

TRANSITIONING INDUSTRY TO A MULTI-CLASS SUBMARINE FLEET

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ABSTRACT

This paper presents an industry perspective on transitioning between two classes of submarines, including reflecting on the transition from the Oberon to the Collins class submarines and more recently implementing the Coles review recommendations. The evolution of the Australian submarine industry's position is contrasted with where it is today at the start of the Future Submarine Program to support both its build and sustainment. Australian industry is in a strong position to capitalise and build on past investments for the benefit of the Future Submarine Program.

INTRODUCTION

It is apt to contemplate our submarine history at the start of the concept design phase of Australia's 12 future submarines and in preparation for operating a multi-class submarine fleet. The notion that Australia requires a 12-submarine fleet was first mentioned in Admiral Sir Reginald Henderson's March 1911 report to the Australian Government after it requested advice on naval defence matters. His recommendations on naval vessels and bases were beyond Australia's means at the time and in 1912 the Government of Prime Minister Andrew Fisher commenced planning to implement his recommendations, in stages, after accepting the general outline. However, this plan was abandoned due to the outbreak of World War I in late July 1914, relegating Henderson's recommendations to history (Jeremy, 1995). Now, more than a century later, another decision to acquire 12 submarines has been made.



A BRIEF HISTORY ON SUBMARINES IN AUSTRALIA

Most of the history summarised in the first three sections of this paper has been sourced from John Jeremy's excellent and more detailed descriptions in his books *Safe to Dive, Submarines at Cockatoo Island* (1995) and *Cockatoo Island: Sydney's Historic Dockyard* (2005). Peter Yule and Derek Woolner's book *The Collins Class Submarine Story: Steel, Spies and Spin* (2008) is also a significant source of information for this paper.

Australia's first two submarines, the **E-class AE1 and AE2** built by Vickers Limited at Barrow-in-Furness, ordered by the British Admiralty on behalf of the Royal Australian Navy (RAN) in December 1910, were commissioned on 28 February 1914. They arrived at the Garden Island Naval base on 24 May 1914 via Singapore. Little was done in preparation for their support as partly evidenced by the decision on 4 March 1914, two days after sailing from the UK, to base the submarines in Melbourne. Both required significant maintenance following an arduous journey from the UK but Melbourne did not have suitable berthing facilities. Initial maintenance was done on *AE1* and *AE2* in Cockatoo Island's Fitzroy Dock, docking together on 3 June 1914. They undocked on 25 June 1914 to have their refits completed on 8 and 10 August 1914 respectively in their Williamstown home port, Melbourne.

Building submarines in Australia was first considered at the time that *AE1* and *AE2* were lost in action in World War I and replacements sought, supported by Parliament, when the British construction capacity was fully committed to production for Britain. Government supported building new warships in Australia but the capability to build submarines was considered lacking. The General Manager of Cockatoo Dockyard, John King Salter, did however send ten personnel to Britain to study submarine construction in 1916 due to continuing interest, from a political and industrial perspective, in constructing submarines in Australia. The study team, led by the naval architect David Mitchell, returned to Sydney in 1918 armed with information on modern submarines, as at that time, and what equipment was required for their construction.

Submarine construction in Australia was again delayed while advice was sought from the Admiralty as to a suitable replacement design and a British gift of submarines to Australia was discussed between Australian Prime Minister Sir Joseph Cook and the Admiralty in August 1918, as the war was coming to an end. The Admiralty recommended to the British Cabinet that six destroyers and six submarines be donated to Australia.

Six **J-class** submarines were commissioned into the RAN on 25 March 1919 and sailed for Australia on 9 April 1919. They arrived in Sydney in July 1919 and, like their predecessors (*AE1* and *AE2*), required refits following an arduous voyage. Preparation for their support left much to be desired. Garden Island was selected as the refitting yard with Cockatoo Island to provide services that were beyond Garden Island's capabilities. Even though only some personnel remained from the submarine construction study team, Cockatoo Island took up the work. Keeping the submarines operational was problematic as a result of their unreliable engines and main motors, combined with a funding shortfall. The Government approved their disposal on 22 November 1922 less than four years after they arrived at our shores.

In October 1924 the Government called for tenders for new submarines and was again supported by the British Admiralty. Two **Odin-class** submarines, designated AO1 and AO2, named HMAS *Oxley* and HMAS *Otway* respectively, were accepted from the builders in September 1927 and sailed for Australia in February 1928. Serious main engine problems were experienced during the voyage with extended repairs performed in Malta. A refit was required after their long journey. It was conducted in Garden Island upon their arrival in Sydney in February 1928. Due to ongoing financial constraints the submarines spent a lot of time secured alongside Garden Island. The Government decided in January 1931 to give both submarines back to Britain and they left Sydney at the end of April 1931.

Australia's record to support submarines up to this point was not a good one. It would be more than 30 years before Australia would again acquire submarines, apart from one **K-class** Dutch submarine that was purchased in April 1942 as a training submarine. The submarine, K9, was commissioned on 26 June 1943 following a long refit but, after a battery explosion in January 1944, it was paid off and returned to the Royal Netherlands Navy. The submarine sank near Seal Rocks on the NSW coast while being under tow, returning to the Royal Netherlands Navy.

