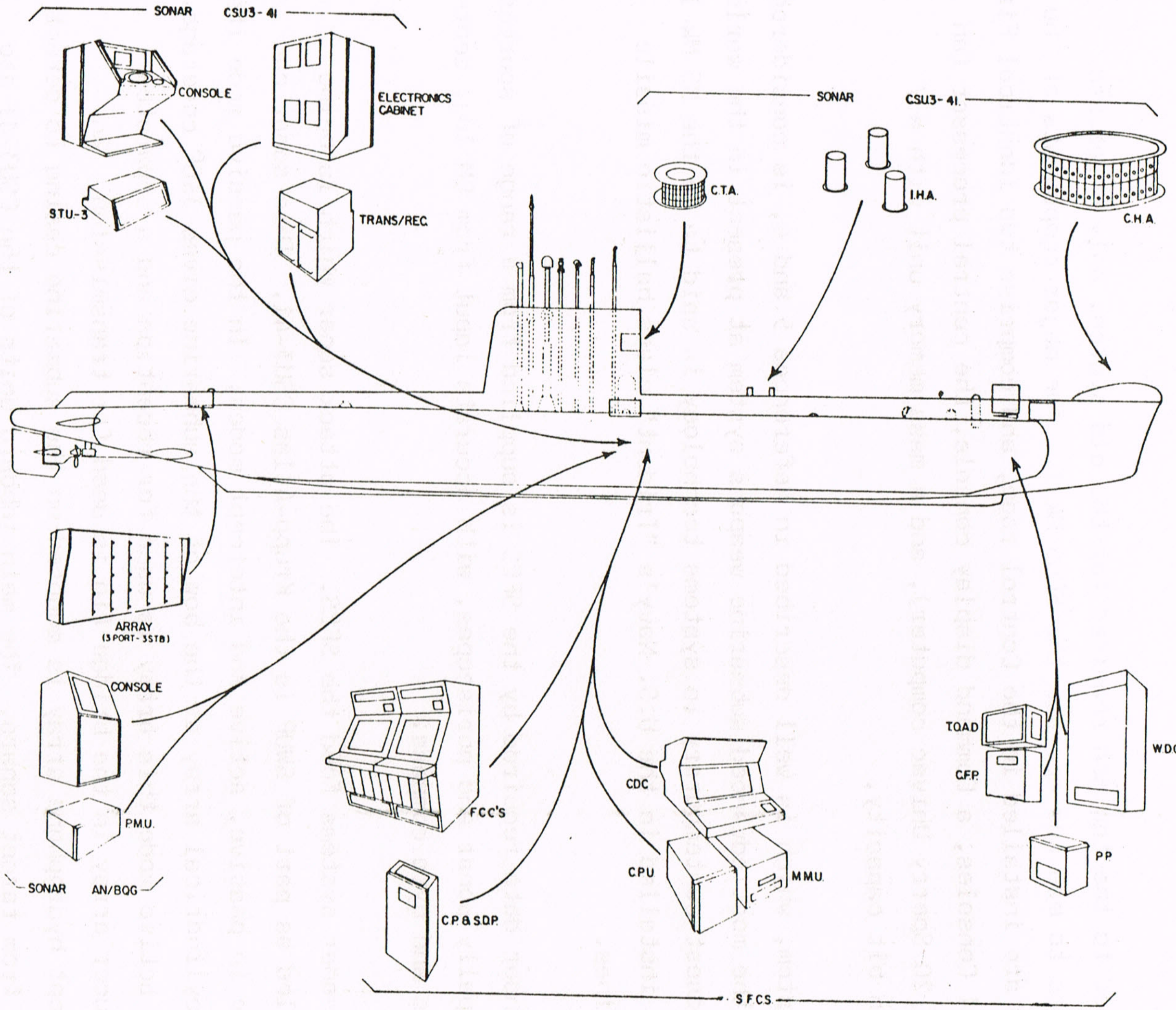
The heart of the new system is the Submarine Fire Control System (SFCS) Mk 1 Mod 0. The SFCS was developed by the Librascope Division of the

SUBMARINE WEAPONS SYSTEM - AFTER S.W.U.P.



