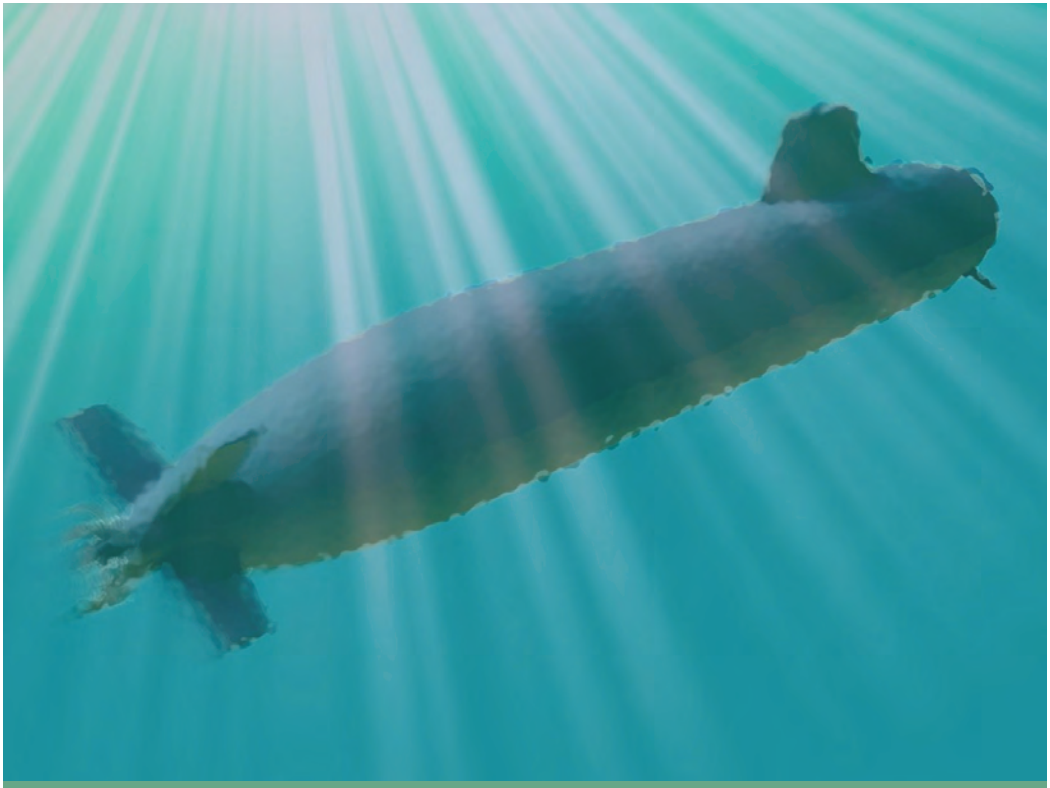
Kokoda
PAPERS

Sub Judice: Australia's Future Submarine

NUMBER 17 January 2012



Brice Pacey

Kokoda Paper No.17
January 2012

SUB JUDICE: AUSTRALIA'S FUTURE SUBMARINE

Brice Pacey

The Kokoda Foundation
www.kokodafoundation.org

Researching Australia's Future Security Challenges

Published in Australia by the Kokoda Foundation, January 2012

National Library of Australia Cataloguing-in-Publication entry

Author:	Pacey, Brice, 1953-
Title:	Sub judice: Australia's future submarine/Brice Pacey.
ISBN:	9780980730661 (pbk.)
Series:	Kokoda papers, 17.
Subjects:	Submarines (Ships)--Government policy--Australia. Australia--Defense.
Dewey Number:	359.9383

Series Editor: Catherine Scott
Publication Management: QOTE Canberra (02) 6162 1258

Printed by: Printed by Blue Star Group Canberra
Published and distributed by:
The Kokoda Foundation
2/10 Kennedy Street
(PO Box 4060), Kingston ACT 2604
T: +61 2 6295 1555
F: +61 2 6169 3019
Email: manager@kokodafoundation.org
Web: www.kokodafoundation.org
Additional copies are available from the Foundation at A$22.00 (including postage and GST) per copy.

EXECUTIVE SUMMARY

Australia's 2009 Defence White Paper recognised the dynamics of the emerging regional security environment by establishing a rigorous program of strategic reviews, the next of which is due in 2014. Yet the strategic uncertainty that necessitates continuous re-evaluation also creates significant problems for defence planners seeking to advise governments on capabilities that might be in operation decades into the future.

Since the Second World War, Australia's strategic geography has helped insulate it from the ambitions of regional competitors and the centres of great power conflict. But the influence of geography is not static. The benefits have accrued from Australia's membership of a dominant maritime alliance and through access to technologies that have helped maintain a capability edge in the maritime domain.

In the 21st Century new powers are rising and deploying new asymmetrical military technologies that threaten to weaken some of the advantages of geography and technology on which Australia has traditionally relied. There are developments underway which threaten to erode the freedom of movement of Australian and allied naval forces and maritime trade.

To meet these challenges in the decades ahead, Australia will require a reinvigorated maritime strategy and investment in force elements that are not only potent, but also survivable in an increasingly complex and potentially dangerous maritime environment.

Submarines and their operations will be central to any viable strategy. They may be the only force structure elements capable of persistent operations in a maritime region that is fundamental to Australia's interests. In particular, submarines may be the only naval vessels capable of secure operations along the length of Australia's sea lines of communication, or interdicting those of prospective adversaries.

While surface combatants will continue to perform important roles because of their versatility, submarines will have a vital role because of their survivability. This was acknowledged in the 2009 Defence White Paper, which called for a larger fleet of more capable submarines to replace the in-service Collins class submarines.

Critics have raised concerns about the cost and capability required of the Future Submarine program. Some suggest that Australia's requirement could be satisfied by a small off-the-shelf design at a much lower program cost. Others argue that a larger design with nuclear propulsion would better meet Australia's needs, and that the cost penalty would be slight.

These criticisms and the misconceptions on which they have been based require thorough and objective analysis to identify issues which should be addressed in the lead up to the 2014 Defence White Paper.

In conditions of strategic uncertainty, any assessment of the strategic environment in which the Future Submarine will operate will be problematic, as the submarine is likely to be in operation well beyond the middle of the century. Changes in the strategic environment will have consequences for the number of Future Submarines that will be required, their capabilities and the rate at which they are produced.

The operations research undertaken in conjunction with the Kokoda study has confirmed that there is simply no commercial off-the-shelf conventional submarine that comes close to meeting Australia's requirements. A design to meet these requirements will involve a unique combination of range, endurance and stealth to operate over the distances inherent in Australia's strategic geography, and to exploit the strategic depth that it affords.

No justification could be found for the additional costs of a nuclear program, thought to be of the order of thirty to forty per cent, even if Australia had a nuclear industry and the supporting infrastructure. The life-cycle costs of a nuclear program would place unacceptable pressure on other elements of a balanced force.

Of the available options, an evolution of the Collins design emerged as the best way to benefit from the experience of operating a modern submarine fleet in Australia's maritime domain.

The Collins is the only available conventional submarine approaching the range and endurance necessary to fulfil the capability requirement for the Future Submarine. It already has the capacity to perform most of the additional roles and missions required by emerging Australian guidance, although there is scope for the incorporation of new and improved technologies to meet

those demands better and to overcome aspects of the Collins design that have proven problematic.

A thorough analysis of comparable programs confirms that the cost of building the submarine will be markedly less than some published estimates and that there is no cost penalty for an Australian build. Furthermore, the technology and construction costs of modern submarines have shown a high level of stability over more than two decades, providing confidence in the project's capacity to meet internationally benchmarked cost, schedule and performance objectives, particularly if on the basis of evolutionary acquisition.

With the appropriate price disciplines in place, a fleet of ultimately twelve submarines capable of meeting all of the current capability requirements might be built for less than half the oft-quoted estimates, perhaps $18 billion in 2011 dollars. Nevertheless, this remains a substantial investment, and the containment of costs will be critical.

For the Future Submarine program to be a success, an appropriate enterprise structure must be established to deliver and sustain the Future Submarine over the life of the project. In the course of the Kokoda study a range of alternatives to the traditional prime contract model have been canvassed by examining approaches that have been successful in complex engineering tasks in the private sector.

Nevertheless, it is important to recognise that successful naval projects have been delivered under a prime contracting model. Consultation with some of the most successful naval program managers and shipbuilders in Australia suggests that the main factors contributing to program success appear to have less to do with the contracting model and procurement ideology than the quality of the project leadership and a broadly based commitment to program success.

The challenge will be to develop an acquisition strategy that draws on the best that the public and private sector can bring to bear. In the case of the public sector, it will be a combination of the operational experience of naval personnel, together with the regulatory and prudential experience of the public service. In the case of the private sector, it will be the much greater

engineering and project management experience combined with the efficiencies that come from operating successfully in a highly competitive international market.

Policy makers need to move quickly to overcome bureaucratically and politically imposed delays in the Future Submarine program. Already, Collins will be required to serve longer than originally planned. The Future Submarine program will need a higher priority and more flexible project management if it is to be in service in the numbers and with the capabilities required to be a force in the undersea environment of 2030.

ACKNOWLEDGEMENTS

The study was made possible by the support and encouragement of more than forty Australian and international workshop participants from both the public and private sectors. Special thanks are extended to the many senior officials who participated and to Commodore Paul Greenfield RAN (Rtd), Mr Derek Woolner, Mr Rolf Polak, Mr Steve Davies, Mr Brett Ackroyd, Mr John Gallacher, Commodore Terry Roach RAN (Rtd), Dr Chris Edmonds, Dr John White, Rear Admiral Peter Briggs RAN (Rtd) and Mr John Heffron.

The Kokoda Foundation wishes to thank the following organisations for their generous sponsorship, and their commitment to fostering innovative research and thinking on Australia's future security challenges.

ASC www.asc.com.au

babcock

FORGACS DEFENCE

PMB DEFENCE

SAAB

Ultra ELECTRONICS

Raytheon Australia

LOCKHEED MARTIN

WorleyParsons resources & energy

DEFENCESA

Foundation Sponsor

JACOBS

ABOUT THE AUTHOR

Brice Pacey is a private sector consultant with wide-ranging experience in defence and national security with appointments in the intelligence community, Army Headquarters, and the Australian Defence Organisation's Strategic and International Policy Division. He is a former strategic analyst at the Office of National Assessments and in the Directorate of Army Research and Analysis.

He has taught at a variety of academic and vocational establishments including the United States Army Intelligence Centre and School. In addition, he has held representational roles in Australia and the region, including in Australia's Embassy in the Philippines.

Following a 25-year military career, Brice spent several years in senior executive appointments and as a strategic and operational analyst in the private sector. He was a government adviser on military strategy and programs.

Brice is a graduate of Macquarie University, the Australian National University, and the University of Arizona. He is also an honours graduate of the Armed Forces of the Philippines Command and General Staff College, and a distinction graduate of the Royal Australian Navy Staff College where he won the Admiral Griffiths prize.

He was a founding director of the Kokoda Foundation, and established the Menzies Research Seminar series on Australian Security in the 21st Century, which delivers an occasional series of seminars on vital national security issues in Parliament House.

He has had papers published by the Strategic and Defence Studies Centre, the Menzies Research Centre and the Kokoda Foundation, and has had articles published in the Asia-Pacific Defence Reporter, the Canberra Times and the US Military Intelligence Journal. His recent projects include writing a history of the concept of national security for Australia's National Security College and a strategic planning task for the International Centre for Complex Project Management.

CONTENTS

INTRODUCTION

The balance of power in the Western Pacific and Indian Oceans is shifting in ways that are neither reassuring nor predictable. New powers are rising and new military technologies are being deployed by states whose long term intentions remain unclear. These are important developments that threaten to progressively erode the freedom of movement of Australian and allied naval forces and merchant shipping in the region.

In the lead up to the Defence White Paper planned for 2014, it may be necessary for Australian defence planners to reassess some of the assumptions underpinning Australia's operational concepts and force structure. It seems increasingly likely that a reinvigorated strategy will require a large investment in force elements which are not only potent, but also survivable in a potentially intense, complex and dangerous future maritime environment.

Submarines and their operations will be central to any viable strategy. Australia's 2009 Defence White Paper recognised this new reality by calling for a more capable submarine force as one of the capabilities necessary to establish sea control and to project force in Australia's maritime environment.

The military strategic concept embodied in the White Paper requires submarines to perform a wide variety of missions including the maintenance of freedom of navigation, protecting shipping, and supporting land forces. In addition, a future submarine force will require a capability to conduct strike operations against military targets including an adversary's operating bases, staging areas and critical military infrastructure.

The plan is to acquire a new force of twelve more capable submarines to replace the current fleet of six Collins Class boats. A fleet of this size has been calculated as necessary to maintain a force at sea sufficiently large to secure Australia's maritime interests during crises, possibly at considerable distances from Australia; and to protect and support other Australian Defence Force assets and missions. These include missions in which the stealth and other characteristics of modern submarines will be critical.

A larger and more capable submarine force will increase the complexities of planning military operations against Australia. It will also increase the investment in military capabilities that would be required for a potential adversary to be able to threaten, coerce or intimidate Australia, or impede Australia's freedom of action.

Current guidance will require a future submarine to possess the capabilities required for anti-ship and anti-submarine operations, with additional roles of strategic strike, mine warfare, intelligence collection and support for special operations.

This combination, together with the need to operate at a distance from Australia, is not available in any existing conventional submarine, and only the in-service Collins class comes close. A design to meet these requirements will involve a unique combination of range, endurance and stealth to operate over the distances inherent in Australia's strategic geography, and to exploit the strategic depth that it affords.

Australia has a unique level of access to advanced technology from Europe and North America, and significant experience in adapting and integrating critical design elements to a demanding maritime operating environment. The strategic importance of the submarine capability, the unique technological access and operational experience, and the need for secrecy regarding the fundamental design and performance, make a strong case for Australian industry involvement in the design, development and construction phases. This should continue through the sustainment and life-cycle of these boats, which will extend beyond the middle of this century.

The proposal is not without its critics.

Productivity Commission Chairman Gary Banks has argued that the Future Submarine program is 'low hanging fruit waiting to be picked as a means of cutting public outlays'. In a recent speech, he claimed that 'the case for Australia spending $36 billion or so on another dozen homemade submarines, when imported alternatives could be purchased for a fraction of the cost (and risk) has never been adequately explained.'[1]

1 Gary Banks 'Australia's Mining Boom—What's the Problem' in ***Conference Proceedings: The Australian Economic and Social Outlook Conference,*** Melbourne Institute, 30 June 2011.

Journalist Greg Sheridan has argued for greater capability instead of savings. Sheridan claims that Australia should use the '$40 billion' to buy or lease a fleet of nuclear-powered submarines to 'replace the calamitous Collins-class boats nearing the end of their working lives'.[2]

These claims cite a cost estimate by the Australian Strategic Policy Institute (ASPI). ASPI projected the cost of the Future Submarine to be a 'staggering' $3.04 billion per boat in 2009 dollars for a total of $36 billion.[3]

A decade of critical press has reinforced an image of 'Dud Subs'. Even as this paper was being drafted, the Collins Class Submarine Sustainment and Projects remained at the top of the Government's Programs of Concern,[4] and the Minister had commissioned a review of submarine sustainment.[5]

The purpose of this study has been to evaluate some of these criticisms and the misconceptions on which they are based, and to consider options for the shape, size and development of Australia's future submarine capability in light of the capability priorities identified in *Defending Australia in the Asia Pacific Century: Force 2030*, the Defence White Paper 2009.

The study is timely. The Australian Government has attached a high priority to the Future Submarine project, and will shortly make strategic decisions regarding the concept design and acquisition strategy, with important implications for Australia's future project management, industrial, and research and support capability.

2 Greg Sheridan 'Paralysed by Our Anti-Nuclear Hysteria' *The Australian*, 23 July 2011.
3 Sean Costello and Andrew Davies 'How to Buy a Submarine: Defining and Building Australia's Future Fleet' in *Strategic Insights* 48, Australian Strategic Policy Institute, Canberra, 29 October 2009.
4 Minister for Defence Stephen Smith and Minister for Defence Materiel Jason Clare 'Reforms to Projects of Concern' *Media Release* 187/11, 29 June 2011 < http://www.minister.defence.gov.au/2011/06/29/reforms-to-projects-of-concern> (accessed 7 November 2011).
5 Minister for Defence, Stephen Smith and Minister for Defence Materiel, Jason Clare 'Release of Terms of Reference for Submarine Sustainment Review' *Media Release* 24 August 2011 <http://www.minister.defence.gov.au/2011/08/24/minister-for-defence-and-minister-for-defence-materiel-release-of-terms-of-reference-for-submarine-sustainment-review> (accessed 7 November 2011).

But if a capability is to be delivered within the time-frames indicated by current guidance, the project has started to fall behind schedule. Furthermore, there has been some loss of public confidence in the capacity of the Australian Defence Organisation and industry to deliver and sustain a submarine capability following difficulties with the Collins Class submarine and a growing list of Defence programs of concern and procurement failures, some of which directly affect current submarine operations. This paper suggests options for dealing with these criticisms.

Primary Research Focus

The primary issues addressed by this study included:

- The strategic environment, with particular emphasis on the emerging maritime environment to Australia's north, and the potential risks to Australia's sea lines of communication and offshore resource industries.
- The unique demands of the Australian operating environment and the reasons that Australia will need a conventional submarine purpose designed for that environment, along with deep Australian involvement in the design, build, and through life support.
- The successes of and lessons learned from the Collins Class submarine project, which has provided Australia with the most capable conventional submarine currently in service.
- Options for project management.