Even with the hiatus in submarine ownership, submarines of allied nations were a regular part of naval activity in Australia during and well after World War II, including refitting submarines at Cockatoo Island. Several K-class submarines visited Australia during 1942 and the submarine *K12* was refitted at Cockatoo Island. Royal Navy submarines operating in the Pacific also docked at Cockatoo Island. This became more regular after Australia and New Zealand signed an agreement with Britain to base Royal Navy submarines in Australia for Australian and New Zealand forces to conduct anti-submarine training. Australia and New Zealand contributed two-thirds of the operating cost of the submarines in local waters. The Fourth Submarine Flotilla, based at HMAS *Penguin*, was established on 18 November 1949. It was later renamed the Fourth Submarine Division. Routine maintenance on the Royal Navy submarines was conducted in Sydney, including annual dockings at Garden Island and Cockatoo Island, but major refits were performed at the Naval Dockyard in Singapore as the requisite experience and capability was no longer available in Australia.

Submarines from allied nations were also based and repaired at the ports of Fremantle and Brisbane, making an important contribution to Australia's submarine industrial capability. These repair bases were chosen due to the availability of facilities and the surrounding supporting populations. For example, some 170 American, British and Dutch submarines made a total of 416 war patrols out of Fremantle Submarine Base between April 1942 and December 1944 (Cairns, 1995). As the war progressed in the Pacific, more and more submarines were transferred to the US Navy submarine base established in Brisbane. Some 51 US Navy submarines made 85 dockings at the South Brisbane Dry Dock for routine work and urgent battle damage repairs. Four Royal Navy submarines also operated out of Brisbane during that time (Jones & Nunan, 2011).

A CONSIDERED START TO AUSTRALIA'S MODERN SUBMARINE ERA

In January 1963, Cabinet approved the acquisition of eight British **Oberon class** submarines for the RAN with an initial order for the construction of four boats in the United Kingdom. The preparation for their acquisition, and specifically for their sustainment, was thorough and stands in strong contrast to previous Australian submarine acquisitions.

Prior to the decision to acquire Oberon class submarines the planning and preparation for submarine sustainment was, at best, haphazard, despite efforts by industry to prepare and facilitate the sustainment and its push to build submarines in Australia to improve competency. The cost of operating and sustaining the submarines was also not sufficiently appreciated up to this point, notwithstanding comments in 1907 by Captain William Creswell, Australia's senior naval officer, that submarines were expensive to maintain and difficult to crew (Yule & Woolner, 2008). Submarines acquired by Australia prior to the Oberon class and that were not lost, were disposed of within four years or less post acquisition with financial constraints cited as a significant factor in the termination decisions.

The approach to sustainment for the Oberon class acquisition was soundly planned and considered well ahead of their arrival; lessons had been learnt. Moves were afoot in 1960 to re-establish a RAN submarine service. In order to prepare to maintain the submarines, inclusive of major refits in Australia, arrangements were made to commence refit of the Fourth Submarine Division's T-class submarines at Cockatoo Island, with the refits paid for by the Australian Government. The Division's three T-class submarines underwent a total of five successful refits from January 1961 to October 1966; the duration of a refit was approximately 14 months. The last of the Division's submarines, HMS *Trump*, sailed home from Sydney on 1 March 1969.

The first of the initial four Oberon class submarines, HMAS *Oxley*, arrived in Sydney on 18 August 1967. Two further Oberon class submarines were ordered in 1971 with the last one, HMAS *Otama*, commissioned on 27 April 1978 after long delays in delivery due to issues with electric cables, bringing Australia's Oberon class fleet to a total of six boats. Johnman and Murphy (2003) reports that the Australian Minister of Defence, Bill Morrison, by August 1975 was frustrated with the late delivery and said that if Australia was to order more submarines, "they would not be going to that goddamned shipyard", referring to the Scott's of Greenock who built the Oberon class.

According to Naval Board minutes from April 1966 the Cockatoo Island Dockyard was selected as the main refitting dockyard for RAN submarines. Cockatoo Docks and Engineering Co. Pty. Ltd., with Vickers Limited as its majority shareholder, leased Cockatoo Island Dockyard from the Commonwealth. The submarine refitting decision occurred three years after Cabinet approved the Oberon acquisition and more than three years before the first Oberon class submarine arrived in Australia and five years before the first refit commenced in March 1971. Notwithstanding the successful refitting of the T-class submarines, the existing Cockatoo Island facilities did not meet the standards required for the Oberon class submarines and the layout did not facilitate efficient work practices.

The dockyard was extensively redesigned and outfitted following two technical missions to the UK and one to Canada and an extensive study with the assistance of a consulting firm on what was required to perform Oberon class submarine sustainment and refits. This study and resultant work was performed under the guidance of a steering committee comprising representatives of RAN, Cockatoo Docks and Engineering Co. Pty. Ltd. who performed the refits, the Department of Works and the consulting firm. The new dockyard facility was completed shortly after the first refit on HMAS *Oxley* commenced in March 1971.

The study report was comprehensive and detailed. Not all the report's recommendations were implemented and the intended equipment flow was not achieved which resulted in double handling of equipment and longer walking times for the refit workforce. The workforce included people who had previously worked on maintaining and refitting the RN's Fourth Submarine Division boats.

The refurbished and new refit facilities were regarded as amongst the world's best for conventional submarines, which was a tribute to the capability of Australian industry at the time. Due to Australia's location it was not practical to return equipment to original manufacturers for refit as was common practise in Britain and Canada. Hence, most of the work was planned to be executed on Cockatoo Island with thorough preparation for it supported by the new facilities.

Any other facilities, such as the existing battery shop and optical facilities for submarine periscopes at Garden Island were used for Oberon refit work if it met the requirements. Provision was made in the newly planned facilities to move such work to Cockatoo Island, should it be required, but this was never necessary.

The majority of the spares and materials for a refit were supplied through the RAN supply system. The RAN acquired spares mostly from the original manufacturers in Europe, often via the UK's Ministry of Defence. If spares weren't available due to delays in supply, which occurred regularly, they either had to be manufactured completely or repaired or old parts had to be re-used. Local manufacture was not always possible due to a lack of manufacturing drawings or insufficient material stocks of the correct specification or of locally made equivalents.