SUBMARINE WEAPONS SYSTEM - BEFORE S.W.U.P.

Figure 19



ABBREVIATIONS

CDC - COMMAND DISPLAY CONSOLE
CFP - COMPOSITE FUSE PANEL
CHA - CYLINDRICAL HYDROPHONE ARRAY
CP&SDP - COMPOSITE POWER AND SENSOR DISTRIBUTION PANEL
CPU - CENTRAL PROCESSOR UNIT
CTA - CYLINDRICAL TRANSDUCER ARRAY
FCC - FIRE CONTROL CONSOLE
IHA - INTERCEPT HYDROPHONE ARRAY
MMU - MASS MEMORY UNIT
PMU - PORTABLE MAINTENANCE UNIT
PP - POWER PACK MK 6
SFCS - SUBMARINE FIRE CONTROL SYSTEM
STU - TRAINING SIMULATOR
TOAD - TUBE ORDER AND ALARM DEVICE
WDC - WEAPONS DATA CONVERTER

SUBMARINE WEAPONS UPDATE PROGRAMME

LOCATION OF MAJOR EQUIPMENT

Figure 20

Singer Company in the United States specifically to meet the RAN requirement. It is a digital system which provides integrated torpedo fire control functions that include the selection and processing of sonar, periscope and other sensor data, analysis of contact motion, generation of weapon orders, and control of weapon selection, firing and guidance.

It is designed to control both conventional and wire guided torpedoes, and can control two torpedoes simultaneously. It has the capability for incorporating the control of other submarine launched weapons, for example HARPOON.

Compared to the ten men required for the old system, only three are required to man and operate the SFCS Mk 1. The major components of the system are installed in the Control room, and comprise two identical Fire Control Consoles, a Command display console, the central processor (an AN/UYK 20 Sperry Univac computer), and a mass memory unit with a 7 million bit capacity.

The system, which is well described in References 5 and 6, is considered to be the most advanced submarine weapons system at present in the world. Its closest contemporary in systems technology is said to be the US Mk 118 system installed in the U.S. Navy's "Trident" class ballistic missile submarines.

The sensor data required by the SFCS is supplied from a range of sources, principally sonar and periscopes, with accurate input from EM log, depth sensors and gyro compass.

Three sonar systems feed the SFCS. The attack sonar which is being installed as part of SWUP is the Krupp-Atlas CSU3-41. This sonar can operate in passive, active and intercept modes. In the passive mode its large cylindrical array at the bow of the submarine gives 360^{o} coverage. In the active mode this array is used for reception and a separate transducer array in the bridge fin is used for transmission. An intercept hydrophone array is mounted on the submarine casing to detect pulses from target sonars. The main inboard units of the CSU3-41 are located in the Control room and comprise an Operators Console, an Electronics Console and an Array Interface unit.

The principal passive sonar in the boat is an AN/BQG "Micropuffs" passive range finding sonar produced by Sperry Gyroscope in the U.S., again specifically for the RAN. This sonar provides range data to the SFCS by measuring the time difference of a target produced sound wave impinging on three widely spaced transducers installed beneath the submarine's casing. The Display Control Console is installed in the Control room. This system will have been installed in all RAN submarines by the completion of the current refit of HMAS *Otway*.

The third sonar, Type 2007, is produced by British Aerospace, and is also a passive sonar intended to detect surface and underwater targets in a low signal to noise environment. Outboard equipment consists of 48 hydrophones, 24 each side of the submarine, fitted in the external tanks, parallel to the centreline of the boat. The electronics for the system are housed in the Control room.

Other components of the system include Type 2004 equipment which provides depth and sound through water velocity, a Litton WSN-2 gyro compass (which replaces the Mk 23) and a Sonar Analysis System.