Procedures/Scope of Work

The Kokoda Foundation Board appointed a Project Director to lead the research effort for the study. The Project Director:

- conducted background research on key issues and evaluated the available literature,
- established close links with key government and non-government stakeholders,
- conducted closed workshops to discuss key issues in depth, and
- prepared this report for publication as a Kokoda Paper.

The workshops involved well informed participants selected with the assistance of stakeholders. Each workshop was of four hours duration, and was scheduled to allow sufficient time for notes to be circulated and for participants to provide comments and corrections as appropriate. The Chatham House Rule applied, participants are free to use the information received during workshops, but cannot reveal the identity or the affiliation of the speakers.

Participation varied between workshops to ensure that the Foundation drew on the full range of expertise available within stakeholder groups. At each workshop, selected participants were invited to present a short working paper, followed by open discussion. Workshops were limited in size only to allow the full involvement of all participants.

The draft Kokoda Paper was the subject of a rigorous review and editorial process before publication. The paper canvasses a range of participant views on the future maritime environment, influences bearing upon the Future Submarine and *Force 2030*, and a range of options for acquiring that capability.

AUSTRALIA'S STRATEGIC ENVIRONMENT

The 2009 Defence White Paper established the capability requirement for the Future Submarine following a significant reappraisal of the strategic environment in the Asia-Pacific region. For the first time, an Australian Defence White Paper has explicitly recognised the dynamics of the regional security environment by establishing a rigorous program of periodic reviews.

Yet the strategic uncertainty that necessitates continuous re-evaluation also creates significant problems for defence planners seeking to advise governments on investments in defence capabilities that might be in operation decades into the future. Any assessment of the strategic environment in which the Future Submarine will operate will be particularly problematic, as the submarine is likely to be in operation well beyond the middle of the century.

Strategic uncertainty will have consequences for the number of the Future Submarines that will be required and for the rate at which they are produced. The design will need to be flexible in providing a range of military response options at short notice and adaptable to changes in the threat environment over time. This will have implications for volume, space, weight, power and cooling design margins.

Nevertheless, there are some enduring characteristics of the strategic environment and some seemingly durable economic and technological trends which should allow planners to establish a reasonable basis for planning.

This chapter identifies some of those aspects of the strategic environment about which defence planners can have some confidence, while suggesting the adoption of planning techniques that might assist in dealing with the residual uncertainty.

Importantly, these changes are occurring amid sharpened expectations of Australia's regional and global role and a growing recognition of Australia's alliance obligations. There is a growing will to invest in the capabilities required to meet new and emerging classes of threats that existing concepts, technology and machinery do not address.

The Regional Balance of Power in 2030

The period between 1999 and 2003 saw a transformation in Australia's strategic setting and international role. Australian contributions to the crises in East Timor, Afghanistan and Iraq were considerably greater than the purely symbolic contribution anticipated by defence orthodoxy from the mid-1980s to the late 1990s.

Australia has been gaining weight as a middle power, and demonstrating a willingness to use that weight in pursuit of wider security objectives through what has been called creative 'middle power diplomacy'. Following East Timor, Australian security constructs have expanded to include larger, and possibly leading roles in regional crises, stability operations and nation and institution building.

Australia has played a particularly important role in ensuring security in the South West Pacific, an area of fundamental strategic importance, through operations such as the ADF contribution to the Australian-led Regional Assistance Mission to the Solomon Islands (RAMSI). The mission is described as assisting 'the Solomon Islands Government in the maintenance of security, law and justice, economic governance and improving the machinery of government.'[6]

But the demands on Australia's maritime capabilities in the coming decades of the 21st Century will be even greater. The strategic environment in which *Force 2030* will be operating will be considerably more challenging than that foreshadowed by Australia's strategic planners in the closing decades of the 20th Century.

The 2009 Defence White Paper was drafted at a time when the regional strategic balance was already tilting in favour of the rising powers of the Western Pacific. Now, as planning is underway for the 2014 Defence White Paper, there is no longer any room for the equivocation of its predecessor.

An official review has been commissioned to assess the implications of a range of developments for the 2014 White Paper including

6 'Australian Operation in Solomon Islands' Australian Government, Department of Defence <http://www.defence.gov.au/op/solomonislands/general.htm> (accessed 7 November 2011).

the rise of the Asia-Pacific and the Indian Ocean rim as regions of global strategic significance. The vital issues of energy security and resource extraction in Australia's North West and northern approaches have been singled out because of the implications of new military capabilities in the region for *Force 2030*.[7]

At the global level, the United States is likely to remain the preeminent power well beyond 2030, in more dimensions and with greater reach than the emerging powers in the Western Pacific and Indian Ocean. Washington's well practised leadership, political and cultural appeal and unequalled military capabilities will continue to be supported by a flexible and innovative economy and deep reserves of human capital.

In contrast, at the regional level, the power balance in the Western Pacific is likely to be quite different from now. China's economy is likely to be larger than that of the United States, and considerably larger than Japan's. And while the United States' superior overall power will be spread globally, China's more qualified power will be focussed on the Western Pacific and Indian Oceans.

While rapidly growing trade with China is one of the factors that underpinned Australia's resilience in the face of recent global economic shocks, there is growing concern over unresolved ambiguities in China's strategic policies. This has been heightened by Beijing's occasionally threatening politico-military diplomacy towards East Asian states that are collectively just as important to Australia's economic well-being and with which Australia enjoys good relations.

Even if the current trajectory of the Chinese economy does not continue, and regional states continue to grow in confidence, China has embarked on the development of asymmetrical military capabilities which will be able to impede, and perhaps deter US

7 *The Australian Defence Force Structure Review* will "address the range of present and emerging global, regional and national strategic and security factors which require careful consideration for the future, including: the rise of the Asia-Pacific as a region of global strategic significance; the rise of the Indian Ocean rim as a region of global strategic significance; the growth of military power projection capabilities of countries in the Asia Pacific; the growing need for the provision of humanitarian assistance and disaster relief following extreme events in the Asia Pacific region; and energy security and security issues associated with expanding offshore resource exploitation in our North West and Northern approaches." in Stephen Smith, Minister for Defence 'Australian Defence Force Posture Review' *Media Release* MIN177/11, 22 June 2011, <http://www.defence.gov.au/minister/Smithtpl.cfm?CurrentId=12013> (accessed 7 November 2011).

air and surface deployments close to China. Chinese capabilities, including modern submarines and surface combatants, will have considerable influence in the Taiwan Straits, and importantly for Australia, the Straits of Malacca and the South China Sea.

Developments in Regional Military Capabilities

While this study does not seek to identify China as a military threat, it is important to recognise that the scale and sophistication of Chinese military modernisation is of a different order to programs in other regional states. Any balanced attempt to discuss developments in regional military capabilities will therefore dwell longer on Chinese capabilities.

For some time, China has been planning the development of a true power projection capability and the ability to conduct precision strike beyond the first island chain that bounds the maritime approaches to China. This strategy will rely on the conventional measures of maritime strength including large surface combatants and carrier borne aviation.

Towards this end, the People's Liberation Army Navy has begun sea trials with a former Soviet carrier, the extensively refitted Varyag, currently deployed with the northern fleet. It is also increasing its modern experience of distant deployments with welcome but cautionary contributions to anti-piracy operations off the coast of Somalia and ship visits to regional countries.

Notwithstanding the development of naval aviation and the potential that it has for power projection beyond 2030, it will be a generation before Beijing can rely on the conventional instruments of sea power to establish sea control along its maritime approaches. In the final analysis, as a continental power, China will need to develop a sufficient margin of superiority along extended and often hostile land borders before it can divert resources to support its maritime ambitions in the manner of the Western maritime powers.

Furthermore, the Chinese economy is not yet in a position to support the sustained investment that would be required for a blue-water fleet without diverting much needed resources away from the problems confronting civil society and more pressing domestic security concerns or peaceful programs designed to enhance Chinese prestige such as the Chinese space exploration program.

China's Strategy of Sea Denial

Nonetheless, China has demonstrated economic and technological expertise in developing a strategy of sea denial in the East and South China Seas by employing a range of asymmetric technologies and tactics, including:

- anti-ship ballistic missiles,
- anti-ship cruise missiles, and
- modern submarines.

Historically a continental power, China continues to attach a priority to insulating its land power from the maritime strengths of its strategic competitors on both sides of the Pacific, while maintaining a capability to project sufficient force to support its policy of coercive diplomacy towards Taiwan and the littoral states of the Western Pacific and South China Sea and to maintaining a sometimes fragile domestic consensus.

Furthermore, an effective sea denial capability is a persistent reminder to countries with overlapping claims in the South China Sea—Vietnam, Malaysia, Indonesia and the Philippines—of China's strategic potential, and undermines the credibility of any western naval security guarantees. China may already possess the ability to dominate the air over the Taiwan Straits.[8]

Anti-Ship Ballistic Missiles

There has been significant progress in the development of Anti-Ship Ballistic Missiles. Much of the information available in the public domain was published in March in the Annual Report to US Congress on the Military Power of the People's Republic of China 2009.[9] This added to evidence of capabilities implied by congressional testimony during 2008 and considerable speculation in open source literature including *Proceedings*, the journal of the US Naval Institute.

8 Sean Scrivener *Hot Air: Has China Finally Achieved Total Force Dominance in the Skies Over Taiwan*,' The Williams Foundation, December 2010 p 11.

9 The US *FY2000 National Defense Authorization Act (Section 1202)* directs the Secretary of Defense to submit a report "…on the current and future military strategy of the People's Republic of China. The report addresses the current and probable future course of military-technological development on the People's Liberation Army and the tenets and future development of Chinese grand strategy.

The main Chinese focus has been on the development of a maritime strike version of the CSS-5/DF-21 Intermediate Range Ballistic Missile. The variant in question, the DF-21D, is a truck mounted solid fuel rocket with a range of perhaps 1750 kilometres, although there has been speculation regarding similar missiles with greater range. Various reports suggest these are equipped with control surfaces for mid-course and terminal manoeuvring, and a form of terminal guidance and target recognition.

During a typical mission, the trajectory might be updated by strategic over the horizon radars and space based sensors before terminal guidance and automated target recognition is used to complete target acquisition. The likely targets are carriers, but the level of discrimination in the missile's terminal guidance remains uncertain.

The fully deployed force may consist of two or more brigades equipped with more than 200 launchers, enabling attacks in barrages. Based on open source estimates of the cost of individual systems, the total capital cost may be in the order of US$ 2 billion. This would represent a very cost-effective capability. By contrast, it might cost Beijing several more billion to deploy its single former Soviet aircraft carrier to sea with a full complement of aircraft, even without the other components of a carrier battle group such as escorts.

It now seems possible that the DF-21D has been deployed much sooner than had been expected. In an interview with an Asahi Shimbun journalist in December 2010, The Commander of US Pacific Command Admiral Robert Willard revealed that the anti-ship ballistic missile system in China has undergone extensive testing and has achieved an operational capability, although further testing is expected and none of the tests so far have been over water.

Neither the United States nor its allies have an anti-ship ballistic missile comparable to the CSS-5/DF-21 under development for the Second Artillery Force. A somewhat similar weapon to the CSS-5, the Pershing II, was abandoned with the signing of the Intermediate-Range Nuclear Forces Treaty between Washington

and Moscow in 1987[10], and exports of comparable systems are subject to the Missile Technology Control Regime.[11] But Beijing is a signatory to neither, although it arguably complies with the second. Notwithstanding the destabilising potential of the anti-ship ballistic missile system in the crowded waters of the East and South China Seas, there has been no public discussion of the possibility of limitation talks.

The progress in developing an effective anti-shipping capability should not be underestimated even though the Chinese literature on the subject is inconclusive and the level of operational capability has yet to be confirmed. Still, it can be inferred that the US Navy considers that the threat is sufficient to defeat all but Aegis equipped guided missile cruisers and destroyers.

As of the writing of this report, Australia has committed to building only three of these vessels, and none as yet are to be equipped with the SM-3 missile, which might form part of the defensive system against anti-shipping ballistic missiles.

There is a case for a fundamental review of any *Force 2030* elements requiring forward deployment within the range of theatre ballistic missiles being deployed within the region, including the surface combatant force and tactical fighter force and their bare bases in northern Australia.

Cruise Missiles

China's ASBM force is not the only, and may not be the most potent element in China's strategy of sea denial. The threat to surface combatants is not limited to the ballistic threat. Anti-ship cruise missiles already exist and have been widely deployed on

10 The Intermediate-Range Nuclear Forces Treaty (INF) is an agreement between the United States and the Soviet Union signed in Washington by U.S. President Ronald Reagan and General Secretary Mikhail Gorbachev in December 1987, and ratified the following year. The Treaty eliminated nuclear and conventional ground-launched ballistic and cruise missiles with ranges of 500-5,500 km. The treaty is formally titled *The Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles*.

11 The *Missile Technology Control Regime (MTCR)* was established in April 1987 to restrict the spread of unmanned delivery systems for nuclear weapons with a minimum payload of 500 kg and a minimum range of 300 km. In 1992 the scope was expanded to include unmanned aerial vehicles for all weapons of mass destruction. Membership has grown to 34 nations, with 3 additional nations committing to the guidelines unilaterally. The People's Republic of China is not a member of the MTCR. It has, however, agreed to abide by the original 1987 Guidelines and Annex, but not the subsequent revisions.

aircraft, surface and sub-surface combatants already deployed in the region.

For example, China now has four Sovremenny class destroyers each equipped with eight SS-N-22 Sunburn supersonic anti-ship missiles, and a dozen stealthy and capable Kilo class submarines armed with the SS-N-27 Sizzler anti-ship missiles.

Submarines

In addition to the deployment of these new asymmetrical technologies, there has been substantial progress across the region towards acquiring modern and highly capable conventional submarines, and increasingly sophisticated nuclear programs in China and India.

Figure 1. Sea Denial Capabilities. The People's Liberation Army's conventional forces are currently capable of striking targets well beyond China's immediate periphery. Not included are ranges for naval surface- and sub-surface-based weapons.[12]

12 Source: Based on 'Figure 2. The First and Second Island Chains. PRC military theorists conceive of two island "chains" as forming a geographic basis for China's maritime defensive perimeter' in Office of the Secretary of Defense *Annual Report to the US Congress on the Military Power of the People's Republic of China, 2009.*< http://www.defense.gov/pubs/pdfs/070523-china-military-power-final.pdf > (accessed on 10 August 2011).

Military Off-the-Shelf Submarines in Southeast Asia

	2010	Beyond 2025
Australia	6	12
Indonesia	2	12
Malaysia	2	2
Singapore	4	4
Vietnam	0	6
Thailand	0	?

Table 1. Submarine Operators in Oceania and Southeast Asia[13]

More positively, the acquisition of submarines by friendly states can also be helpful in strengthening regional resilience and providing opportunities for new areas of longer term cooperation. In the time-frame under consideration, new generations of submarines will be operated by Vietnam, Singapore, Malaysia and Indonesia.

- ***Indonesia*** Indonesia currently operates two HDW Type 209 submarines which have been progressively upgraded. There have been indications of interest in up to 12 submarines at some point in the future, although Jakarta has indicated that the fleet will be built at a rate the economy can sustain. An initial purchase of three 1400 tonne submarines is currently being negotiated with Korea's Daewoo Shipbuilding and Marine Engineering.[14]
- ***Malaysia*** The Malaysian Navy has recently taken delivery of two modern and very quiet Scorpene Class submarines from the Franco/Spanish DCNS/Navantia consortium.

13 The sources for submarine numbers in 2010 include Anthony H. Cordesman, Robert Hammons *The Military Balance in Asia, 1990-2010* Center for Strategic and International Studies, 3 January 2011 <http://csis.org/publication/military-balance-asia-1990-2010> (accessed 7 November 2011) . The main source for the projected number of submarines in 2025 is Mackenzie Eaglen and Jon Rodeback 'Submarine Arms Race in the Pacific: The Chinese Challenge to US Undersea Supremacy' in *Backgrounder* No 2367, The Heritage Foundation, 2 February 2010.

14 "Defense Minister Kim Kwan-jin is to visit Indonesia early next month to seal a $1 billion deal that would result in South Korea's first submarine exports. If the deal is secured, Daewoo Shipbuilding and Marine, which is likely to be chosen as the preferred bidder by the Indonesian government, will sign a memorandum of understanding to sell three 1,400-ton submarines to the Southeast Asian country." 'S. Korea close to clinching Indonesia submarine deal' in *The Korea Herald*, 26 August 2011 <http://www.koreaherald.com/national/Detail.jsp?newsMLId=20110826000596> (accessed 23 October 2011).

- ***Singapore*** Singapore has signed an agreement with the Swedish firm Kockums for the supply of two Archer Class submarines to replace two of the four much older Challenger Class submarines which entered service with Singapore's Navy in the mid-1990s. The Archer Class submarines have been modernised with improved sensors and adapted for tropical use, and will be the first operational submarines in Southeast Asia fitted with an air-independent propulsion system.
- ***Vietnam*** Vietnam has entered into a contract to buy six Kilo class submarines from the Admiralty Shipyards in St Petersburg. Ironically, the likely strategic intent is to offset superior Chinese surface forces, in much the same way that China is developing asymmetrical capabilities to neutralise the power projection capabilities of US carrier battle groups in the Western Pacific. This view is supported by the refurbishment of Cam Ranh Bay naval base and offers for it to be made available for use by the China's strategic competitors in the Western Pacific, including Russia and the United States.
- ***Thailand*** Thailand does not currently operate submarines, but has expressed interest in acquiring a submarine capability in response to regional developments.