The first Oberon class refit experienced problems and delays when compared to the refits performed on the T-class submarines. This is not unusual when commencing deep level maintenance on a new class of vessel where new procedures, routines and work processes have to be established and refined. The Oberon class was also much more complex than the T-class. Delays in the supply of spares from the UK also slowed down the initial refits. The refit work at Cockatoo Island became routine as progress was made along the learning curve with refit performance becoming predictable and reliable.

Partly as a result of Vickers' involvement and reach-back to the parent company in the UK the Oberon refit philosophy was modelled on that of nuclear submarines, aiming to restore the submarine's performance and reliability to an "as new" state. The RAN required Cockatoo Dockyard to

establish modern planning, costing and quality control systems. In the absence of commercially available solutions the Dockyard developed proprietary software planning systems which, at the time, became one of the largest use of network analysis techniques in Australia.

The RAN-developed Submarine Weapons Update Program (SWUP) commenced in October 1977 to fit an advanced digital fire control system, new sonars and the capability to fire both the US Mark 48 wire-guided torpedo and the Harpoon submarine launched air flight guided missile on the Oberon class. This was the first of this type of extensive modernisation of Oberon class submarines anywhere in the world; the Royal Canadian and the Royal Navy later adopted similar modernisation programs. As Yule and Woolner (2008) put it, the success of the SWUP “gave the navy’s submariners enormous confidence in the ability of the navy, the dockyards and Australian industry to carry out complex technically demanding projects. The SWUP was the overture to the Collins symphony”.

The SWUP, from an industrial perspective, required wide-ranging modifications to the submarine’s structures and systems, both internally and externally, including new bow structures. The RAN, in their own right, exerted significant effort to fully integrate the new weapons and systems “black boxes” through programming to make the software work with the hardware and to amend operations and tactics to exploit the new capabilities.

REPLACEMENT OF THE OBERON CLASS SUBMARINES

Yule and Woolner (2008) best describes the history of the lead-up to and eventual replacement of the Oberon class submarines, as well as how the **Collins class** was selected. Cockatoo Dockyard played a central role in triggering the program to replace the Oberon submarines. Early studies, initiated and conducted by the company, then known as Vickers Cockatoo Dockyard Pty. Ltd., partly financed by Government, resulted in a report to Government in March 1981 which concluded that it was practical to build modern submarines in Australia and that it would present many opportunities for Australian industry. The study highlighted that local construction would benefit the future support and refit of the submarines. It did however take much more effort to convince decision makers to opt for an Australian build.

A significant disruption to Australia’s industrial submarine capability was about to occur in the lead-up to the selection of the supplier of the replacement for Oberon class submarines. On 1 April 1987 the Minister for Defence, Kim Beazley, announced that the lease of Cockatoo Island Dockyard was not going to be renewed beyond the end of the Oberon class submarine fleet’s refit work which was scheduled to be completed by the end of 1992. The announcement also referred to the potential early termination of extension of the refit contract. At this stage neither HMAS *Orion* nor HMAS *Otama*, the two newest submarines, had their third refits scheduled or contracted. The Treasurer’s announcement in May 1987 that the government will be selling Cockatoo Island at the earliest opportunity significantly increased the level of uncertainty for the Oberon refit contract held by Cockatoo Dockyard and for their other business conducted on the Island. Uncertainty about its future resulted in major industrial action being undertaken by shipyard labour later in 1987, over claims for increased redundancy pay.



THE FIRST TRANSITION TO A MULTI-CLASS FLEET

While more industrial action was brewing at Cockatoo Island Dockyard the Kockums design was selected in May 1987 as the replacement for the Oberon class. A contract was signed on 3 June 1987 with the Australian Submarine Corporation to build six newly designed modern submarines in Adelaide, South Australia.

The submarine capability disruption was about to be exacerbated when government advised Cockatoo Dockyard in September 1988 that it was investigating the early termination of the Cockatoo Island Dockyard lease. The RAN, being concerned for the support of its submarines should the lease be terminated early, sought expressions of interest from other organisations to take over refit work for the next two Oberons and for it to be conducted at Garden Island in Sydney or in Western Australia. The uncertainty and doubts about government's actual intentions for Cockatoo Island led to what Jeremy (2005) describes as a crippling 14-week strike over the May to August 1989 period. The strikers wanted the last two refits to be conducted at Cockatoo Island as originally contracted. The strike was ended after government agreed to improvements in redundancy pay and financial incentives for improved performance on the two refits that were in hand at the time; i.e. the fourth- and third-last Oberon refits.

The strike influenced government to such an extent that it decided to place the last two Oberon refits, that of HMAS *Onslow* and HMAS *Otama*, with Garden Island. This was despite Defence's recommendation for it to remain at Cockatoo to prevent the inevitable cost and time penalties that would be incurred by such a move. The refit of HMAS *Onslow* commenced a year late and took a year longer than it would have at Cockatoo. HMAS *Otama* remained alongside the wharf in Neutral Bay from late 1990 to the end of August 1993 when the refit began almost three years late. HMAS *Otama* re-joined the fleet in December 1995 after a five year absence. These last two refits were significantly more costly than those

conducted at Cockatoo Island and probably contributed to the decision to retire the last two submarines HMAS *Orion* and HMAS *Otama* early by not performing a third refit for each. The cost, in current dollar terms, of the last Oberon refits was more than that of a Collins class submarine refit (Full Cycle Docking) today. Unforeseen at this time, it would take another 20 years for submarine sustainment in Australia to again approach world benchmark performance.