In the second refit of HMAS *Oxley*, the first SWUP refit, the introduction of these new equipments has resulted in wide-ranging modifications to the submarines systems and structure. Other major work in *Oxley* includes a complete re-construction of the Comcentre (radio office) and a re-arrangement of the radar office. Changes in the Control room area are particularly extensive, and in order that as many of the interface and installation problems might be overcome before work was begun on board, a full size mock-up of the control room was constructed. The timber mock-ups of the new equipment were made so that they would open in the same manner as the real thing to prove accessibility for maintenance.

The new electronic equipment is air-cooled, instead of being cooled by water, the method used for the old equipment, and this has meant considerable alteration to ventilation and piping systems in the congested control room area. These arrangements were included in the mock-up, which was complete in all respects, including lighting and minor fittings. It has proved to be of considerable assistance for the *Oxley* refit, and is expected to help resolve those problems which will arise from the minor differences between each boat during

34/....

the following five SWUP refits.

Structural work in the control room has included insert plates in the deck, which is over one battery tank and the auxiliary machinery space. The major structural item in this area is an insert in the pressure hull, about 4 feet square, which provides through hull penetrations for the CSU3-41 sonar, below the bridge fin.

Other structural work has been extensive, including inserts in two main transverse bulkheads, and further inserts in the Forward Torpedo compartment for cable penetrations. Removal of redundant equipment has required inserts in way of removed penetrations or through hull fittings. In *Oxley* some 25 inserts in the pressure hull structure have been completed, generally in QT35 or QT28 steel in the QT28 pressure hull and 'B' quality bulkheads. All welding has been subject to rigorous non-destructive testing, including 100% radiography and crack detection.

Externally, the CSU3-41 sonar has required the fitting of a new bow structure, as the new transducer and dome are much larger than those they replace. The active transducer in the fin has required modification to the fibreglass structure. The AN/BQG transducers are mounted on top of the pressure hull, and two original fibreglass sections of superstructure casing have been replaced by steel sections fitted with fibreglass windows.

All cables associated with the old sonars and fire control system have been removed. The original equipments had generally been hard wired, but the new units are connected by means of plugs and sockets. This has enabled much of the crimping of the connectors on the interconnection cabling to be completed ashore before the cables are run in the boat. A small facility especially for this purpose has been established.

To assist access on board, and to protect the sensitive electronics as far as practicable, equipment shapes have been made in aluminium alloy to accurately represent each console. The shapes are mounted in the boat on the equipment seats, and each is fitted with sockets in exactly the correct position, to which the cabling is installed. Each terminal on the sockets is led to tag strips within the shape, to enable wiring checks to be completed before the actual equipment is shipped. By this means the installation of equipment consoles can be delayed to

35/....

the last possible moment before setting to work. In some cases, the shipping time is governed by access considerations.

On completion of the installation, the new systems will be set to work by the equipment suppliers and the dockyard weapons team. To ensure adequate support to the submarines during the first installation and subsequent refits, dockyard technicians have been trained by the equipment suppliers overseas, and dockyard personnel were present during the setting to work of the first SFCS Mk 1 in the United States before it was shipped to Australia.

The phasing out of the older sonars and the TCSS 9 fire control system will be complete when the latest of the submarines, HMAS *Otama*, which arrived in Australia in early 1979, completes her first refit. Existing refit facilities for these systems will be retained sufficiently to provide support to operational boats during this period. Refit facilities and test rigs will be updated to suit the SFCS and CSU3 sonars prior to HMAS *Oxley's* third refit. Facilities for the other new sonars already exist on Cockatoo Island.

CONCLUSION

The refit of a submarine is a major task, involving over one million manhours of dockyard effort. The refit programme is highly sequence-governed and very sensitive to problems resulting from the supply of information and material. This has necessitated the introduction of management systems and procedures which, together with very close liaison between the dockyard and the Navy, seek to solve the problems as they arise with a minimum of disruption to the refit schedule, and without compromise to the high technical standards required.

Besides achieving the best material state of the submarines for their operational service, the opportunity taken at each refit to update the submarine systems and equipment has resulted in a modernisation programme which will ensure that the Australian Submarine Squadron is amongst the best equipped in the world.

ACKNOWLEDGEMENTS

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