Most of these submarines will be small off-the-shelf designs with limited payloads, range and endurance. Together with the limitations inherent in their designs, the relatively small number of submarines being acquired by Southeast Asian states will be insufficient for sustained power projection. They will, however, be useful to their parent navies for intelligence collection, limited maritime strike, and sea denial operations of a short duration within the confines of the archipelagic region, albeit with some considerable imposition on their overall resources.

They will provide their operating navies with opportunities to train with submarines, to develop doctrine and operating procedures, and to gain experience in anti-submarine warfare. Even in small numbers, submarines complicate the planning of any potential adversary, and greatly increase the cost of aggression.

Submarines add to the complexity of the undersea environment in the region, creating higher demands, not simply to detect, but to identify submarines, with significant implications for Australia's

Future Submarine and other elements of *Force 2030*. They have the capacity to threaten maritime traffic in the region, or even Australia's offshore resources, if there were unexpected political changes over the decades ahead.

Submarines in the Wider Asia-Pacific Region

	China	Japan	North Korea	South Korea	India	Pakistan	Taiwan	Russia (Far East)
Submarine, Nuclear								
Ballistic Missile	3							4
Attack	6				1			11
Submarine, Diesel							4	
Coastal			21			5		
Inshore				2				
Other	2							
ASW Capability	54	16	22	11	16	5	4	9
Total 2010	**65**	**16**	**43**	**13**	**17**	**5**	**4**	**24**
Projected 2025	**78**	**22**	**?**	**26**	**24**	**6**	**8**	**14**

Table 2. Submarine Forces of the Major Asia-Pacific Powers[15]

Developments in the wider region are more challenging again.

China

China has the largest submarine fleet in Asia, complementing developments in other asymmetric technologies. The underwater fleet currently consists of more than sixty attack submarines, of which six are nuclear powered. The most recent developments include:

- the replacement of older noisier and generally less capable

15 The sources for submarine numbers in 2010 include Anthony H. Cordesman, Robert Hammons *The Military Balance in Asia*, 1990-2010 Center for Strategic and International Studies, 3 January 2011 <http://csis.org/publication/military-balance-asia-1990-2010> (accessed 7 November 2011). The main source for the projected number of submarines in 2025 is Mackenzie Eaglen and Jon Rodeback 'Submarine Arms Race in the Pacific: The Chinese Challenge to US Undersea Supremacy' in *Backgrounder* No 2367, The Heritage Foundation, 2 February 2010.

submarines with growing numbers of very quiet modern diesel electric submarines of the Yuan, Song and Kilo Classes;

- the deployment of new nuclear attack boats of the Shang Class and ballistic missiles of the Jin Class; and
- the equipping of Chinese submarines with advanced torpedoes and long-range anti-ship cruise missiles, providing a potent surface warfare capability.

There have been some indications that a combination of Russian technology transfers and advances in Chinese submarine design capabilities will allow the development of submarines approaching the capable Russian Akula class in terms of quieting, performance, range and weapons.[16] However, there is also growing disquiet in Russia over allegations of Chinese industry copying weapons systems incorporating Russian intellectual property.

In addition, China has developed new supporting infrastructure on Hainan Island in the South China Sea, close to the vital sea lines of communications which carry a large proportion of China's energy supplies and raw materials.

East Asia

Japan and South Korea both operate fleets of modern conventional submarines, and have well developed plans for future growth. There are strong incentives for Australia to deepen naval and industrial ties with Japan and South Korea, and to explore options for increasing technical and intelligence exchanges.

- ***Japan*** Japan operates a modern submarine fleet of sixteen boats, the most recent of which are fitted with an air-independent propulsion system. There has been talk of increasing the fleet to twenty two. Japanese submarines are built in Japan to indigenous designs, and are well supported by industry policies that recognise that the submarine force is a strategic asset of national importance. The Japanese build program sustains a viable industrial base and enables continuous development to maintain a technological edge. This is an approach that could provide valuable lessons for Australia.

16 Richard D. Fisher JR, 'The Impact of Foreign Technology on China's Submarine Force and Operations' in Andrew S Erickson, Lyle J. Goldstein, William S. Murray and Andrew R. Wilson ed. *China's Future Submarine Force*, Naval Institute Press, Annapolis 2007.

- ***South Korea*** South Korea has a fleet of eleven modern conventional submarines, with plans to increase its fleet to twenty six over the coming decade. Following Japan's lead, South Korea is developing the industrial infrastructure required to design, build and sustain submarines. The export of submarines to Indonesia will be an important step towards achieving this ambition.
- ***Taiwan*** Taiwan has a fleet of two submarines, and has explored options for expanding its fleet to eight diesel electric submarines.

These are countries with which Australia enjoys strong economic ties, a mutual dependence on maritime trade, shared democratic values and a deep respect for the rule of law. Like Australia, they have a need to maintain a qualitative edge to balance the quantitative advantages of the emerging great powers in the region.

South Asia

There appear to be real prospects for Australia to deepen its maritime cooperation with India, a potential balancer to the strategic ambitions of East Asian powers. This is substantiated by the growing support for the new Indian Ocean Naval Symposium, modelled on the similar grouping that has been operating in the Western Pacific for some two decades. These Symposia provide a mechanism for regional chiefs of navy or other maritime agencies to consult on matters relating to maritime security with a view to arriving at agreed courses of action.

- ***India*** India is also increasing its submarine fleet of both nuclear attack and ballistic missile submarines, but at a lower rate than China. On the other hand, India has progressed much further in developing carrier borne aviation, perhaps reflecting its easier blue water access and more relaxed relationship with the United States.
- ***Pakistan*** Pakistan operates a fleet of small coastal submarines, but is in talks with China to buy six submarines to reduce the capability gap with India.

India's geostrategic and geo-economic strengths make it important for Australia to consolidate what has been an occasionally prickly and often undervalued relationship.

The United States

There can be a tendency for some commentators to prematurely write the United States out of the Western Pacific. Pessimistic assessments of US naval capabilities in the region often underestimate three things:

- the long-standing naval tradition and deep understanding of maritime affairs that will inform research, development and capital investment by the United States in maritime capabilities;
- the presence of major US allies in the region, notably Japan, Korea and Australia, all of which already have advanced naval capabilities of their own and are investing heavily in submarine capabilities; and
- economic, demographic and geographic constraints on any prospective peer or regional competitor in the first half of the 21st Century.

Furthermore, the United States has clearly reaffirmed its commitment to the Western Pacific, most recently during President Obama's visit to Australia. While US economic leadership may arguably be under some threat over the longer term, the United States retains much broader ideological and cultural appeal than any prospective competitor. For the most part, regional states are comfortable with US security guarantees and Washington's well practised leadership, and help keep the US engaged in the region by allowing the US Navy access to their ports and harbours.

Most accept that, for the foreseeable future, it will be US and allied naval power which will secure the sea lines of communication to vital energy and raw material supplies in the Middle East, Africa, South America and Australia.

Nevertheless, there is concern in the United States about the size and age of its submarine fleet and a relative decline in its underwater capabilities. Unless there is a change in US policy, the number of US submarines available for operations in the Western Pacific might decline over the next twenty years. Still, the reduction in numbers will be offset by a shift from 'platform intensive' to 'sensor rich' and networked underwater operations, a change that Australia is following with an active interest.

Implications

The recently released Chinese White Paper[17] conveys a willingness to collaborate and to develop confidence building measures in the region. There are a great many common interests including the security of the sea lines of communication. The free flow of trade between Australia and China is a shared interest that suggests an opportunity for constructive engagement.

Furthermore, the prospects for the peaceful resolution of unresolved sovereignty claims in the region remain strong. And there is a general regional hope that China will move to engage constructively in cooperative security arrangements.

But there are also deep concerns about Chinese strategy, including:

- the possibility that Beijing will make more muscular use of its growing military power; and
- the destabilising effects of the deployment of new asymmetrical sea-denial capabilities in the East and South China Seas.

There is a risk that Chinese technological and naval developments will undermine welcome diplomatic efforts aimed at presenting a peaceful and non-threatening image to the region and to the world.

As a consequence of these and other developments in regional military capabilities, there are now reservations about the ability of surface combatants to operate in the South China Sea, with the possibility of a credible sea denial capability being deployed within years rather than decades.

Of arguably greater concern is the possibility of the proliferation of anti-ship ballistic and cruise missile technology to a rogue regional state such as North Korea. If this were to occur, the lack of a comprehensive missile defence will prove to be a weakness in the Defence White Paper's *Force 2030*.

For middle powers such as Australia, the risk of approaching the East Asian mainland on the surface of the sea might soon prove too great to attempt during periods of tension or uncertainty. The risk might be reduced by fitting Australia's Air Warfare Destroyers

17 *China's National Defense in 2010*, Information Office of the State Council of the People's Republic of China 31 March 2011 <http://www.china.org.cn/government/whitepaper/node_7114675.htm> (accessed 7 November 2011).

with upgraded Aegis software and the version of the Standard Missile optimised for ballistic missile defence the, SM-3. But this is not yet planned.

US Defense Secretary Robert Gates recently provided support for this approach by stating that 'we now have proven capabilities to intercept ballistic missiles with land and sea based interceptors, supported by much improved sensors.'[18]

And doubts remain. Notwithstanding progress in theatre ballistic missile defence and cooperative engagement capabilities, recent developments in sea denial capabilities in the region have implications for *Force 2030* and the proposed Future Submarine.

It is now clear that submarines may be the only force structure elements capable of persistent operations in a maritime region that is fundamental to Australia's interests. In particular, submarines may be the only naval vessels capable of secure operations along the length of Australia's sea lines of communications, or interdicting those of prospective adversaries.

18 Secretary of Defense Robert Gates and Vice Chairman, Joint Chiefs of Staff Gen. James Cartwright *US Department of Defense News Briefing* 17 September 2009 <http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4479> (accessed 7 November 2011).

AUSTRALIA'S MARITIME ECONOMY AND JURISDICTION

Australia is a uniquely maritime nation in a region comprising large expanses of open ocean to the east, south and west, and a complex of archipelagic, island and littoral states to the north. The region to the near north contains the greatest cluster of strategically significant maritime straits in the world. Australia is not simply defined by oceans, they are central to Australia's cultural identity as well as providing a source of sanctuary and prosperity.

The United Nations Commission on the Limits of the Continental Shelf recently confirmed recognition of additional areas bringing the total under Australian maritime jurisdiction to 13.5 million square kilometres, the third largest of any nation. Furthermore, Australia has strong commitments to its regional neighbours, especially in the vast South West Pacific.

The extension of Australia's maritime jurisdiction has been described as a 'major boost to Australia's offshore resource potential'[19], confirming Australian rights to resources including oil, gas, and biological resources. But this may also be a development that Australia is not yet equipped to secure.

This vital contribution of the sea to Australian prosperity and cultural identity will be accompanied by significant challenges for maritime forces in the 21st Century. These challenges will be complicated by the developments in the strategic environment described in the previous chapter and sharpened community expectations that Australia's maritime forces will be able to operate anywhere within Australia's maritime jurisdiction with an appropriate level of force or restraint.

Yet few Australians have thought deeply about Australia's key maritime roles and tasks. This chapter examines the economic and legal implications of Australia's maritime jurisdiction for the maritime roles and tasks identified in current guidance, and the increased demands they will place on Australia's naval and border protection capabilities.

19 Martin Ferguson, Minister for Resources Energy and Tourism 'UN Confirms Australia's Rights Over Extra 2.5 Million Square Kilometres of Seabed' *Media Release* 21 April 2008. <http://minister.ret.gov.au/MediaCentre/MediaReleases/Pages/UNConfirmsAustralia'sRightsOverExtra25MillionSquareKilometresofSeabed.aspx> (accessed 21 November 2011).

Figure 2. Australia's Maritime Zones Map[20]

Australia's Maritime Economy

The economic contribution of Australia's maritime jurisdiction and the adjacent seas by way of trade and resource endowment underpins Australian prosperity and growing integration in the economic and cultural life of the broader Asia-Pacific region.

Australia relies on sea transport for 99% of exports by volume, while a substantial proportion of Australia's domestic freight is moved by coastal shipping. In 2009, a large proportion of Australian exports of coal and iron ore worth $70 billion were shipped through the international straits to the north of Australia to markets in East Asia.

20 © Commonwealth of Australia (Geoscience Australia) 2011, Geoscience Australia <http://www.ga.gov.au/image_cache/GA17424.gif> (accessed on 10 August 2011).

It is not simply the size of the contribution made by the maritime economy to Australia's wealth that is important, but also its distribution. Over 90% of Australia's liquid hydrocarbon and 74% of Australia's natural gas production occurs offshore. Of this, some 85% of the oil and 92% of the gas is located in the area bound by the three circles off the north western coast of Western Australia shown in Figure 3. Last year the exports of liquefied natural gas alone grew by 12% to exceed $10 billion for the first time.[21]

A single offshore resource development is sufficient to demonstrate the significance of the northwester maritime domain. The Greater Gorgon Area gas fields located 130 kilometres off the north-west coast of Western Australia are the centre of the largest natural gas project in Australia's history. During the first thirty years of the project Gorgon will provide a projected $64 billion boost to Australia's Gross Domestic Product and support employment of around 10,000 people during the peak construction period.[22]

A relatively short distance away, Shell is developing the world's first floating liquefied natural gas facility for operations in its Prelude gas field located more than 200 kilometres off the north-west coast of Western Australia. This facility alone will be able to meet all of Hong Kong's natural gas needs.[23] There are many similar resource projects either in development or production.

21 Martin Ferguson, Minister for Resources Energy and Tourism, 'Record Smashed for Resources and Energy Export Earnings' *Media Release* 15 September 2011 <http://minister.ret.gov.au/MediaCentre/MediaReleases/Pages/RecordResourcesEnergyExport.aspx> (accessed 21 November 2011).

22 'Gorgon—Its Time is Now' Chevron Australia website <http://www.chevronaustralia.com/ourbusinesses/gorgon.aspx#z> (accessed 7 November 2011).

23 "Floating liquefied natural gas (FLNG) is a revolutionary technology that will allow Shell to access offshore gas fields that would otherwise be too costly or difficult to develop. Prelude FLNG (100% Shell) is the world's first FLNG development" in 'Prelude FLNG—an overview' Shell website. <http://www.shell.com/home/content/aboutshell/our_strategy/major_projects_2/prelude_flng/overview> (accessed 29 September 2011).

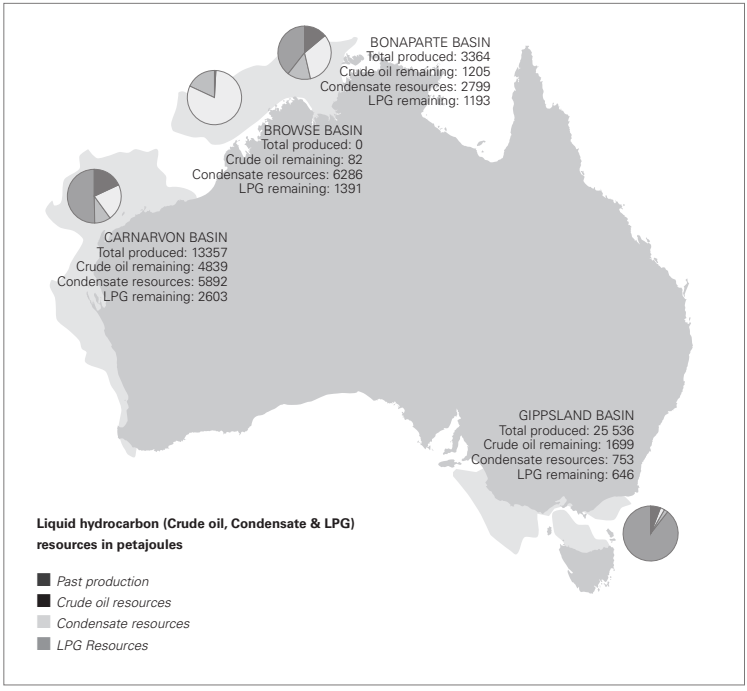


Figure 3. Australia's Liquid Hydrocarbon Resources[24]

Australia's Maritime Jurisdiction

Australia's maritime forces are required to operate in an increasingly challenging jurisdictional environment, not simply because of the size of Australia's maritime jurisdiction and its economic importance, but also as a consequence of changes to maritime law, in particular the 1982 United Nations Convention on the Law of the Sea (UNCLOS).[25]

24 Source: Based on map *Australian crude oil, condensate and naturally occurring LPG resources, infrastructure, past production and remaining resources* © Geoscience Australia. <http://www.ga.gov.au/energy/petroleum-resources/oil.html> (accessed 10 August 2011).

25 The Third United Nations Convention on the Law of the Sea (UNCLOS) is the international agreement that resulted from the third United Nations Conference on the Law of the Sea, which took place between 1973 and 1982. The Law of the Sea Convention defined the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for economic activities, the environment, and the management of marine natural resources. <http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm> (accessed 7 November 2011).

The conventions limit the activities, but not the movement of maritime forces through the region to Australia's north. They also impose considerable responsibilities within Australia's maritime jurisdictional zones. No other nation confronts a larger or more complex combination of littoral and economic zones. Furthermore, the growing complexity of international law means that while old tasks seldom disappear, new ones keep emerging.