The decisions from April 1987 proved costly in terms of money, lost submarine operational availability, the disorderly transition of submarine industrial experience to the Collins class program and in opportunities lost by not preventing a capability gap. The gap could have been reduced by performing a third refit on each of the last two Oberon class submarines or alternatively extending the life of some of the other submarines if planning had commenced early enough and the industrial base had not been eroded. One could speculate that the implementation of these Government policy changes might, in hindsight, have been done differently with today's knowledge of the outcome of submarine availability and the Submarine Enterprise's operation to deliver better outcomes.

Concurrent with the events above, the submarine squadron was transferred from Sydney to Western Australia which presented significant difficulties when the transfer commenced in 1988. This was brought about by Government's Two Ocean Navy Basing Policy which eventually relocated half of the RAN's fleet to HMAS *Stirling*, not only submarines. Submarine maintenance commenced with the Intermediate Docking of HMAS *Oxley* on the shiplift at Henderson, Western Australia, in early 1989. This required intense planning between the RAN and Industry in Western Australia; for most of the eastern states this was out of sight and out of mind.

Figure 1 depicts Australia's submarine history from 1914 through to how it might evolve to 2080 with the current Future Submarine Program.

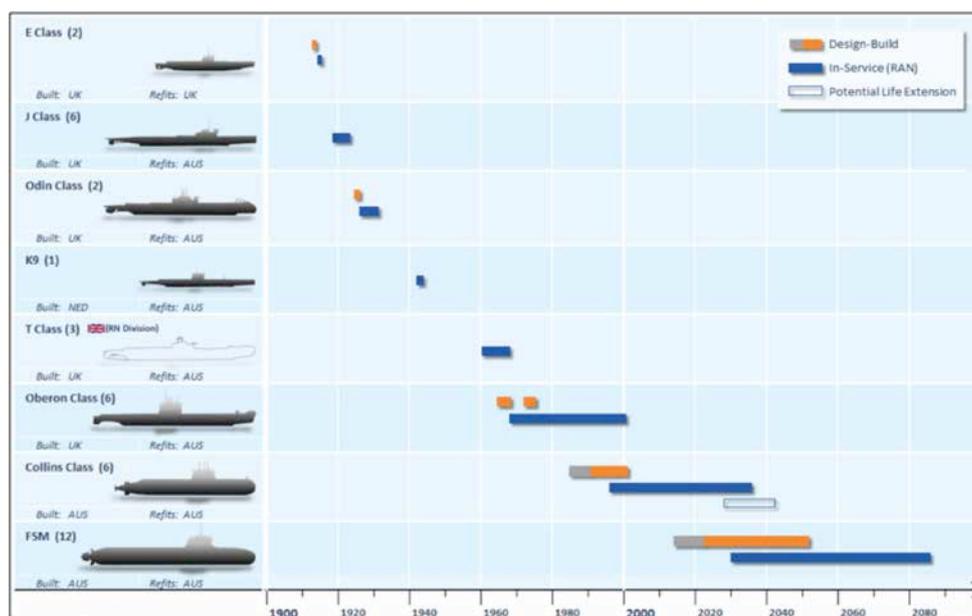


Figure 1. Australia's submarines – 1914 to 2080

THE COLLINS BUILD

Building the Collins class submarines in Australia was ambitious, notwithstanding SWUP's success. There were only pockets of industrial submarine experience in Australia but nothing that would resemble an industry ready to take on a submarine building program. The largest concentration of submarine industrial skill and experience was at Cockatoo Island. The decision to cease its operations early and the lack of a coordinated transition between the Oberon and Collins industrial activities dispersed that capability. Jeremy (1995) describes it; "As the work declined at Cockatoo Island some employees transferred to ADI to help with the refits there, others left for South Australia to help build the new Collins class submarines, and in due course the remainder departed to other industries, occupations or early retirement. Apprentices who could not complete their time at Cockatoo Island were found employment elsewhere."

To put the Cockatoo dockyard impact in context, with the start of the T-class refits at Cockatoo Island in 1961 the dockyard employed just over 2,000 people. This reduced to approximately 1,300 people in 1974 as the Oberon refits settled into a predictable pattern. The island's workforce built up to a peak of almost 2,600 people in 1984 when the ship HMAS *Success* was also being built at the dockyard amidst the Oberon refits (Jeremy, 1995). With the demise of the Cockatoo dockyard, most of this workforce scattered into the general market, away from shipyard work.

Australia's submarine industrial capability had to be re-established for the build of the Collins class submarines. Significant Australian industrial content was achieved during the Collins build on the back of the renewed growth in Australia's industrial submarine capability. This included, for example, setting up a design office in Adelaide that was initially staffed by 40 Australians and 20 Swedish staff; its function was to perform detailed designs and production engineering as the design effort transferred from Sweden to Australia.

The public perception that the Collins build program was a financial disaster and delivered hopelessly late continues to prevail despite not being fully supported by the facts. Yule and Woolner (2008) concludes that: "the project was a rarity among military procurements in that the original budget was still relevant at the end of the project." The project was delivered within approximately 4% of its original budget in outturn dollars. The original budget had only a 2.5% contingency allowance rather than the 10% to 15% which is more common for complex projects; the Collins program was not only complex but also comprised of a developmental platform and developmental combat system (Schank, et al., 2011).

Yule and Woolner (2008) calculated that the submarines were on average delivered 26 months late, relative to the original schedule. When the schedule is evaluated with reference to the large number of agreed scope changes and their resultant contract changes, the submarines were, for contractual intents and purposes, delivered on time and on budget. The first of class, HMAS *Collins*, was launched 9 years after Government's decision in May 1985 that led to the Project Definition Studies.



This compares well with many less ambitious submarine build programs elsewhere in the world. This was achieved for a newly designed modern conventional submarine which was much larger and more complex than any other conventional submarine ever built, constructed by a brand new submarine yard in a country that had never built a submarine. Other submarine programs of the time have taken several years longer in much more favourable circumstances.

Such an outcome requires a lot of hard work; the Collins build program was not short on challenges. In mid-1999 the tide, politically and publicly, had turned against the Collins program to such an extent that it was at real risk of being shut down. Many of the changes, apart from solving technical problems on the new submarines, became necessary due to an increase in threat level and changes in technology in the time since the contract was awarded. One of the program challenges was the immense schedule pressure that came to bear on the Collins build and partly contributed to the instigation of the "fast track" program. "Fast track" was initiated after a national security committee meeting in October 1999 to effect design enhancements, augment capability of the submarines and ensure the delivery of HMAS *Dechaineux* and *Sheean*. The early retirement of the Oberon class fleet combined with their sustainment difficulties towards the end of their life resulted in a capability gap. This came to a head with the HMAS *Otama's* pending certification expiry in December 2000 with the need to deliver two new submarines to replace it in order to reduce the capability gap. HMAS *Dechaineux* and *Sheean* were delivered to the RAN in July and August of 2000 respectively, arriving in Western Australia in mid-December 2000 after a major effort by both the RAN and ASC to complete the submarines.

BECOMING A SUBMARINE “PARENT NATION”

The Collins program challenged Australia to become a “parent nation” for its new class of submarines. The Coles Phase 1 Report (2011) describes the requirements of owning a submarine design as “to invest in facilities and equipment to allow it to operate the submarines effectively - shipbuilding facilities, docks, manpower and training, operational support facilities, engineering and scientific resources, access to the necessary industry resources and skills, and a properly resourced and effective supply chain.”

The decision to build the Collins class submarines locally was strongly motivated by the benefits a local build would hold for future sustainment and refit. The 1987 Defence white paper (Department of Defence, 1987) states:

It was recognised from the outset that Australian industry had little of the specialised knowledge and experience needed to design and build submarines to replace the present fleet of Oberon class vessels. Industry had, however, many of the basic industrial capabilities and the existing submarine designs needed substantial modification to meet Australian operational requirements. The vessels require a large and complex infrastructure for their through-life support, independently of the overseas source, which would be assisted by local construction.

This Government decided that the vessels would be built in Australia. It judged that the cost premium for local construction could be justified in terms of the self-reliance gained in the local capabilities established for subsequent set-to-work, repair, maintenance, modification, refit and, probably, mid-life modernisation.

The Government also agreed that Australian industry should be encouraged to take a major role in the project, including sharing the risks, and consortia were formed between local organisations and the overseas tenderers for the platform and combat systems to undertake Project Definition Studies and to bid for production. A substantial portion of the work will be subcontracted by the prime contractors to Australian enterprises, which will have to comply with strict quality standards within delivery schedules and to cost.

This model for Australian industry participation in a major defence development and production project offers the prospect of substantial industrial and defence self-reliance benefits. It is demanding on the resources of industry and Defence project management.

The benefits a local build would hold for the sustainment and refit of future submarines remains. An explicit aim of the Future Submarine Program is to ensure sovereign sustainment of the future submarines.

The Collins project office developed detailed plans in the early 1990s for the support and maintenance of the new submarines, inclusive of in-service support plans along with a contract and acquisition strategy. These plans were not implemented and submarine maintenance and sustainment was performed under ad hoc arrangements which impacted submarine availability and sustainment execution. This stands in contrast to the meticulous approach that was taken to prepare for and execute the sustainment for the Oberon class submarines more than three decades earlier.

It is encouraging to note the preparedness in Defence to plan for and execute a comprehensive sustainment program for the future submarines. Australia’s submarine industry is supportive of this approach.

THE COLES REVIEW

Defence entered a long-term Through Life Support Agreement (TLSA) with ASC for the sustainment of the Collins class submarines in 2003 to replace the prevailing ad hoc arrangements. In 2009, after six years of the TLSA, the RAN, Defence Materiel Organisation (DMO) and ASC commenced negotiation of a performance based In-Service Support Contract to improve on the weaknesses of the TLSA. The In-Service Support Contract set about establishing improved business arrangements and performance benchmarks to meet whole-of-government objectives. The Department of Defence commissioned the Coles Review into the business of sustaining the Collins class submarines in August 2011, amidst ongoing low submarine availability. The review team, led by John Coles, was requested to advise all three parties on the establishment of the In-Service Support Contract (Coles, et al., 2011).

The Coles Review’s first phase report identified various deficiencies and explicitly stated the problems observed in ASC and Department of Finance and Deregulation, as the owner of ASC and in the RAN and DMO, both in the Department of Defence. Of the ten findings only part of one related to the submarine and its systems, the rest were ascribed to enterprise level management and organisation. It was clear that it took much more to be a parent nation for a unique submarine than just having the assets, entities and structures in place.

The combined second and third phase report from the Coles Review made 25 recommendations to address the 20 key issues that were identified as the drivers of the low level of sustainment performance. The issues could be traced to five root causes, namely:

- Unclear requirements;
- Lack of performance based ethos;
- Unclear lines of responsibility;
- Poor planning; and,
- Lack of a single set of accurate information to inform decision making.

This report and its recommendations provided the impetus for a step change in submarine availability. It resulted in the establishment of the Submarine Enterprise, comprising of RAN, DMO and ASC and a reorganisation of the submarines’ usage and upkeep cycle and a plan to migrate enterprise arrangements to the newly adopted usage upkeep cycle as effectively and efficiently as possible.