Within this body of law and convention, there are provisions that apply specifically to submarines that are relevant to operations in Australia's maritime approaches and the archipelagic region to Australia's north:

- ***Innocent Passage*** Submarines exercising innocent passage through territorial seas are required to travel on the surface and to show their flag. Without prior approval, the collection of intelligence, the conduct of survey activities, or any exercise or practise with weapons of any kind would be considered to be prejudicial to the good order or security of the coastal state.[26]
- ***Transit Passage*** In international straits, all ships have the right of passage in their normal mode, including the right of submarines to travel submerged, although they must proceed without delay and refrain from any threat or use of force.[27]

A submarine passing through the straits that lead to Australia's maritime zones would be permitted by the conventions to do so submerged, and would only be required to surface within twelve miles of the Australia baseline, essentially the coast.

Australia's Maritime Roles and Tasks

Australia's strategic guidance uses the terminology in common usage in Western naval literature, in which the basic tasks of middle power navies are described as being to conduct sea control, sea denial and power projection missions:

- ***Sea Control*** Sea control is the ability to use the air and sea for friendly purposes, and to deny that use to an adversary. It is generally limited in time and space, often in terms of a specific operation or campaign.

26 UNCLOS Article 20.
27 UNCLOS Article 38 and 39.

- ***Sea Denial*** Sea denial is a related but more restricted concept in which an adversary is denied the ability to use an area of the sea for his own purposes for a period of time. But it does not imply the unrestricted use of the sea for friendly forces, and it does not ensure the safe conduct of trade and other economic activities.
- ***Power Projection*** The ability to deliver force from the sea is called power projection, and it represents a particular objective of sea control. The level of power can be implied or threatened, as well as asserted. Used skilfully, power projection can be a major source of persuasion against littoral states.

Maritime forces are highly versatile elements within the total force that have a unique range of applications over a wide span of operations, commonly falling into one of three roles.

- ***Diplomacy*** Diplomatic tasks derive to a large extent from the instrumental value of naval forces. Navies can exercise freedom of navigation to achieve a presence denied armies and air forces in situations short of war. They can be used for strategic objectives ranging from coalition building to coercion in ways denied to land power other than in the case of contiguous states. Naval vessels are also emblematic of the wealth and technological achievement of their flag nations.
- ***Constabulary Operations*** Constabulary operations are those that operate within a framework provided by Australian domestic and international law. They encompass defence force aid to the civil power and community, border protection, environmental and resource management and protection, anti-piracy operations, disaster relief fisheries protection and quarantine operations and search and rescue.
- ***Warfighting*** As is clear from the 2009 Defence White Paper, high-end warfighting continues to be seen as the core task for the Navy, and that submarines will play an increasing role in defining Australia's maritime capability. It is the capacity for operations at the more demanding end of the conflict spectrum, both real and perceived, that underpin a navy's effectiveness in less demanding diplomatic and constabulary tasks. The utility of submarines varies across this continuum.

Defence White Paper Roles and Tasks

The 2009 Defence White Paper reflects a bipartisan consensus that the primary obligation of the Australian Defence Force is to deter and defeat attacks on Australia. In addition, there is a strong consensus on the need to shape the future security environment and to be able to respond to a range of possible crises.

The strategy is described as 'a fundamentally maritime strategy, for which Australia requires forces that can operate with decisive effect throughout the northern maritime and littoral approaches to Australia, and the Australian Defence Force's primary operational environment more generally.[28]

The strategy is 'a proactive one in which' Australia seeks 'to control the dynamics of a conflict, principally by way of **sea control** and air superiority, and also by defeating hostile forces in their bases, in staging areas, or in transit.[29] **Sea control** is a precondition for a range of typical contingencies requiring amphibious or sea-lift operations. In some politically or militarily unstable environments, sea control might even be required to perform humanitarian missions.

Where necessary, Australia will use **power projection** in the form of strategic strike, naval blockade and land operations along the maritime approaches in support of that strategy.

Beyond this high-end requirement, the 2009 Defence White Paper requires forces appropriate to a full range of **constabulary** and **diplomatic** functions, including domestic security and emergency response efforts. Some of these roles will involve the provision of support to other services and agencies.

The utility of submarines in the maritime security environment of 2030 derives in large measure from the sea control and power projection roles and tasks that they can perform at the high end of the capability spectrum in support of Australia's national interests during periods of tension or war.

28 *Defending Australia in the Asia Pacific Century: Force 2030: Defence White Paper 2009* Department of Defence, Canberra 2009 < http://www.defence.gov.au/whitepaper/docs/defence_white_paper_2009.pdf> (accessed 7 November 2011).

29 Ibid.

Submarines have fewer applications in constabulary and diplomatic functions. But there are some areas where submarines might have particular value, such as special recovery operations required following, for example, a terrorist attack on an offshore facility or an act of piracy. And the possible presence of an advanced conventional submarine, unseen and unheard, can have a psychological effect that more transient force structure elements such as aircraft cannot match.

The Implications of Australia's Maritime Economy and Jurisdiction

The economic benefits of Australia's maritime trade and industries are welcome as a source of prosperity for Australia and an assured source of energy and raw materials for the growing economies of the region.

But Australia's security situation has been made more demanding by the location of those resources in close proximity to waters requiring effective constabulary operations at one end of the spectrum, and substantial warfighting capabilities to deter aggression at the other end.

Such demands have been heightened by the growth in regional capabilities that will bring Australia's offshore resources within the range of asymmetrical capabilities such as new generations of theatre ballistic missiles as well as the more conventional measures of naval power, particularly submarines.

In this environment, Australian surface combatants will continue to have important roles in securing maritime trade and resources because of their versatility. But submarines will have a vital role because of their survivability.

Concerns about the size of the investment required to develop and maintain the Future Submarine capability must be weighed against the immense value of the Australian maritime economy and resource endowment that the Future Submarine will help secure.

AUSTRALIA'S CAPABILITY REQUIREMENT

The rapidly shifting balance of power in the Western Pacific and Indian Oceans, Australia's maritime geography and a growing maritime economy mean that the security of Australia's maritime jurisdiction and trade routes are vital national interests, the security of which can no longer be taken for granted.

This chapter examines the roles and missions of the submarine in Australia's future maritime strategy, and their implications for the capabilities that will be required from the submarine with a particular emphasis on the difficult issues of range, endurance, missions and cost.

There are compelling reasons why submarines can be found at the heart of 21st Century naval modernisation programs, and will be a significant component of Australia's *Force 2030*. Submarines exploit the cover that can be provided by the sea to conduct a wide variety of covert operations ranging from intelligence collection to strategic strike. Submarines are capable of launching attacks on surface ships or land targets with little or no warning, closing ports with sea mines before slipping away unnoticed or inserting special forces as part of wider joint force operations.

Even the implied threat of a submarine's presence can have a disproportionate effect on the operational behaviour of an adversary or an opposing commander's allocation of resources to tasks. Any littoral state with a modernising economy integrated with the global economy will consider investing in submarines as part of its naval force, as is evident in the increased number of submarine operators in the Western Pacific and Indian Ocean.

A submarine operating independently has the potential to be disruptive, but submarines can only be decisive when operating as part of a balanced force within a coordinated network of command, control, communications and intelligence systems and with a full range of logistics support.

Submarines have a particular value as they may be the only element of *Force 2030* that has an assured operating capability throughout Australia's maritime jurisdiction and along the sea routes so vital to Australia and her trading partners. As such, they are an indispensable component of any viable maritime strategy for Australia.

Submarines are classified according to their propulsion system and armament, although the distinctions are becoming blurred with the development of new technologies. There are currently four main type relevant to this study:

- Diesel Electric Submarines (SS and SSK),
- Nuclear Powered Attack Submarines (SSN),
- Guided Missile Submarines (SSG and SSGN), and
- Nuclear Powered Ballistic Missile Submarines (SSBN).

Propulsion

Conventional submarines have electric drive systems powered by batteries. The batteries are recharged, perhaps daily, by diesel generators drawing atmospheric oxygen through a snorkel, in a process commonly referred to as snorting. The electric propulsion system enables diesel electric submarines to be extremely quiet when submerged and operating on their stored battery power.

But the requirement to regularly recharge batteries introduces a number of vulnerabilities that can be exploited by anti-submarine warfare forces, not the least caused by exposing the snorkel to anti-submarine sensors and the machinery noise of the diesel generators themselves.

The requirement to snort during long ocean passages is particularly hard on diesel engines, and has adversely affected their reliability in Australian service. Because Australian submarines transit long distances, the resolution of this problem is an engineering challenge that Australia has a particular motive to solve.

Methods for quieting the diesel generators and improving their reliability will have important implications for the overall submarine design, and will need to be considered early in the design process. This would best be achieved through the use of a propulsion test facility, as a risk mitigation measure to resolve issues well before a propulsion system is installed in a first of class Future Submarine.

Improving battery technologies such as those being developed for electric automobiles might improve submerged speed and endurance. But there are problems of cost, safety and heat dissipation that need to be overcome before the use of newer battery technologies becomes widespread. The choice of battery type will also need to be made early in the design process because of its design implications.

In contrast to conventional submarines, nuclear submarines can generate power while submerged, and only need to operate close to the surface for brief periods to allow high bandwidth communication or for the operation of some sensor types. This provides nuclear boats with their main advantage, their capacity to continue operating at high speed for extended periods of time while remaining submerged. In contrast to conventional boats, nuclear boats also have the advantage of abundant electrical power which gives them a greater capacity to operate sensors and digital signal processing equipment.

Nuclear propulsion comes at the cost of some radiated machinery noise, although the latest designs are almost as quiet as the best conventional boats, without the risks of detection inherent in the requirement to periodically recharge batteries through snorting.

The increased costs of nuclear submarines, thought to be perhaps 30 or 40% higher than conventional boats, might partially be offset by the smaller numbers that are required because of their advantages of speed and endurance. But these efficiencies arguably accrue only to states with nuclear industries and investments in the infrastructure required to support nuclear propulsion. These are assets unlikely to be available in Australia for at least the next generation of submarines. For Australia, the life-cycle cost of a nuclear submarine fleet would place significant pressure on other elements of a balanced force.

Conventional submarines with air-independent propulsion enjoy similar advantages to nuclear submarines when on station, operating at slow speed for long periods without the need to snort.[30] The air-independent propulsion can generate something of the order of ten times the energy that can be stored in a battery, allowing conventional submarines to remain submerged on station, for perhaps weeks rather than hours or days.

The power provided by an air-independent propulsion system is still limited, and is not used for transiting at higher speeds. Because air independent propulsion is a supplementary rather than a primary

30 The term air-independent propulsion means generating electricity for storage in batteries or the provision of power for propulsion and 'hotel services' without the need to 'snort'. The power supplied might be sufficient for patrol speeds, but not transit speeds, so air independent systems are used as a supplementary rather than as a primary source of power.

source of power, it increases the size, weight and complexity of a submarine, and may need specialised facilities in port for refuelling.

Armament

The combination of stealth with the ability to deploy its armaments with little or no warning makes the submarine an extremely effective platform. Submarines are fitted with armaments for one of two main roles, a tactical role that includes attacks on naval surface and submarine targets, or a theatre or strategic role involving the delivery of cruise or ballistic missiles.

For the tactical role, attack submarines have traditionally been fitted with torpedoes to allow them to neutralise or attack the naval forces of an opponent. In a blurring of what was once a clear distinction, attack submarines are increasingly able to launch cruise missiles for attacking targets on the surface of the sea and on land, contributing to broader theatre operations.

The strategic role of ballistic missile submarines derives from their ability to carry submarine launched ballistic missiles, commonly nuclear armed. For those great powers with a variety of nuclear delivery systems, ballistic missile submarines form part of the reserve of nuclear forces in order to provide an assured second-strike capability.

This is because their ability to hide increases the chance that they might survive an otherwise disarming first strike by an adversary, thereby increasing the range of available retaliatory options. In order to further increase the chance of surviving a first strike, ballistic missile submarines operate deep in the open oceans, or in bastions which friendly forces attempt to deny to their adversaries during periods of tension or conflict.

The power, reach and survivability of submarines, particularly those armed with cruise or ballistic missiles, make them an ineluctable factor in the calculation of the strategic weight and influence of states. The emergence of new operators with increasingly capable submarines is a major complication in the maritime environment of the Indian Ocean and Western Pacific.

Submarines are widely considered to be the most potent platforms in modern anti-submarine warfare systems, as they are designed to operate quietly in the same underwater environment as their

targets. The key to their success is their ability to maintain a relative noise advantage over potential adversaries, through the extensive use of measures designed to absorb, isolate, or suppress sources of noise. A modern conventional submarine should have a lower noise signature than a nuclear powered submarine.

Stealth

Conventional submarines can exploit the relative advantages of stealth and quietness to be highly effective when operating in a complex littoral environment, or in maritime choke points such as straits. Conventional submarines fitted with air-independent propulsion can remain submerged on task continuously for weeks in these high intensity roles and missions. Still, conventional submarines generally need to operate at slow speeds if they are to maintain their advantage of stealth over extended periods. And their slow transit speed limits their effectiveness in blue water or for operations at long distances from their bases.

The submerged speed and endurance of nuclear submarines offer significant advantages, particularly in blue water operations and when transiting. While nuclear boats can also reduce their signature by operating at slower speeds, sustained high speed operation does not require them to regularly risk ascending to snorkel depth to recharge batteries.

The difficulties of detecting, tracking and destroying submarines remain immense, and the likelihood of locating them once they leave their port of origin declines quickly. Therefore, pre-emptive attacks on submarine bases, communications and maintenance facilities are likely to be part of an anti-submarine warfare plan during conventional conflict. This has implications for the characteristics and the operations of submarines themselves.

The incentives to attack supporting ports and infrastructure has important consequences for the use of Australia's strategic geography, suggesting that it would be prudent to continue holding key strategic infrastructure well to the south, including the bases and industrial support used in the Future Submarine program.

Australia's strategic geography also provides some obvious options for preventing hostile submarines from entering Australia's maritime jurisdiction. Quiet conventional submarines have a particularly

important role to play in these sorts of operations, complemented by maritime patrol aircraft and remote sensors and systems. The number of concurrent activities that might be required for these operations will influence the number of submarines required for *Force 2030*.

The Implications of Current Guidance

The special characteristics of modern submarines have led to a renewed emphasis on submarines and anti-submarine operations. Australia's current strategic guidance recognises the possibility that in some unlikely but highly consequential future scenarios, Australia could be subjected to raids against offshore facilities; the mining of ports and maritime choke points; and threats to or harassment of critical shipping between Australia and its trading partners. All of these might be closely associated with hostile submarine operations in Australia's maritime approaches.

Separate studies commissioned by the Australian Minister for Infrastructure and Transport suggest concern about the possibility of terrorist activity directed against offshore facilities.[31] By implication, special recovery operations by Special Forces should be added to the list.

This has led to a view that an expanded submarine fleet will be required to sustain a force at sea large enough in a crisis or conflict to be able to defend Australia's maritime approaches and sea lines of communication, often at considerable distances from Australia, to protect and support other defence force assets, and to undertake a range of strategic missions where the stealth and other operating characteristics of modern submarines would be crucial.

A larger submarine force is expected to significantly increase the military planning challenges confronting a potential adversary, and increase the size and cost of the force they would have to commit to attack Australia directly, or coerce, intimidate or otherwise employ military power against Australia.

31 "In response to the growing threats from international terrorism and piracy, the Gillard Labor Government has commissioned the first ever comprehensive review into the security of our nations offshore oil and gas facilities" in Anthony Albanese, Minister for Infrastructure and Transport 'Inquiry into the Security of the Offshore Oil and Gas Sector' Media Release: AA012/2011, 1 February 2011 <http://www.minister.infrastructure.gov.au/aa/releases/2011/February/aa012_2011.aspx> (accessed 26 September 2011).

The Future Submarine is currently planned to be capable of a range of tasks including anti-submarine and anti-surface ship warfare; mine detection and mine-laying operations; intelligence collection and gathering battlespace data in support of operations; supporting special forces including infiltration and exfiltration missions; and strategic strike.

The long transits and potentially short-notice contingencies in Australia's primary operational environment demand high levels of mobility and endurance in the Future Submarine. The boats need to be able to undertake prolonged covert patrols over the full distance of Australia's maritime approaches and jurisdiction and during more distant operations. They will require low signatures across all spectra, including at higher speeds.

The Characteristics Required in an Australian Submarine

A sensible shift from continental to maritime defence and from sea denial to sea control has significant implications for the capabilities sought in Australia's Future Submarine. Not just any submarine will do.

Australia is Different

The challenges posed by Australia's large maritime jurisdiction and the growing contribution to the economy of resources sourced from or transported over the sea are immediately apparent when a map of Australia is superimposed over a map of Europe. This provides a better understanding of the environment for which the conventional off-the-shelf solutions sourced from Europe are designed, and why they will be found wanting in the Australian operational environment.

Figure 4. Map of Australia Superimposed over a Map of Europe

Not only are the transit distances and patrol areas much greater in the Australian environment, but the sea states commonly encountered in Australia's maritime approaches create difficulties for submarines not designed for snorting in rough seas, and not adapted to operations in warm waters. Together, these factors mean that in a submarine designed for Australia service, size matters.