THE COLLINS CLASS SUSTAINMENT TRANSITION

The transition to the new “10 + 2” usage and upkeep cycle, where a submarine is in service for 10 years followed by a two-year Full Cycle Docking (or refit), was recently completed with the delivery of HMAS *Famcomb* to RAN following completion of its full cycle docking.

This transition was the direct result of extensive collaboration between ASC, Capability Acquisition and Sustainment Group (CASG) and the RAN working together as the Submarine Enterprise, supported by Australia’s wider submarine industry and various support organisations.

There are several industrial elements that facilitated this transition.

The second and third phase Coles report depicted the Submarine Enterprise value chain and proposed a distribution of responsibility to achieve good practice. This led to the shipyard being made responsible for and taking control of a larger part of the supply chain and rationalising it in order to be better in control of its own sustainment outcomes. Hull cuts were introduced as part of the Full Cycle Docking (refit) process which allows diesel generators, the main propulsion motor and other equipment to be removed from the submarine to rebuild and test them in a more efficient manner in a workshop environment and not the cramped insides of a submarine. A general rule of thumb is that an hour’s worth of work in a workshop environment grows to five hours if it has to be performed inside a submarine on the hard stand and to eight hours if the submarine is moored alongside. A dedicated diesel generator test facility was constructed. The refurbished diesel generators are now tested off the submarine under full operating conditions to more easily address any problems before it is re-installed into the submarine with the confidence that it is fully operational. Work practices and arrangements were improved by constructing a permanent maintenance support tower structure. It provides workers safe, efficient and time saving access to their work fronts on the submarine with their tools, consumables and materials available close at hand along with canteen and ablution facilities. Supervisory staff and supporting engineers have offices co-located in the support tower next to the submarine to further improve efficiencies. ASC will continue to modernise facilities and work practices to maximise production efficiency and further improve cost effectiveness to the RAN in the future.

Although much continues to be done to improve performance on Collins class sustainment to maintain a potent and enduring submarine force with a regional capability edge, the results so far achieved since the initiation of the Coles review has been described as “outstanding” by the Secretary of Defence (Richardson, 2016). Even back in March 2014, Coles wrote: “What has been achieved to date is remarkable, delivering a level of performance that would not have been viewed as possible two years ago. It has been an enormous pleasure to observe the astonishing turnaround of a seriously failing project...” In releasing the follow-up Coles Review on 21 October 2016 the Government called the Collins class sustainment program an “exemplar”. Coles has been similarly impressed by the achievements to date since the first of the reviews under his direction was published (Coles, et al., 2016).

RECOGNITION AS A SUBMARINE PARENT NATION

Ongoing improvement effort will be applied to sustaining the Collins class submarines to achieve and maintain beyond benchmark performance. The maintenance program has become “uniquely balanced” (Coles, et al., 2016) between operations and maintenance and will be sustained through the symbiotic relationship between the RAN and industry to meet the RAN’s objective of two deployable submarines consistently available. Australia has never-the-less now achieved recognition as a submarine parent nation through its long submarine history, experience and many lessons learnt along the way.

Today, on the eve of commencing the design and readying for the build of the future submarines to replace the Collins class submarines, Australia is in a much better position than it has ever been to become the parent nation to a new submarine. The nation’s sovereign industrial submarine capability is much better developed than at a comparable stage in the development of the Collins class submarine program. Australian industry is now well experienced in both the build and sovereign sustainment of conventionally powered submarines of bespoke design to meet Australia’s unique requirements.

Almost all of ASC’s supply chain requirements for the platform sustainment of the Collins class submarines are now sourced from Australian industry. This is a significant improvement on the Collins class build program. In addition, ASC holds certain design and engineering authorities for the Collins class platform and is very familiar with the unique operating environment faced by the Collins class submarines with their long range patrols that are more akin to those of nuclear powered submarines.

The aims stated in the 1987 Defence White Paper, as quoted above, have now been met and exceeded through the decision to build the Collins class submarines in Australia and the flow-on effects that it has had. Australian involvement in the design and the build of the Collins class fleet has been an essential stepping stone for Australia to become a submarine parent nation. Australia has become mostly industrially self-reliant for its Collins class platform needs and more cost efficient compared to the Oberon class. The cost to maintain a Collins class submarine after it has started to undergo refits (or Full Cycle Dockings as it is called today) is on average approximately 7% of its Replacement Asset Value (RAV) per year compared to Oberon class submarines at an average cost of over 15% of their RAV per year. Note, the percentage of RAV metric, often denoted as %RAV, is a globally accepted method that is used to compare periodic maintenance costs of high value assets; it is regularly used to benchmark maintenance expenditures for (physical) assets of varying size, value and type whether it be for ships, industrial installations, chemical processing plants, motor vehicles or aircraft.

The design intent for the Collins class is well understood and to such an extent that the design authority is now held in Australia. The design has since successfully been modified to improve and upgrade the class. In other words, the “recipe” used for the Collins design and build, where the designer involved the shipyard in the production design process, proved successful.

THE SECOND TRANSITION TO A MULTI-CLASS FLEET

To maintain Australia's submarine capability, as stated in the 2016 Defence White Paper's Integrated Investment Program, the Collins class fleet will be operated alongside the future submarines for a significant period. Industrial support for the Collins class submarines will be required for possibly another two decades while industry expands its capability to participate in the build and sustainment of the future submarines. Maintaining Australia's existing submarine industrial base will be necessary to ensure that the Collins class is maintained as a capable platform throughout its remaining life. Their potential life extension and ongoing capability upgrades are vital to retaining Australia's submarine capability to maintain a potent and enduring submarine force that is regionally superior. The success of these endeavours will be reliant on cooperation between the Future Submarine Program and the tasks at hand on the Collins class submarines.

Australia's submarine capability will comprise of two classes of submarines. If planned well and properly scoped, operating a multi-class fleet provides an opportunity to transfer submarine knowledge, capability and experience in an orderly fashion for the benefit of both classes of submarines. One such opportunity would be to exploit supply chain and sustainment system synergies across the programs, utilising capability that is already in place and functioning well. Such an outcome will benefit Collins class sustainment and help to shape a stronger industrial base for the future submarine's build and sustainment phases.

During the past financial year ASC's submarine supply chain transacted with just under 1,600 vendors, issued over 25,000 invoices and executed more than 11,400 purchase orders in support of the Collins class platform maintenance. Almost all of these maintenance supplies and services are sourced from Australian entities. In short, there is a well-functioning and capable submarine support industry and experienced supply base of materials and services outside of ASC that is central to the sustainment of the Collins class submarines.

From the future submarine program's perspective, a Collins class submarine life extension can mitigate potential schedule risk by, as far as practically possible, de-coupling the retirement of the Collins class fleet from the delivery schedule of future submarines. It is important to recognise that, due to its new design, the future submarine will initially be in a development phase which is likely to present schedule challenges, as was the case with the Collins class submarines and even the earlier Oberon class. Government has indicated that the future submarine program's schedule will be realistic and it is hence expected that previous experience will be heeded.

History demonstrates the transition between the Oberon and Collins classes left much to be desired due to a range of matters impacting multiple fronts. It is apparent that the transition plan was based on overly optimistic assumptions that did not recognise the challenges of building a newly designed conventional submarine, larger than any built previously, in a country that was building a submarine for the first time.

A contributing factor was the poor implementation and execution of the Collins class's maintenance planning; that for the Oberon class's introduction, several decades earlier, was done much better.

The transition of the workforce and facilities from sustaining Collins class submarines to future submarine construction will require careful management. Demand for submarine skills and experience will need to be managed. Highly experienced workers from the current Collins class sustainment workforce are required to maintain ongoing Collins class capability but may also be used to become the kernel around which the future submarine build workforce is developed.

ASC's Collins class sustainment workforce comprises of approximately 1,200 people with around 180 degree qualified engineers in 16 engineering disciplines. About 800 of these employees, inclusive of engineers, constitutes ASC's submarine technical workforce who are highly proficient and skilled in submarine technical work. Subcontractors are regularly used and typically vary between 60 and 200 positions, depending on demand. More than 20 ASC technical specialists are currently seconded on a full-time basis to government's SEA 1000 Technical Organisation in support of the Future Submarine Program. The workforce can be expected to, over time, almost double with the doubling of the submarine fleet's size. This will be done in concert between Government agencies and industry to ensure proper workforce planning, recruitment and training to meet demand.

Figure 2 illustrates the progression of Australia's submarine industrial capability with respect to a simplified value stream, starting with the Oberon class and ending with the potential outcome for the future submarine. It illustrates the ambitious transitioning challenge from the Oberon class to Collins class given the majority design, build and supply chain activity of the Oberon value stream was conducted in, or centred on, Europe. Whereas the strategy to execute the Collins class build in Australia clearly laid the foundation for our nation's future build and sovereign sustainment capability.

ASC, apart from supply chain dependencies, also relies on a technical capability and support network through which it continually develops its submarine expertise. ASC's capability and support network is largely Australian based and comprises of capability partners (internationally based), industry (some international), subject matter experts (some international), universities, institutions and government research establishments.

The Australian submarine industry will continue to develop its skills and ability to meet Government's needs. These needs are for Government to decide and could include extending the life of more of the Collins class to maintain or even expand capability. There could also be a requirement to vary the production rate of the future submarine fleet.