Size Matters

There are many influences on the size of a submarine, but in Australia's case, the dominant ones relate to range and endurance. In general, a greater range requires the carriage of more fuel which, in turn, requires a larger submarine. Range and endurance are, however, subjects about which it is easy to be inadvertently or deliberately misled. There are several reasons for this:

- Range is highly dependent on speed. An approximately square law dictates that the rate at which fuel is used increases much faster than the rate at which speed increases.
- Range is at least as dependent on the 'hotel load', the power used by the platform to support the crew, sensor and weapons systems.
- Range can be reduced significantly by standard operating concepts and procedures that require a fuel reserve at the end of a mission (typically 30%).
- The real range is often regarded as classified or at least commercial in confidence.
- The effective range may be limited by endurance rather than fuel capacity. The limiting factor might be the stores carried for the crew, especially if very low speeds lead to long missions.[32]

It is clear is that competent submarine design is a zero-sum or balancing game. If a submarine is designed to have a range that is longer than normally expected for a given size, some other characteristic of the submarine will need to be sacrificed.

32 Some of the more ambitious ranges claimed for smaller conventional submarines require transit speeds slower than the speed at which sixteenth century sailing vessels operated along Australia's Indian Ocean approaches, at a time when a voyage from Europe to Australia's west coast took more than six months.

Typically this will be the weapon load, in which case capability is compromised, or hull structure, in which case the deep diving depth or shock resistance will be reduced.

It might also be necessary to reduce the crew size, in which case more subjective measures of endurance and opportunities for training will be compromised. Submarines from an earlier era like Australia's Oberon Class had a high range relative to their size, but had very low hotel demands as they had few power-hungry electronic systems. The submarines of that era had relatively large crews, but the habitability standards of the day were much lower than would be acceptable today.

There is a great deal of open source data available on this subject. But the readily available data requires expert interpretation to weigh market driven distortions and security driven misinformation programs.

Considerable effort has been made to develop reliable and comparable figures for the purposes of the Kokoda study. In order to gain some sense of the range and endurance figures claimed for different submarines, data has been collected from the public domain for several modern designs. The data was normalised to reflect the range when snorkelling at ten knots using the square law relationship. Some missing data items were then interpolated on the basis of reasoned judgement.

The data was then plotted as a radius of operation for a standard mission; in order to calculate the distance the submarine can transit to a patrol area, maintain a patrol at low speed for fourteen days and then return without any external support. The radius of operations might typically be something of the order of forty per cent of the quoted maximum range. These figures might be considered modest for submarines operating in the Australian maritime environment.

The following graph shows the results of this data collection for fourteen different submarine designs plotted against the most meaningful measure of submarine size, surfaced displacement. The linear best fit (the black line) clearly shows the overall trend, that larger submarines have a greater range. The spread of points shows that submarine designers make just the sort of trade-offs discussed. For example, one medium sized submarine with a very long range also has the lowest steel weight and a relatively small crew.

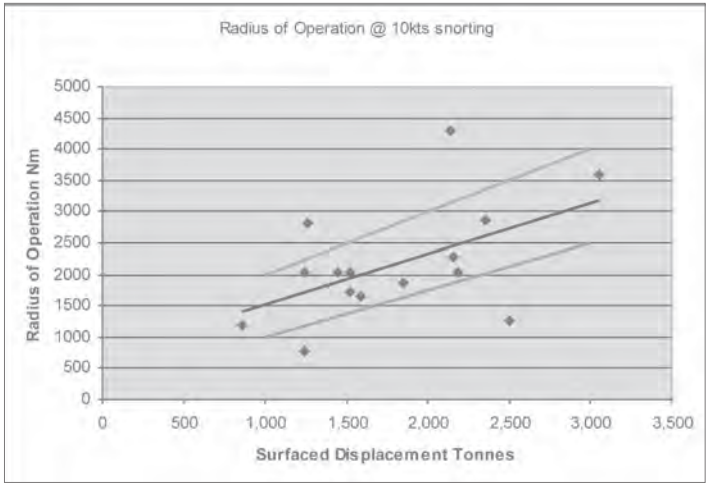


Figure 5. Open Source Data for Radius of Operation of a Conventional Submarine

The graph also depicts the upper and lower limits for typical submarine designs (the upper and lower lines). Designs which fall within this range will meet most of the typical requirements for shock resistance, diving depth, crew size and comfort, and weapon load. These upper and lower limits were used in developing Figure 6, which depicts the potential operating areas for a submarine operating out of *HMAS Stirling*, the Royal Australian Navy's primary base on the west coast of Australia, near Perth.

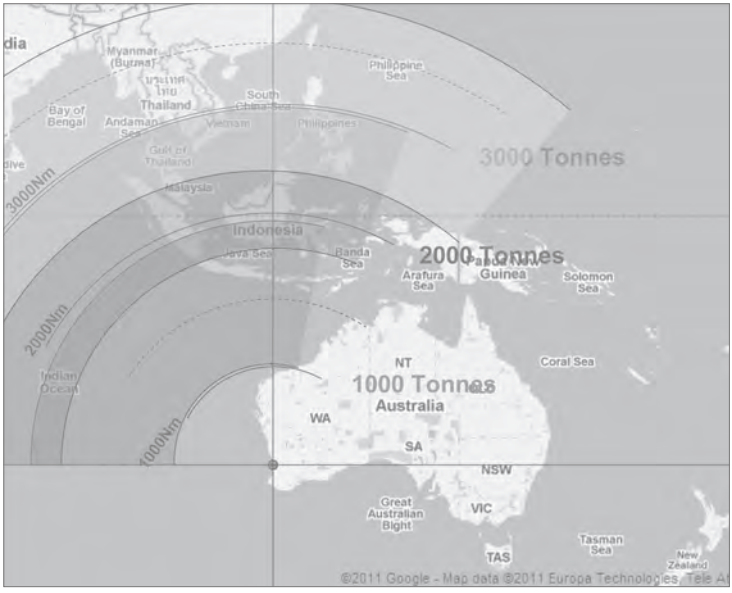


Figure 6. Maximum Area of Operation for Typical 1000, 2000 and 3000 tonne Submarines

Payload

One of the pressures on the size and cost of the Future Submarine will be the expanded roles required by *Force 2030*. Of these, anti-surface warfare and anti-submarine warfare must remain priorities as core roles for the platform. The other roles required by current guidance, mine warfare, intelligence collection, support to special operations and strategic strike, are necessarily secondary, as they cannot be performed in the absence of the weapons required for self-defence and sea control missions for securing Australia's maritime geography and economy.

Consideration will also need to be given to the increasing role of off-board sensors and systems such as autonomous and remotely piloted vehicles. While these might once have been delivered through the torpedo tubes, there are mature systems for carrying and deploying a wider variety of payloads that are the subject of ongoing feasibility studies. However, these will need to be evaluated against constraints inherent in conventional submarines.

Habitability

It is also easier to improve the habitability of a larger submarine, in which a crew might typically be confined for missions measured in months rather than days or weeks. This will be necessary to reach contemporary expectations or standards, as an aid to increasing the attractiveness of submarine service.

Engineering Margins

Strategic uncertainty during a long service life means that the submarine must be able to be adapted to changes in technology or the threat environment. Space is at a premium in any submarine, but it is easier to obtain the engineering margins or reserves required to adapt or modify the submarine while still in the concept or design stage. The areas where margins or reserves will be required include volume, space and weight, cooling and power for the full service life. This is a dimension of an assessment of value for money that is often overlooked.

Numbers Count

The number of submarines required to deliver the effects required of *Force 2030* will be determined by four basic factors: the number of different roles and tasks (flexibility), that have to be performed at the same time (concurrency), the level of continuous presence required for some roles and tasks (persistence), and the number of submarines required in the total fleet to ensure the availability necessary to achieve the required number of concurrent activities for the duration required (availability).

Understandably, there is very little detail in the public domain about precisely what the Future Submarine will be required to do. Even the obvious primary role of sinking ships and submarines will vary according to the nature of potential adversaries, their capabilities, and their port of origin.

Some things, however, can be surmised. *Force 2030* will be a much more rounded force than that at sea today. The addition of the Canberra Class Amphibious Ships will be particularly welcome for responding to contingencies ranging from disaster relief to expeditionary warfare. Given the nature of the emerging threat environment and the deployment of modern conventional

submarines by potentially unstable regional states, it would be prudent to ensure that any future expeditionary task group deployed within the region is protected by at least two submarines.

These could conceivably be deployed forward of the task force in time and space, each in turn moving forward at speed before stopping and listening to deter or destroy surface or sub-surface threats. An alternative scenario might seek to maintain a persistent presence in the planned area of operations, and at critical points along the route, involving perhaps three or more submarines.

Alternatively, there may be a requirement to monitor the movements of submarines seeking to exploit the right of transit passage through the international straits in the region leading to Australia's maritime jurisdiction, requiring three or more submarines. Perhaps there will be a requirement to persistently monitor developments in an area of interest at a distance in the region, requiring a submarine in the area or operations at all times, and therefore two additional submarines, one in the process of deploying or relieving, and one preparing to deploy.

In a complex future maritime crisis, it is likely that more than one of these types of activities will be required concurrently, allowing a simple calculation of the size of fleet required to sustain the number of submarines available at short notice (i.e. submarines not undergoing essential maintenance).

One method available is to calculate a working ratio, the number of platforms required in the fleet to ensure that one is available at any time. Comparable navies, including the UK, US and French, operate on figures of perhaps four to one with four submarines required to guarantee one continuously at sea. It might be possible to maintain working ratios as high as two to one for short periods.

If this were applied to the *Force 2030*, twelve submarines would be able to provide three submarines continuously at sea, six with some notice, and perhaps nine with some limitations and consequences for maintenance over the longer term. This is a sufficient force to complicate the planning of any adversary.

The final number should be calculated on the basis of strategic necessity, a number which is likely to change as we move towards *Force 2030* in a rapidly changing regional security environment and growing maritime economy.

Once the number of submarines has been determined, industry should be engaged in discussions about the establishment of a durable submarine enterprise capable of delivering and sustaining them. It would be most unwise to determine the submarine fleet size on the basis of requirements to sustain an industrial base, because in all probability, that base will be built on economies of scope, not scale.

Implications

This analysis provides strong evidence that a submarine of more than 3,000 tonnes will be required to meet the core functionality required of the Future Submarine. Additional roles, missions and characteristics, such as the desire to maintain a strategic edge and to operate 'at a distance' would suggest a final design that will be larger again, although not necessarily in excess of 4,000 tonnes as some commentators have argued.

Importantly, the broadly similar requirements for the Collins Class drove Kockums, accustomed to designing small submarines, and understanding all their advantages in cost and stealth, to implement a 3,000 tonne design. Experience has shown that decision to have been correct.

If the requirement is to have a greater payload, to enable a land attack role for example, then a larger submarine will be required to reach the required operating areas and deliver this payload. But these additional requirements need to be subject to rigorous analysis because of the implications for cost and technical risk.

Price

It is difficult to conduct an informed debate about the Future Submarine in the absence of credible cost estimates for the available options. Governments need to know what equipment might cost long before programs are precisely defined and scoped.

There are many unknowns confronting any attempt to cost the ADF's planned Future Submarine at this time. The capability requirement has yet to be specified in all of the necessary detail, although the characteristics of the submarine required to perform its White Paper roles and tasks and the solutions are generally understood by submarine builders.

The most accessible methodology for forecasting the cost of the Future Submarines at this stage is to use historical data. A great deal of work is required to ensure that historical data is reasonably comparable across different projects, time, countries and economic conditions. The data must be harmonised for variables such as exchange rates, labour and materials inflation, different approaches to reporting military expenditure, and cost escalation due to changes in size and of course capability.

There have been some preliminary attempts by commentators to forecast the cost of the Future Submarine which have had some significant limitations. More accurate and up to date estimating models exist within industry. They recognise that submarine prices are driven by numerous factors when viewed over a long period of time. Some factors have an approximately linear effect whilst others have a significantly nonlinear effect. Many adjustments must be made to arrive at a reasonable set of historical data with an equivalent current price, and the data must be separated into comparable subsets.

For the purposes of the Kokoda study the requirement has been to make reasonable cost comparisons and to forecast the price of building a submarine today in terms of a commercially complete 'sail-away' cost for small batches or flights of submarines. Sail-away costs do not include project overheads or extras such as infrastructure. The key driving factors include:

- Continuous Factors. These factors have a relatively linear effect and so may be applied to normalise cost factors over time within like-for-like data subsets. Factors include labour inflation, materials inflation, currencies, size parametric and hull types (double, single).
- Transitional and Disruptive Factors. These factors drive the need to separate historical data into like-for-like subsets. They can have a radical effect on cost. They can involve changes in design (submarine architecture, stealth, and safety), paradigm shift in technology (software intensive electronic systems), construction methods, national economic factors (western versus eastern economies, periods of hyperinflation), and large batches versus small batches (for example: 50-100 units in World War II era versus 2-6 units in the modern era).

- Commercial Completeness Factors. These include insurance, warranties, commissions; royalties, offsets and subsidies and are significant cost items often not properly accounted for. These factors can vary significantly between projects for parent navies and projects for export.

Figure 7 (on page 50) is derived from historical cost data for over 40 western projects delivering some 350 conventional submarines larger than 1,400 tonnes (surfaced) since 1920. The costs are per metric tonne for single hulled submarines in current (2011) dollars.

The most conspicuous feature of the chart is the rapid rise in cost density of submarines across the 1970s to the 1980s. This transition era saw tremendous changes and new developments in the architecture, redundant systems, technology and capability of conventional submarines.

The *modern era* conventional submarine is more complex, subtly different in architecture and structure, stealthier, safer, and packed with software intensive electronic war fighting and ship control systems.

The effect of these radical changes has been to make it difficult or impossible to compare cost data from earlier eras with cost data from the *modern era*, thereby substantially reducing the useable dataset. There is, however, sufficient data available from the 1980s onwards (20 build projects and over 80 submarines) to provide a basis on which to model costs with some confidence.

The figure also shows that the Collins Class submarines entered near the start of the *modern era*. The Collins class provides a key calibrating point, as the costs have been documented in detail and are well understood within the Australian submarine community. Importantly, the data shows that the costs of the Collins class were on a par with other modern era submarines, sitting slightly below the best fit line. Contrary to claims often made in the media, there was little cost penalty for building the Collins class in Australia.

Analysis of related programs within the *modern era* show relative stability in the cost per tonne metric regardless of where the submarines are built. In the *modern era*, production runs have been historically small (two to six submarines). Most of the costs of a modern submarine lie in its components and sophisticated systems, sourced from only a handful of suppliers in the western world.

Thus the cost of a submarine in the modern era is largely determined by its size. As discussed previously, a submarine is a 'balanced system'. Its size is driven by the range, endurance and payload required to perform its roles and missions. There is no statistical evidence of additional price inflation or cost escalation of submarines during this era claimed by some commentators.

The dataset underpinning the *modern era* in Figure 7 represents the majority of conventional submarine projects in the western world. The small numbers of *early era* designs that have been built during the *modern era* have been removed.

The cost data for the *modern era* used to plot Figure 7 enabled the calculation of a complete sail away price for building a Future Submarine of between 3,000 and 4,000 tonnes to be within the range of $1.2 to $1.6 billion in 2011 Australian dollars.

A complete project budget would need additional provisions non-recurring costs such as design, risk mitigation, program management and test and training facilities or other infrastructure.

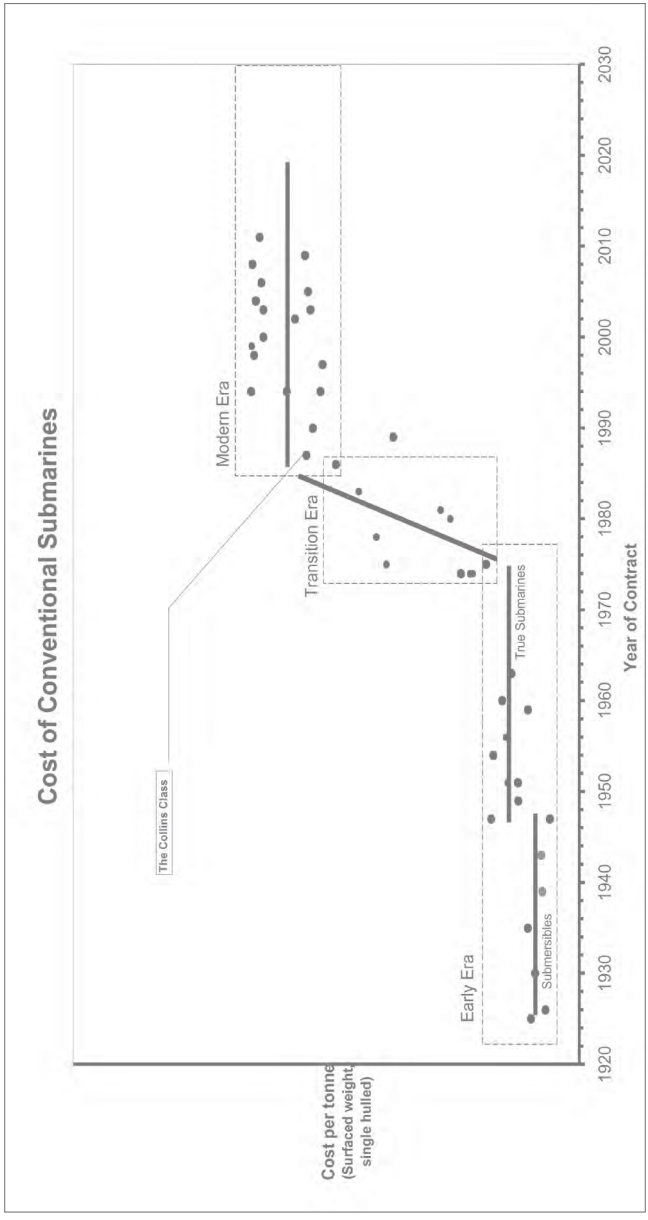


Figure 7. Cost Density of Conventional Submarines (Greater than 1,400 Tonnes)

First Pass Approval

One of the Kinnaird recommendations accepted by Government that is often misrepresented is the requirement to consider an off-the-shelf solution at first pass. The inclusion of an off-the-shelf option was designed to establish a benchmark against which the costs, military effects, and the schedule of all proposals could be assessed.[33]

Advocates of off-the-shelf solutions often fail to note that the Procurement Review went on to say that *'Australia's operating environment often requires specialised equipment to handle large distances and our particular geographical circumstances'*. The Review noted that equipment designed for the Northern Hemisphere may not be suitable for operations in Australia's region.

Furthermore, the small size of Australia's defence force limits the number and types of platforms that it can acquire and operate. Australian military platforms are often required to perform several roles, which might be performed by more specialised equipment in larger forces. Kinnaird concluded that Australia's operating environment often leads to unique Australian requirements.

While Kinnaird required the costs and risks of a unique Australian requirement to be fully assessed, he did not recommend the more restrictive approach advocated by some commentators over recent years which has tended to favour off-the-shelf purchases without the comprehensive disciplines recommended by Kinnaird.

Considerable work is required within the Defence Organisation to develop a mechanism for evaluating value for money that delivers better long-term outcomes than that which will be provided by some recent investment decisions.

Conclusions

Notwithstanding the great versatility of the modern submarine, the key roles remain anti-submarine warfare and anti-surface warfare. Submarines must be able to survive in a high threat environment in order to perform their other roles. It is also important to ensure

33 Malcolm Kinnaird, Len Early and Bill Schofield *Defence Procurement Review 2003*, The Secretaries Task Force on Defence Procurement (Task Force), 2003 p. 19 <http://www.defence.gov.au/publications/dpr180903.pdf> (accessed 7 November 2011).

balance across the total force, and to ensure that this balance is optimised for effect within a realistic budget allocation.

Some of the secondary tasks planned for the submarine have few implications for cost and size, while others will require careful analysis to determine whether they should be design determinants. It may be assessed that some tasks would better be performed by other platforms or systems, while the ability to perform others might be the subject of compromises or carefully assessed limitations.

One approach that should be considered is to use cost as an independent variable, so that the options put to government reflect different balances of cost and capability. In this way, the Kinnaird requirement for the inclusion of an off-the-shelf solution would properly be seen as a benchmark and discipline rather than as a realistic option. The cost trade-offs could then be assessed through the use of empirical data, systems dynamics modelling and statistical analysis.

It is unequivocally clear that the cost of building the submarine is markedly less than some published estimates, and that there is no evidence of any cost penalty associated with an Australian build, as build costs for comparable projects have been found to be consistent across the western world.

It is also clear that Australia's unique strategic circumstances impose significant constraints on the choices available to decision makers. There is simply no commercial off-the-shelf submarine that comes close to meeting Australia's requirements, even if purchased in greater numbers and following significant and highly risky investments in the northern infrastructure required to support a fleet of smaller and less capable designs.

This leaves several important decisions to be made. Most submarines are evolutions of earlier designs. In the case of the Future Submarine, the options include an ab initio design, or an evolution or adaptation of either a European commercial design or Collins itself. An ab initio design would entail the highest risk, and would be the slowest to realise. An evolution (and scaling up) of a European commercial design would be accompanied by all of the risks that flow from adapting a design untested in the demanding Australia maritime environment. An evolution of the Collins design represents an option that is discussed in greater detail in the next chapter.

THE BENEFITS OF THE COLLINS EXPERIENCE

The Collins class submarine has been a controversial defence equipment project that has polarised public opinion. Yet it is widely appreciated within the global submarine community that the Collins submarine has provided Australia with a capability that is unmatched in the region. It is the only conventional submarine known to be capable of sustained, stealthy operations throughout Australia's maritime jurisdiction and beyond. Subject to availability, the Collins class provides Australia with a leading anti-surface and anti-submarine asset possessing a marked technical advantage over any potentially hostile submarine currently deployed in the region.

The capability provided by the Collins class submarine constitutes a significant complicating factor for any naval power seeking to act in a manner contrary to Australia's national interests, or those of Australia's friends and allies. Even the critics of Australia's current fleet of submarines acknowledge that important lessons have been learned from designing, building and operating the Collins class. The capabilities of the Collins class remain a benchmark for Australia's Future Submarine.

To its detractors, the Collins submarine failed to meet the program's budget, schedule, and performance objectives. Indeed, the Collins Class Submarine Sustainment and Projects remained at the top of the Government's Programs of Concern[34] towards the end of 2011 and the Minister for Defence commissioned a major review of submarine sustainment to address ongoing issues of availability.[35]

Few of the critics are mariners, and even fewer are submariners. To its supporters, the Collins is a major technical achievement, a vital contributor to Australia's strategic capability edge, and a significant boost to the Australian economy in general and manufacturing in particular. Furthermore, those with the most experience of the Collins class argue that the design provides the best and most

34 Minister for Defence, Stephen Smith and Minister for Defence Materiel, Jason Clare 'Reforms to Projects of Concern' *Media Release* 187/11 29 June 2011 <http://www.minister.defence.gov.au/2011/06/29/reforms-to-projects-of-concern> (accessed 7 November 2011).

35 Minister for Defence, Stephen Smith and Minister for Defence Materiel, Jason Clare 'Release of Terms of Reference for Submarine Sustainment Review' *Media Release* 24 August 2011 <http://www.minister.defence.gov.au/2011/08/24/minister-for-defence-and-minister-for-defence-materiel-release-of-terms-of-reference-for-submarine-sustainment-review> (accessed 7 November 2011).

logical starting point on which to base the next generation of Australian submarines.

In many ways the project enjoyed advantages that have eluded subsequent defence projects. The capability requirement flowed from a deep understanding of Navy's requirements following the retirement of the Oberon class. And in its early stages the program benefited from strong political, naval and departmental leadership that responded to demands for participation from the states, industry, and labour.

There are things that have been done well, and things that could be done better.[36] This chapter assesses the Collins experience, identifies the lessons learnt, the issues needing resolution, and the implications for the development of the Future Submarine capability.

The Potential Demonstrated by Collins Class

Perhaps the single greatest benefit gained from the Collins program is an understanding of the potential role of conventional submarines in the future maritime environment. The Collins was designed towards the end of an era that brought a transformation in submarine concepts and technologies. This resulted in a submarine with a more subtle and complex design resulting in greater speed, control, stealth, capability and safety, not the least through the extensive use of new generations of software and microprocessors.

The Collins class has demonstrated its performance by achieving noteworthy successes during exercises and deployments. The ability of the Collins to penetrate the defences of US carrier battle groups under exercise conditions has reaffirmed the threat to surface combatants posed by modern conventional submarines. The Collins has demonstrated a capacity for submerged speed greater than that which can be maintained by surface combatants in some sea states commonly found in Australia's region. In addition, the low acoustic signature has fuelled a debate within

36 For a complete understanding of the Collins story, read the excellent Yule, Peter, and Woolner, Derek *The Collins Class Submarine Story: Steel, Spies and Spin*, Cambridge University Press, Cambridge; Port Melbourne, Vic. 2008. The purpose of this chapter is not to revisit the Collins story, but simply to draw out some of the lessons learned for the Future Submarine.

the operational community about the need for air-independent propulsion.

The Importance of a Clear Capability Requirement

The operational performance of the Collins class is the result of analysis by Australia's submarine community in the 1980s of what would be required of an Australian submarine in the future and how technology might help meet those demands. The naval leadership developed a strong operational concept that underpinned a coherent and realistic capability requirement with a focus on persistent submarine operations at a distance from Australia. The demanding objectives relating to capability requirement included:

- range,
- endurance,
- stealth through a low indiscretion rate and new construction methods and materials;
- mobility, including a high average transit speed;
- systems capacity; and
- habitability.

The underlying capability requirement remains broadly the same today, although new roles such as land attack, and new technologies such as remotely piloted or autonomous vehicles, could lead to demands for a larger payload and submarine. As an early example of the *modern era* of submarine design, the experience gained during Collins operations will inform the development of the Future Submarine in a way that experience with the Oberon class could not a generation earlier.

The development of the Future Submarine should follow the benchmark set by the Collins class and respond to a thorough analysis of future strategic and technological developments. Still, a capability requirement for the 21st Century should be based on Australia's strategic geography and the growing military capabilities in the region.

The current regional security environment is much more challenging, with the rise of new powers, the growth of capable regional submarine fleets, and the proliferation of new weapons technologies that will make operations on the surface of the sea and from forward operating bases more difficult. The stability in

current submarine concepts and technology should ensure that the lessons learned from the Collins program can be readily applied in a future design.

The Development of a Greenfield Site and a New Industry

The decision to build a new class of submarine on a green field site in Australia was ambitious for a country with a modest shipbuilding industry, regarded at the time as in inevitable decline. The project developed in response to changing strategic circumstances against a background of recession and industrial obsolescence and at the beginning of a new era of economic reform.

An aspect of the Collins program that should ensure confidence in a Future Submarine enterprise is the success achieved in developing a submarine construction capability for the Collins class from little more than an idea. The facility achieved a rate of production that was more efficient than most comparable build projects. Indeed, Collins was a pioneer of modular construction in the submarine world. This approach worked so well that the hull sections were produced with the anechoic tiles attached. Following assembly, the only adjustment required was a bead of adhesive run around the joint.

In many respects the Collins program, and the subsequent highly successful and competitive Anzac Class Frigate and Huon Class Coastal Minehunter naval construction programs were model industrial undertakings that have left a valuable legacy. This includes modern naval construction facilities, a modern submarine base, and an experienced workforce.

These are supported by a network of complementary industrial capabilities and international relationships, not the least of which is the deep relationship with the US Navy and industry. Supporting infrastructure now exists for through life support in locations that exploit Australia's strategic depth and draw upon the supporting infrastructure in the broader economy.

The common user facilities spread across the continent and the modular construction approach allow selective competition where appropriate, and lower the barriers to entry for innovative new firms with skills and technology to contribute.

Notwithstanding the many benefits, the original approach also led to some activities that were not sustainable beyond the build phase and did little to either develop the broader industrial base or contribute to the submarine support base over the longer term. More recent defence industry policies have attempted to identify those areas that are genuinely strategic in character, although the analytical framework for this needs further development.

The engagement of small to medium sized enterprises in the Collins program also led to some innovative solutions. Some of the locally designed and manufactured pumps are amongst the quietest in the world. There are local companies ready to build on knowledge gained during the Collins program, using innovative and creative solutions for some challenging technical problems.

The Need for Science, Technology and International Collaboration

With the benefit of hindsight, there was a degree of technology over-reach in the Collins program, but at a level typical of technology projects of the era, particularly software projects. As shown in the previous chapter, the decades during which the Collins was developed saw tremendous changes in submarine technologies and capabilities. Comparable problems with a wide range of command, control, and information technology projects at the time attracted less publicity because the need to accept developmental risk was better understood.

The Collins technical issues, while common to new designs and usually resolved on the first of class, unfortunately continued some years after the first boat was launched. These issues included problems with the fuel system, diesel engines, noise, propellers, communications and combat system. However, the process of overcoming these first of class issues has created a much broader base in Australia for analysing submarine technologies and improving performance. The technology developments and support provided by the Defence Science and Technology Organisation have been very successful, and included contributions to:

- metallurgy and welding,
- anechoic tiles and adhesives,
- ship noise and vibration, and
- the sonar and weapon systems interface.

In cases such as metallurgy, the need for technical support had been foreseen and provided an essential underpinning to the success of the industrial undertaking. Importantly, the requirement for metallurgy and welding led to the establishment of a trade training regime that provided the project with a skilled workforce when many other sectors of the economy found skilled labour shortages to be a problem.

The Collins experience highlights the importance of the early involvement of the Defence science community and for creating an environment that facilitates international collaboration. The range of technical support provided through the Defence Science and Technology Organisation, which now includes keeping the periscope mast and systems operational, has created a firm base on which to develop a program for the Future Submarine.

Notwithstanding the success of the Australian design effort in resolving some of the issues with the Collins, the US Navy and industry were needed to provide important support for remediating the combat system and propeller noise. The replacement combat system for the Collins class will continue to draw upon US Navy developments and will enable an evolutionary approach to progressive system improvements relevant to the Future Submarine. This is complemented by a collaborative agreement between the US Navy and Australia for development of the Mark 48 torpedo.

This should provide the basis for a US Navy standard tactical system that can be migrated directly to the Future Submarine, thus avoiding the main problem that beset the early history of the Collins class. American submarine propeller expertise and hydrodynamic research facilities are unequalled and privileged access to these should ensure that the experience is not repeated. No proposal for the Future Submarine should be contemplated that puts US Navy and industry support at risk.

The lesson learnt from the first of class problems in Collins is the need to complete detailed engineering work and to integrate all systems in land-based test facilities prior to their installation in the first of class submarine—and to allow sufficient time before commencing construction of the follow-on boats. It also indicates that the optimal solution might be to adopt an evolutionary

approach, with several batches of submarines (say 4+4+4), to produce the number of submarines required by the emerging strategic analyses.

Procurement Approach

Some of the key decisions regarding the Collins project were influenced by a period of unsuccessful defence procurement in the 1980s involving significant cost and schedule overruns. Derek Woolner argues that 'it is unlikely that the program would have proceeded if the fix-priced approach had not been approved'.[37] The Collins project was conducted in the firm belief that meddling with system specifications had caused considerable grief in earlier projects.

The reluctance to accept specification changes and tight internal control were not suited to an era in which significant technological changes were underway in areas such as microprocessors and software development. This led to instances of obsolescence before the Collins entered service and contributed to operational deficiencies in areas such as communications and electronic warfare.

The authors of the most influential of the early reports on the Collins Class Submarine found that the difficulties stemmed *'from a lack of over arching capacity to deal with the scale and complexity involved, given the changes in mission and technology that should have been recognized as inevitable in a project of this size and ambition'*.[38]

From the outset, there was insufficient recognition of the developmental nature of the project. The 2.5% contingency provision was insufficient to deal with the inevitable problems, and the fixed price contract was neither suitable nor complete. As the project continued, these weaknesses contributed to a culture of crisis management, with Defence taking over responsibility for the combat system from the prime contractor for example.

37 Derek Woolner, *Getting in Early: Lessons of the Collins Submarine Program for Improved Oversight of Defence Procurement* Research Paper 3, 2001-02 Australian Foreign Affairs, Defence and Trade Group, Department of the Parliamentary Library, Canberra, 18 September 2001 <http://www.aph.gov.au/library/pubs/rp/2001-02/02RP03.htm > (accessed 7 November 2011).

38 Malcolm McIntosh and John Prescott, *The Report to the Minister for Defence on the Collins Class Submarine and Related Matters*, June 1999, Paragraph 8 <http://www.defence.gov.au/minister/1999/collins.html> (accessed 7 November 2011).

Regrettably, this situation continued until recently.

A more appropriate contingency provision of 10-20% and a contract suited to the developmental nature of the program would have made it possible to resolve the majority of the technical issues expected in a first of class design far earlier. Indeed, a modest level of contingency would have allowed the remediation to be completed within budget, and would almost certainly have preempted much of the counter-productive publicity that continues to attach to Collins.

In the decades since the start of the Collins project there have been substantial advances in project management and contractual frameworks for large complex projects in both the defence and commercial sectors that should allow the future submarine project to avoid the problems encountered by its predecessor. These developments are discussed in the next chapter.

Support and Sustainment

The Collins is a unique design, but the Defence Organisation overlooked the implications of the parent navy role. The situation was made more difficult by a decision to progressively move engineering and support functions out of Navy at the very time they would be needed most, and the lack of adequate funding to establish a functioning through life support program. It was compounded by the lengthy gap between the final Oberon refit and the first Collins refit, and the loss of corporate knowledge and experience during this period.

Part of the reason for the divergence of views on Collins is that it was developed at an inflexion point in the development of the modern generation of conventional submarines. Collins has benefitted from the new technologies that greatly influenced submarine design in the latter part of the 20th Century, and markedly increased their survivability and lethality.

But Collins also has some design features that need analytical and professional management, rather than a mechanistic and process driven approach. Some of these have not been managed well, either by Navy or by the Defence Materiel Organisation. Still, the maintenance and sustainment issues can be addressed, and are not unusual for a submarine program even if the publicity attached to those problems is.

The reliance on the commitment of offshore original equipment manufacturers has not assured adequate availability and affordable sustainability. The transition from production to through life support was planned well before delivery, but was ignored by the Defence Organisation, and has remained largely unsatisfactory ever since. This may in part be due to a lack of adequate financial provision for maintenance and the parent navy role and the loss of the corporate and technical knowledge and experience of managing submarine maintenance, repair and upgrades.

The through life support for the Collins has been adversely affected by the unreliability of a few components and the difficulties that the Navy has had providing experienced crews. A report under development at the time the Kokoda study was in progress should lead to improvements in the long-term sustainability of the Collins class.

Measures to improve the operational availability and reduce the overall cost of ownership will have to be an integral part of the Future Submarine program.