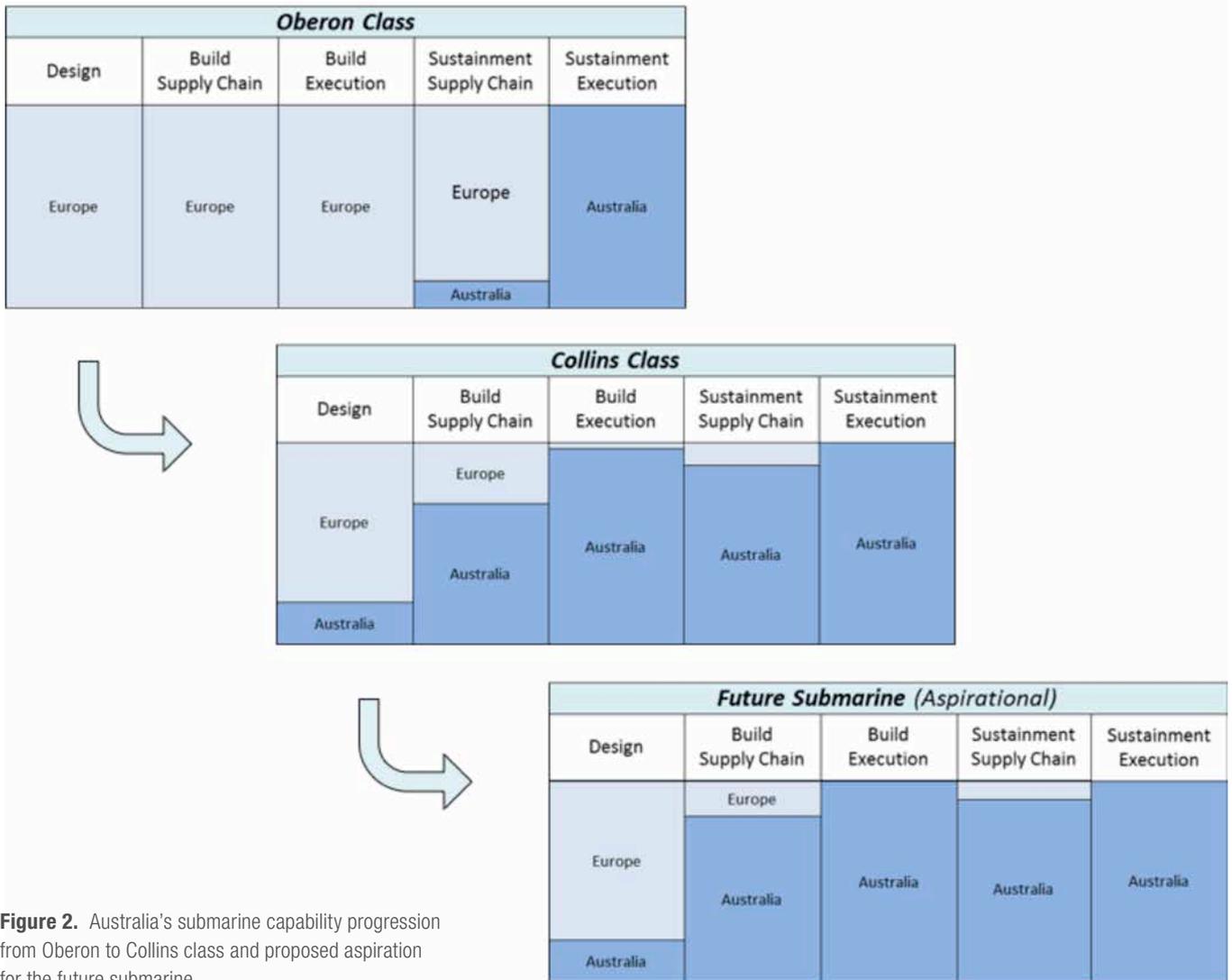


Figure 2. Australia's submarine capability progression from Oberon to Collins class and proposed aspiration for the future submarine

Hence, the industrial capability must be flexible to meet changing requirements as events evolve.

To meet the requirements for operating a multi-class fleet there will, beyond the submarine industrial base, more than likely be duplication of some aspects that hasn't recently been experienced in Australia. Training and staffing will have to be provided for two classes of submarines. Systems on the future submarine might not only be different from a generational perspective but also from an origin perspective. The future submarine will not be an evolution of the Collins class,

it will be a new "brand" and architecturally different from the Collins class. This change might be similar to what was experienced in the transition from the Oberon to Collins class. This will require industrial organisations to continue to operate at high performance levels to mitigate program risks for both classes of submarines and exploit synergies.



CONCLUSION

We have a proud submarine history of over 100 years. Industry has developed along this journey by growing its capability to where it is now able to support a parent navy. The next step in its evolution is to support a parent navy of two classes of submarines.

The Australian submarine industry is, indeed, today a fundamental input to capability and now formally recognised as such. Australia is vastly more capable and experienced than at the transition from the Oberon to the Collins class fleet, having learnt many lessons and overcome numerous challenges on its way to becoming the Collins class parent nation. ASC stands ready to contribute to the Future Submarine Program by building on the Collins class experience to support government's aim of sovereign sustainment of the future submarine. The past investments in submarine building and maintenance puts Australia in a good position to retain sovereign control over its future submarine fleet and enhance the realisation of benefits from its earlier investments as foreshadowed as far back as 1987.

The Future Submarine Program will initially be focussed on the design and build of the submarines. Equally important, though, is the focus on sustainment and establishing an appropriately funded and structured sustainment program to ensure the submarines meet the required in-service capability and availability targets. The lessons from Australia's submarine history are loud and clear. Industry will enthusiastically support such efforts to meet government requirements in a timely fashion to support a multi-class submarine fleet.

ASC is supportive of and heartened by Government's clear direction for the Future Submarine Program to establish a sovereign submarine sustainment capability as an overarching principle of the program. This capability has been achieved for the Collins class submarines through investment, learning hard lessons, and persistence.

Industry's part in this capability can be built on to capitalise on these lessons and investment through careful planning of an orderly transition to maintain skills and experience by avoiding the pitfalls of previous transitions.

Operating a multi-class submarine fleet for a substantial period of time will be a new endeavour for the Australian submarine industry and the Submarine Enterprise. A successful transition to a multi-class fleet will present challenges across a number of fronts but these can be overcome. Many navies of the world operate multi-class submarine fleets as a matter of routine and these may provide insight and advice to our Submarine Enterprise and the wider support industry. Collaboration will lay the basis for a successful transition. The best plans and solutions will be obtained through consultative and cooperative leadership by our Submarine Enterprise to optimally utilise the benefits that the two submarine eco systems will offer. Industry is supportive of the planning that has already been initiated by the Submarine Enterprise.

Maintaining Collins class submarines as a capable platform for the next 20+ years will enable and facilitate the transition to a multi-class fleet with opportunities such as for force generation to serve a larger fleet, potentially testing new technologies and incorporating them in submarine operations, and much more. The sovereign sustainment of the future submarines is a clear aim of Government. This can be achieved through Australia's current level of sovereign sustainment capability by diligently and purposefully building on it. Australia's sovereign submarine technical capability, as it exists today, allows it to maintain and upgrade the Collins class submarines and it is capable of extending the operational life of the fleet. ASC, as part of the Submarine Enterprise, will maintain its focus on the Collins class to ensure a potent and enduring submarine force with regional superiority whilst also developing our capability in support of the Future Submarine Program.

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