Personnel Development and Retention

There is general recognition that problems with the availability of trained submariners and crews were in part a result of poor administration, modern lifestyle factors and partly a result of the unavailability of the submarines, none of which has been fully overcome. There was a failure to allocate the human resources to sustain the submarine capability despite the importance of the capability in Australia's defence strategy.

Key Lessons

A successful Future Submarine program will require the establishment of an appropriate enterprise structure to deliver and sustain the Future Submarine over the life of the project. This will be essential if the contractual disputes and antagonisms experienced during the Collins project are to be avoided.

The challenge will be to ensure that the goodwill that accompanies the start of major projects continues through the life of a national enterprise that will extend beyond the middle of the century. To the extent that it is possible, a priority should be attached to identifying

partners in the project with a long-term strategic commitment to submarine production.

A successful submarine program will depend on better collaboration between the Defence Organisation, the Defence Materiel Organisation, the Defence Science and Technology Organisation, the Navy, and industry. There is already evidence of growing cooperation in the Future Submarine program, but it needs to be nurtured.

A well-developed media plan will be required to explain the need for the Future Submarine program, the need to accept at least some developmental risk, to provide substantial and well managed provision for contingencies, to allow for and accept the possibility of delays and variations from originally specified performance objectives, and to explain an evolutionary approach to implementing the Future Submarine capability. This should be extended, through new media to the younger audiences from which future crews will be drawn.

The transition from Collins to the Future Submarine program must be managed carefully, as the two fleets will overlap by more than a decade. Drawing upon the capabilities that have been developed within Australia's submarine industry, the Collins should serve as a test bed for the Future Submarine. This suggests that the two programs should have some common oversight, involving not only submarine sustainment but also the direction of upgrade projects such as the Collins replacement sonar suite.

A capability requirement for the 21st Century should be based on Australia's strategic geography, alliance obligations and the growing military capabilities in the region, not simply an extrapolation of the capabilities of the Collins class. The current regional security environment is more challenging.

Australia has made a significant investment in skills, facilities and knowledge in executing the Collins and other naval programs and their through life support. The Future Submarine should, where possible, build on and leverage this investment, rather than attempt to start again.

A Future Submarine based on an evolution of the Collins design is the best way to benefit from the experience of operating a modern submarine fleet in Australia's maritime domain.

The Collins is the only available conventional submarine approaching the range and endurance to meet the capability requirement for the Future Submarine. It already has the capacity to perform most of the additional roles and missions required by emerging Australian guidance, although there is scope for the incorporation of new and improved technologies to meet those demands better and to overcome aspects of the Collins design that have proven problematic.

Nations with a history of successful domestic submarine programs, such as Japan and Sweden, have developed each successive class of submarine based on its predecessor, in small batches, continually evolving capability while minimising risk. The Collins is well understood; the management of the Collins through life support issues will continue to be improved, and the underlying issues will be eliminated from a future design and management arrangements.

Policy makers also need to move quickly to overcome bureaucratically and politically imposed delays. Already it appears likely that Collins will be required to serve longer than originally planned, and the Future Submarine will need a more flexible project management structure than current projects if it is to be in service in sufficient numbers to be a force in the undersea environment of 2030.

A commitment must be made to understanding and fulfilling parent navy responsibilities. This will be assisted if the Future Submarine is designed at the outset for supportability and sustainability through the life of the type. This applies not only to the design of the submarine itself, but also in to the creation of the submarine enterprise that will be required to support it over time.

Australian industry participation in the program must assist in developing a response to unique requirements and in developing a long term and secure support base. This capability must be durable within an appropriate contractual and project management arrangement. Full advantage should be taken of small to medium enterprises as a valuable source of innovation.

Price discipline will be critical, but cannot sensibly be obtained through a fixed price contract for all phases of the Future Submarine project, especially for the first of class, or through the uncritical use

of competition. In matters of national security, the Commonwealth inevitably assumes the ultimate risk. The Defence Organisation has yet to master the art of developing contractual models appropriate to the purpose, an issue addressed in the next chapter.

In the final analysis, it will be necessary to put the Collins experience in its proper perspective, as something to be learned from and built upon rather than rejected. Perhaps the most important lesson is that Defence and industry can achieve outstanding results, when the objective is not confirmation of a procurement ideology, but a successful program.

FUTURE SUBMARINE ACQUISITION AND PROJECT MANAGEMENT

Introduction

In addition to the lessons learned during the Collins program, Australia is now able to draw upon the significantly improved engineering and program management skills developed in naval shipbuilding and the general economy over the past 25 years. The success of many projects in other sectors of the economy of comparable cost and complexity has removed any doubt that the Future Submarine can be delivered in Australia with appropriate international support.

In a very real sense, some of the industries which a Future Submarine capability will benefit most by ensuring the security of their commercial infrastructure and sea lines of communication; also have the capacity to contribute to the development the Future Submarine. It is worth considering the lessons learned in project management and engineering during the development of Australia's onshore and offshore resources.

Notwithstanding the development of a range of industrial capabilities, significant challenges remain for determining a methodology and developing the culture required for delivering the Future Submarine, and sustaining it beyond the middle of the century. Although the Future Submarine program is being developed in a period of relative stability in submarine design and performance, submarines involve complex engineering and are the subject of continual, if incremental, improvement through life if a relative capability advantage is to be maintained.

These challenges include all of the normal technical and program issues. They will be compounded by the scale, duration and complexity of what will be one of the most demanding engineering projects in Australia since Collins itself. Close cooperation with allied governments and navies, and their industrial bases will be critical.

Increasingly, projects such as the Future Submarine must negotiate diverse and emerging issues in a dynamic and changing political, technical, economic, social and environmental context. The implementation and deployment of such programs demand

approaches and skills that are different from traditional project management disciplines, static leadership models and the bureaucratic organisational systems that support them.

Selection of the acquisition model will be a key enabler, as it will lay the foundation for program success. The decision will have far reaching consequences for the associated industrial capacity and capability that needs to be developed and sustained in order to efficiently deliver and support the submarines throughout the full life of the program.

This chapter evaluates options for procurement and industry policy, before concluding with comments on the role of competition and collaboration in delivering the Future Submarine in a timely and cost-effective manner,

Creating the Conditions for Success

There is no single cause of the difficulties in delivering complex projects, and no single solution. But it is possible to identify the conditions that will increase the likelihood of a successful program. At the outset, it is important to recognise the size of the project, and the complexity of designing and building a modern submarine, and sustaining a submarine capability in service.

During the early phases of the Future Submarine Project, a much greater proportion of project funds must be spent on analysis to ensure that government is provided with financially and technically sound advice and to reduce the risk of problems emerging during the later stages of the acquisition process. In one of the central recommendations of the 2003 *Defence Procurement Review*, this was described as including *'external scrutiny and verification'*.[39]

While the strategic rationale for a submarine capability is well understood, there are many questions of detail that have yet to be fully assessed. The program office needs assured and flexible funding to ensure appropriately skilled and experienced people are engaged and that all of the necessary studies are carried out in a timely manner.

39 Malcolm Kinnaird, Len Early and Bill Schofield *Defence Procurement Review 2003*, The Secretaries Task Force on Defence Procurement (Task Force), 2003<http://www.defence.gov.au/publications/dpr180903.pdf> (accessed 7 November 2011). The review is commonly referred to the 'Kinnaird Review'. It established a framework for Defence procurement that has delivered some improvement, but may have suffered in implementation. Spending on early analysis is currently well below the levels recommended by Kinnaird.

Effort should be directed at growing the leadership team and the pool of senior advisory staff by recruiting from the broader economy. At the time the Collins program was started there had been a long hiatus in naval construction in Australia. A generation later, Australia enjoys access to significant human capital in the form of experienced and successful naval project managers and ship-builders, although many of the most experienced personnel are now working in other sectors of the economy.

The leadership team should be provided an appropriate level of authority and resources, as well as direct access to both state and federal governments across a range of relevant portfolios. A whole of government approach should seek to maximise the economic benefits of the program while minimising the opportunity costs, and to ensure that the strategic infrastructure developed for the Future Submarine is sustainable over the life of the program.

There are significant opportunities for the early and more meaningful involvement of industry, and the creation of a culture that overcomes the adversarial relationships developed within certain projects over recent years. Some of the mechanisms for engaging industry are discussed in greater detail in Annex A.

The management structure should facilitate clear accountability and open reporting to all stakeholders, with a particular emphasis on engaging the uniformed leadership in decisions that will have significance for future operations. There needs to be a culture of openness and accountability to ensure that problems do not remain hidden,[40] and a level of contingency funding to address issues as they arise.

In addition to adequate contingency funding, there should be early and sustained investment in risk mitigation measures. While submarine design and technology is currently relatively stable, the Future Submarine is a developmental program and will be accompanied by a manageable level of developmental risk. The establishment of a propulsion test-bed bed and land-based test facilities for other systems should be seen as a priority element of the risk mitigation program.

40 A concept the Kinnaird Review described as 'no secrets no surprises'.

The US experience with the Virginia class, is instructive and should inform the approach to the Future Submarine program. The program should be planned to allow sufficient time and resources to complete design and pre-test integrated command, control and communications and propulsion systems before installation in the first submarine.

While much of the early work can be simulated, the shipbuilder, staff and navy operators should be identified and engaged in the design process as early as possible. The work-packages and modules should be distributed as widely as possible in a competitive process, with appropriate levels of pre-engineering and construction controls and pre-testing prior to consolidation.

The acquisition strategy must reflect the reality that some risks associated with programs such as the Future Submarine cannot be transferred to industry, and that any attempt to do so will add to the program cost with little benefit. Put simply, in matters of national security, the Commonwealth cannot easily walk away from programs where a contracting partner fails.

There are many advocates of competing contracting models for the Future Submarine project. However, in the absence of a government agreed acquisition strategy, it is too early to settle on a particular contract model.

In order to address these subjects, and to avoid further delays to the Future Submarine program, consideration should be given to establishing an appropriate program organisation supported by a level of funding consistent with the recommendations of the 2003 *Defence Procurement Review*.

An obvious model for such an organisation would follow a traditional approach to Defence procurement. However there has been both internal and external criticism of the past performance of major program offices run within the Defence Materiel Organisation. The focus should be on developing the most suitable solution; not following a pattern set by recent Defence projects. Accordingly, consideration should also be given to acquisition strategies that have succeeded in other private and public sector projects of similar scale and complexity.

The Traditional Approach to Procurement

A traditional Defence Project Office is a familiar and well tested approach to major program management. It involves a military and public service team accountable through the Defence Materiel Organisation which is responsible for the budget and is accountable to the relevant Minister. A project structured in this way remains independent of industry in performing its regulatory and prudential responsibilities.

Familiarity facilitates a close working relationship with the Chief of Navy as the Capability Manager and with the Capability Development Group which develops a capability requirement that links strategic guidance to operational realities.

On the other hand, there are few staff available in the public sector with the experience required to run major complex projects, and few senior managers with executive experience of major programs on the scale of the Future Submarine.

Recent efforts to improve the training and level of understanding of project management disciplines are welcome, but are no substitute for the hands-on experience that can be gained in the private sector. Furthermore, it can be difficult to attract the staff required for a project of the Future Submarine's scale and complexity to traditional public service appointments, subject as they are to relatively inflexible public service cultures and conditions.

Recent programs have tended to adopt a narrow Defence procurement perspective. A project of this size should take a whole of government and nation approach and draw on the best that the public service and private sector can provide in terms of governance and guidance, while taking account of a broader range of social, economic and regional interests.

Experience indicates that programs structured this way are not necessarily as responsive to the interests of the Capability Development Group and Capability Managers as might be expected. Furthermore, through life support planning is often compromised as a result of capital budgets being split from sustainment budgets.

A Modernised Approach to Procurement

A more modern approach to the acquisition strategy would take greater account of the twenty five years of cultural and economic change in Australia since the Collins program was conceived. A suitable enterprise would be designed to build on the best that the public and private sector can each provide, and take account of the flexibility provided by the *Financial Management Act and Commonwealth Procurement Guidelines.*

In the foreword to the 2008 edition of *Commonwealth Procurement Guidelines* then Finance Minister Lindsay Tanner described the purpose of the guidelines as achieving value for money by agencies when undertaking procurement, reflecting the Government's approach 'of doing what works to get the job done'.[41]

The public sector can draw together the operational experience of the Australian Defence Force and the regulatory and prudential experience of the Australian Public Service to ensure that the program delivers the capability required in the future maritime environment while safeguarding broader social and economic interests.

The private sector can contribute its much deeper project management, engineering and ship building expertise and experience to bear while ensuring the Commonwealth benefits from efficiencies that only private sector competition and experience can sharpen over time.

A Future Submarine Authority

There is scope for adopting an innovative approach to all of the challenges facing the development of the Future Submarine capability, and to capitalise on the strengths of Defence Organisation while addressing some of its limitations. This might involve exploring the sophisticated market for project management that has developed in Australia.

41 *Commonwealth Procurement Guidelines*: Financial Guidance Management No. 1, Department of Finance and Deregulation (Asset Management Group), December 2008, http://www.finance.gov.au/procurement/procurement-policy-and-guidance/CPG/docs/CPGs-2008.pdf (accessed 7 November 2011).

The methods for drawing upon the expertise available in the market might include the establishment of an authority similar to those created to manage other major engineering projects in Australia. A modern version of the Snowy Mountains Hydro-electric Authority could serve as a widely respected example of this approach.

The establishment of a *'Future Submarine Authority'* would demonstrate an understanding of the scale and complexity of the Future Submarine program and facilitate the recruitment of a high level leadership team with authority, accountability and funding to advance the program. It would attract program management and technology leaders freed from the constraints of public service culture and conditions.

Defence and industry personnel could be co-opted, assigned or hired directly for the program. This need not be seen as a threat to current Defence staffing, as Defence has yet to recruit the future workforce that will be required by the Future Submarine project. During the course of the Kokoda study, Defence personnel have expressed keen interest in working in the environment that might be created in an enterprise established to deliver and sustain the Future Submarine capability.

An independent Authority, responsive to the Defence leadership, could be tasked to assess development and capability options for government, including the engineering design, and to make recommendations regarding contracting models.

The tasks will change over the life of the program, at different levels of activity within the program, and at different stages of development. These might include concept development, detailed design, skills development, system integration and testing, materials and equipment procurement, distributed module construction, submarine consolidation and final outfit, training, commissioning, and through life support. The aim would be to make the optimum use of competition in the market for the non-developmental stages of the program and to deliver best value-for-money.

The charter of an independent Authority should include an obligation for early planning of the through life support phase of the Future Submarine, including planning for through life modifications, upgrades and eventual disposal. This would address the

shortcomings of many projects which have compromised through life support during the design and build phases. A comparison of options should be made on the basis of a *'whole of life'* costing in accordance with Commonwealth Procurement Guidelines.

The corporate structure should include representatives from all of the key stakeholders, including the Department of Finance, the Navy, the Capability Development Group, the Defence Materiel Organisation, and the Defence Science and Technology Organisation. It should have available independent and experienced program managers as well as science, engineering, financial, and legal advisers.

It should have advisory boards or committees which include industry or technology specialists. The leadership of the Authority should be appropriately empowered and held accountable for cost, capability, schedule and performance of the whole program, like any corporation. The Authority should form an enduring national capability based on clear objectives, stable governance arrangements, long term planning and long tenures for senior staff.

The Authority would engage private sector engineering and project management specialists from Australia and overseas by a commercial tender process to establish the project management organisation, schedules and options. And it could request and manage submissions from industry and suppliers, an approach which would reduce the risk of bias in the assessment process.

The Role of Industry

A recent RAND Corporation team study of the capabilities of Australia industry identified four key issues, the importance of long range planning, ways to achieve design and production efficiencies, the need to sustain hard to replace resources and the requirement for robust testing.[42]

The study confirmed the importance of a comprehensive long-term ship building strategy or plan. The purpose would be to provide the facilities and workforce skills required over the life of the program, and to help eliminate the boom and bust cycle that has plagued

42 John Birkler 'Industry and infrastructure for Future Submarine: an International Perspective' in *Conference Proceedings*, Submarine Institute of Australia's 5th Biennial Conference, Perth, November 2010.

naval ship-building in Australia. The plan must account for multiple ship types if it is to 'better manage the design base, shipyards and vendors over time'.[43]

RAND made several general recommendations, including:

- smoothing out demand peaks and troughs over the design and production cycle for each ship type by planning over the long term—that is decades, not years;
- resisting the trend towards shifting responsibility and liability to the private sector, with the pressures this places on program cost. Contracting arrangements notwithstanding, the government is the ultimate risk bearer and should remain responsible for cost-benefit trade-offs;
- making competition optional rather than the default method for obtaining value;
- protecting and enhancing the design and integration industrial base;
- deepening collaboration with key allies;
- standardising design tools across industry and government; and
- building test facilities to test integrated command, control and communications systems and propulsion and energy alternatives.

There are additional lessons for industry policy to be gained from case studies of the US Virginia class submarine program. The Virginia class was chartered from the outset to develop a less expensive alternative to the earlier Seawolf program through reform to the acquisition process. The techniques adopted included modular construction, a process to reduce the number of distinct parts, the adoption of advanced commercial off-the-shelf technologies, and a disciplined approach to setting the capability requirement.

Involvement of production and design personnel in an Integrated Product and Process Design (IPPD) process helped match the submarine's design and the shipbuilder's construction processes and facilities, while maintaining a stable design. This smoothed the

43 John Birkler 'Industry and infrastructure for Future Submarine: an International Perspective' in *Conference Proceedings*, Submarine Institute of Australia's 5th Biennial Conference, Perth, November 2010.

transition from design to build and reduced the number of changes required during the construction of the lead ship. An emphasis was placed on reliability, with a focus on preventive rather than corrective maintenance, critical in a submarine environment.

There is also a need in Australia's case to address inevitable questions about the allocation of labour resources in a program that could, unless properly managed, divert engineering skills from other areas of the economy. If a whole of government and nation approach is taken, the Future Submarine project has the potential to use the highly regarded Defence skilling program to develop the skill base in ways that will benefit the overall economy. This program could usefully sponsor the development of skills ranging from welding to naval architecture, systems integration, project management and integrated logistics support.

The Role of Competition

The role of competition in the Future Submarine program is an area which requires careful consideration. Defence procurement tends to involve a mix of competitive and sole sourcing, with a reliance on single-source arrangements at the prime contractor level. In practice, there will be a number of constraints upon competitive tendering for the Future Submarine resulting from imperfections in the market and national sensitivities relating to the technologies involved in submarine design and construction at the system, sub-system and integration levels.

Trust and relational issues will be central to developing and maintaining shared goals in the program. In particular, it would be unwise to contemplate any procurement strategy which places access to US naval and industrial expertise and technology at risk. RAND research has shown that there might not be enough viable contractors to enable effective competition in many aspects of the submarine program.

Implications

There are many inter-related issues to consider in deriving an optimal acquisition model for the Future Submarine Program. Much can, and should, be drawn from the models adopted historically by the Defence Organisation for similar naval shipbuilding programs, from overseas contemporary successes and failures in submarine procurement and by industry in general for the delivery of complex commercial programs for both private and public sector customers.

The choice of acquisition model is a key enabler for program success. It will be important to draw from this wealth of background experience, and carefully apply the derived processes that enable proper consideration of those candidate structures deemed most suitable for the specific circumstance. In the case of the Future Submarine, the acquisition model selected must be structured to enhance, not inhibit, Defence - industry collaboration and engage and align global program stakeholders so as to deliver shared objectives.

Much work needs to be done to remove the cultural impediments to successful collaborations between the public and private sectors. Part of the answer will lie in adoption of a contracting mechanisms designed for success in a complex 21st Century project. But a large part will come from old-fashioned leadership. The Defence Organisation would do well to look to its highly regarded operational leadership, and to encourage a more positive view of service in the procurement programs that might determine the outcome in future operations.

THE WAY AHEAD

The strategic orthodoxy in the latter part of the 20th Century held that Australia's strategic geography was generally beneficial, insulating Australia from the ambitions of regional competitors and from the centres of great power conflict. Australia's membership of a dominant maritime alliance was one of the implicit assumptions underpinning defence planning.

But the military balance of power in the Asia-Pacific region is shifting. New powers are rising and new military technologies are being deployed by states whose strategic ambitions are uncertain.

There are now doubts about the ability of surface combatants to operate in the archipelagic region to Australia's north, and along the extended sea lines of communication that connect Australia with its trading partners. There is an increasing risk of accident or miscalculation, exacerbated by the spread of destabilising technologies to rogue states and non-state actors.

These trends are combining to present Australian security planners with diminishing choices at a time when Australia has a deepening interest in securing not only Australia's maritime approaches, but also a maritime jurisdiction and an economy dependent on offshore resources and trade.

It is now clear that submarines may be the only force structure elements capable of persistent operations in a maritime region that is fundamental to Australia's interests. In particular, submarines may be the only naval vessels capable of secure operations along the length of Australia's sea lines of communication.

It will not be sufficient simply to buy an off-the-shelf submarine designed for operations in another theatre. There is no off-the-shelf submarine that meets Australia's requirements for a capability edge in range, endurance and payload, or is proven in the demanding physical environment found in Australia's maritime jurisdiction and approaches.

An evolved Collins seems likely to be the lowest risk option while assuring the highest level of security for the intellectual property needed to build and sustain the Future Submarine.

The Collins is the only available conventional submarine approaching the range and endurance needed to meet the capability requirement for the Future Submarine, and already has the capacity to perform most of the additional roles and missions required by emerging Australian guidance.

The Kokoda's research reaffirms the need for a Future Submarine of more than 3,000 tonnes to deliver the core capabilities required by Australia's 2009 Defence White Paper. The additional roles and missions suggest that the design will need to be larger again, although not necessarily larger than the 4,000 tonnes suggested by some commentators.

The Kokoda study has made it clear that the cost of *building* the submarine is likely to be substantially less than some early but oft quoted estimates. Furthermore, the technology and construction costs of modern submarines have shown a high level of stability over more than two decades, giving confidence in the project's capacity to meet cost, schedule and performance objectives, particularly if an evolutionary acquisition process is used.

With the appropriate price disciplines in place, a fleet of ultimately twelve submarines of 3,800 tonnes capable of meeting all of the current capability requirements might be delivered for half some earlier estimates, or $18 billion in 2011 Australian dollars.

There are characteristics of the Future Submarine Program that need close monitoring if costs are to be contained. The military value of the secondary tasks required of the Future Submarine need to be weighed against the alternative means of delivering capability, especially where those secondary roles and missions place additional pressure on the size of the submarine.

While one of the key objectives of the program should be to develop a sustainable industrial base to support the Future Submarine, the number of submarines should be determined by strategic necessity rather than an attempt to achieve a theoretical build efficiency.

A critical feature of the acquisition strategy and industry policy will be the need to restore public confidence in the capacity of Defence and industry to deliver and sustain a submarine capability.

The Kokoda study canvassed a range of alternatives to the traditional prime contract model, by examining a range of promising approaches that have been successful in complex engineering tasks in the private sector. Nevertheless, it is important to recognise that Australia's most successful naval projects have been delivered under a prime contracting model.

The quality of the project leadership and a broadly based commitment to program success is more important than the contracting model or procurement ideology. The challenge will be to develop an acquisition strategy that combines the operational experience of naval personnel, the regulatory and prudential experience of the public service with the engineering and project management experience of the private sector.

Industry policy has long been a weak link in Australia's strategic planning, notwithstanding attempts by successive governments to improve the quality of defence industry policy. The current priority industry capabilities could be improved by a more cohesive analytical framework to assist in identifying industries that are truly strategic in character.

There is little doubt that the strategic importance of a submarine capability and its unique character in the Australian context would identify a Future Submarine enterprise as a strategic industrial capability.

A projected force of twelve submarines provides a useful basis on which to plan a submarine enterprise, although the numbers would better be viewed in the context of an evolutionary development program. This might involve the delivery of the submarine capability through a series of smaller batches, with perhaps three or four submarines in each batch. This would provide the stability needed for a construction program, while allowing the progressive adoption of new and improved technologies and capabilities.

Importantly, there will need to be a change in attitudes towards relations between Defence and industry if a submarine enterprise is to be developed as a fully integrated element of Australia's national security planning. Australian industry participation in the program must be designed to assist in developing a response to unique requirements and a long term support base, and to be durable within an appropriate contractual and project management arrangement.

It would be beneficial to increase the involvement of people and enterprises associated with successful Australian engineering projects, including naval contracts such as the Anzac Class Frigate and Huon Class Coastal Minehunter, and to access the creativity and innovative problem solving skills found in small to medium enterprises.

A build program of with delivery intervals of eighteen to twenty four months, plus eight or nine years for development and testing, would mean more than more than a quarter century of assured submarine construction even before the Future Frigate and Offshore Combatant Vessels are taken into account.

Properly managed by the Defence Organisation, these programs are more than sufficient to provide industry with a basis for long term planning, and investment in the facilities, knowledge and skills required for successful naval shipbuilding program in Australia.

Priorities

Policy makers need to move quickly to overcome bureaucratically and politically imposed delays in the Future Submarine program. Already it appears likely that Collins will be required to serve longer than originally planned, and the Future Submarine will need more flexible and better funded project management if it is to be in service in sufficient numbers to be a force in the undersea environment of 2030.

The early selection of the build contractors within the submarine enterprise will enable participation in the design process, in order to ease the transition from the design to build phase. A key lesson from both the Collins and Virginia programs is the importance of settling on the design details before construction begins.

There is a need to better understand and to develop the machinery required to meet parent navy responsibilities. From the outset, the design of both the submarine and the submarine enterprise should emphasise supportability and sustainability through the life of the program.

There will be a requirement to manage carefully the transition from Collins to the Future Submarine. The two fleets will overlap for more than a decade. Ideally, Collins could serve a test bed for some aspects of the Future Submarine design. This suggests

that the two programs should have some common oversight. An Australian submarine authority could usefully take responsibility for both programs as part of a broader ship building plan.

Key risk mitigation exercises should be started as soon as possible allowing the time and resources necessary to design and test integrated command, control and communications systems and propulsion systems before installation in the first submarine.

Malcolm Kinnaird recognised that 'Australia's operating environment often requires specialised equipment to handle large distances and our particular geographical circumstances'. The Kinnaird Review noted that equipment designed for the Northern Hemisphere may not be suitable for operations in Australia's region. It is difficult to conceive of a program that better meets the criteria established by Malcolm Kinnaird for identifying a unique Australian requirement than Australia's Future Submarine.

Annex A

DEFENCE PROCUREMENT—NAVAL PROGRAMS

This Annex covers a review of several candidate contract models, none of which should be selected until the program leadership organisation and acquisition strategy have been established. None of the contract models is a substitute for the establishment of either a Program Office; or a Future Submarine authority.

Prime Contracting

The Australian Defence Organisation has tended to adopt a 'one size fits all' approach to procurement involving the (theoretical and often illusory) placement of delivery risk at arm's length via a prime contract with a single company sourced from a small group of defence industry primes. Such contracts have progressively evolved to include more of the follow-on support scope of the ships once in service. This ranges from the incorporation of the traditional Integrated Logistics Support package (comprising spare parts, training and operational manuals) through to contracting long-term support obligations.

While prime contracts have been used in successful naval shipbuilding programs, Defence pays a premium for transferring risk to industry. If industry fails to deliver, Defence invariably re-inherits the risk in terms of late delivery, cost overrun and substandard performance during delivery and or support.

The adoption of the prime contracting methodology has been regarded as the pathway to achieving value for money, as it puts in place a competitive environment during the proposal and tender phases preceding contract award. This process in itself however has often proven protracted and costly. At contract, the risk has been placed at arm's length with the Prime Contractor via an amalgam of functional, performance and product specifications, often setting up an adversarial contracting environment as the foundation for future contract change and dispute.

Furthermore, the level of contractual specificity increases the risk of adverse audit findings in areas of compliance. These are often of little real consequence in terms of the overall program objectives.

Similarly, excessive Defence oversight of contractual arrangements made by the prime with suppliers and sub-contractors can increase costs and schedule risk.

Prime Contracting (also known as lump sum or turn-key engineering, procurement and construction contracting in other industry sectors) has its applications—but usually in circumstance quite different to those normally associated with major naval capital procurement programs.

The commercial sector generally adopts a prime contracting methodology on the basis that:

- The project is well-defined and non-complex, experienced technology providers and major contractors with experience in designing and constructing the particular asset are readily available.
- Once the contract is let, a 'hands off' approach is acceptable where changes are either not anticipated or are unlikely to be costly.

It can be argued that such lump sum contracts, once in place, may focus prime contractors on cost reductions and profit to their account, rather than the achievement of overall project outcomes in the best interests of the customer.

Alternative Capital Acquisition Program Models

Evaluating Candidate Models

Different industries use a range of alternative models, each having different advantages depending on the candidate program attributes. The most appropriate model is selected based on a case-by-case analysis of the important criteria and constraints unique to each program. This convergence on the most appropriate model for the particular program circumstances is best achieved through a process of facilitated engagement workshops with the customer and other program stakeholders.

A set of weighted criteria that vary according to the program can be used as part of the process in order to shortlist the most appropriate acquisition model options. Important criteria for consideration, the weighting of which will vary from program to program, include the

degree of customer involvement sought, level of scope definition, cost, schedule, technical complexity, risk and industrial capability.

Significantly, a workshop of candidate options for a typical naval shipbuilding program acquisition model might identify an optimal methodology quite different to the commonly adopted prime contracting model, or recent attempts at alliance contracting.

This poses the question as to whether there are any constraints peculiar to Defence that would prohibit the adoption (or adaptation) of one of these acquisition models that appears, at least on face value, more appropriate. This could relate to standards of workmanship required ('Defence quality'), security and intellectual property concerns, or merely the complexity of the asset itself.

However these considerations equally apply, if perhaps not to the same extent, to the development of a complex commercial asset such as a liquefied natural gas process "train" for example, with its associated "black box" technology and safety-critical process plant.

The Program Alliance

While programs such as the Air Warfare Destroyer sought to establish different arrangements from the conventional prime contracting approach, there is some question as to whether the existing Air Warfare Destroyer Alliance is a genuine alliance as it is understood to comprise a hierarchical series of bi-lateral contracts between Defence as the customer and the other alliance and sub-alliance members.

So why not adopt an alliance construct such as the Air Warfare Destroyer Alliance for the Future Submarine Program, or even better, use a 'true commercial' alliance model?

Successful commercial alliances are based on the collective assumption of shared risk, and are not simply a different version of most contracting models, that work on the premise of allocating risk to the party(s) most able to manage it. The best alliances adopt a true best-for-project resourcing approach, shared across the entire program scope, with each party contributing to more than just 'their own' scope.

Regardless of the contribution of each alliance partner, pain and gain share at the program-level can be structured in advance of the program on an agreed percentage basis (independent of variations in resource/cost inputs)—and ideally those percentages should be equal. All parties, including the customer, enter into the alliance via a single, multi-party contract.

Notwithstanding the promotion of Alliances as a means of delivering shared risks and accountability, Alliance partners can, in the absence of a strong alignment of company cultures on truly shared outcomes, remain competitive in the pursuit of control and in maximising their own work share. This can in turn serve to limit access to broader (and/or better) industry capabilities more suitable for elements of the program.

In addition, notwithstanding the shared responsibility, the program risk ultimately still remains with the Customer, who has little recourse should the alliance fail to deliver on targets, other than to invoke any embedded contractual pain-share arrangements.

Engineering, Procurement and Construction Management

Engineering, Procurement and Construction Management (EPCM) delivery involves a Contractor performing the engineering design, procurement and construction management on behalf of the customer as the customer's agent. However both procurement and construction contracts are normally placed directly with others by the customer on the "customer's paper".

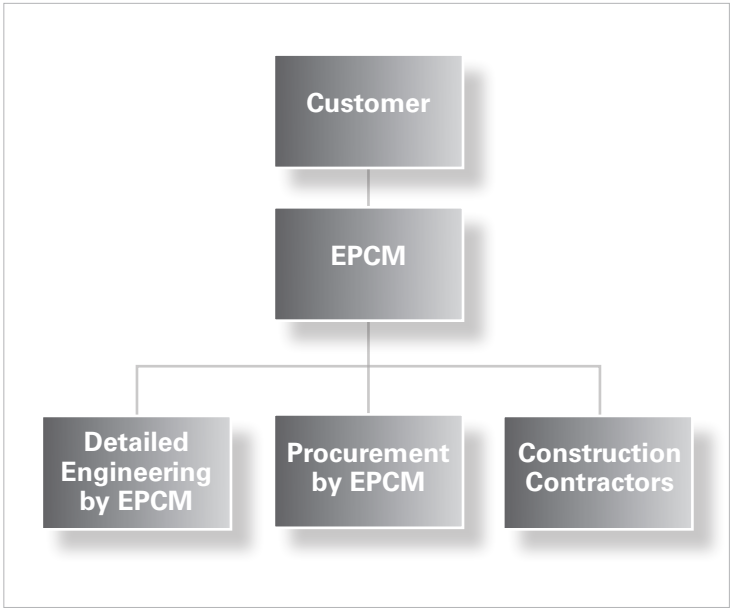


Figure A1. Typical Engineering Procurement and Construction Management Program Structure

For appropriate programs, Engineering, Procurement and Construction Management contracting has demonstrated the following attributes in comparison to a conventional prime contract:

- lower overall cost;
- increased customer control and flexibility to capitalise on synergies as they arise from the overall integrated project perspective;
- better customer access to both the head system designer or integrator, as well as subsystem designers and equipment vendors;
- schedule benefits through flexibility to accelerate in selected areas and take advantage of market conditions as they arise;

- transparent cost control; and
- the retention of project contingency by the customer, to be released only if required.

The Engineering, Procurement and Construction Management contractor is usually engaged on a reimbursable fee-for-service basis, although this is commonly mixed with performance incentive arrangements such as a capped fee and or an associated pain or gain share.

The Engineering, Procurement and Construction Management methodology is somewhat aligned with Defence's concept of having a dedicated Combat Systems Integrator, in concert with a Platform Systems Engineering Agent performing the platform engineering. However an Engineering, Procurement and Construction Management Contractor carries a broader program scope beyond engineering integration, in terms of the procurement and construction management elements.

Program Management Contracting

There are many labels for Program Management Contracting (PMC), and many derivations in terms of the level of integration with the Customer's own in-house team. Delivery Partner, Capability Partner, Integrated Owners Team and even a Joint Venture or Alliance between the Customer and an industry partner may all be considered as derivatives of Program Management Contracting.

Program Management Contracting brings to the owner all of the additional program resources (both systems and people) necessary at each phase to develop, engineer, deliver and support the program—beyond those that the customer is able to provide himself. The team is established as an integrated Program Management Office (PMO) fully responsible for all aspects of program delivery.

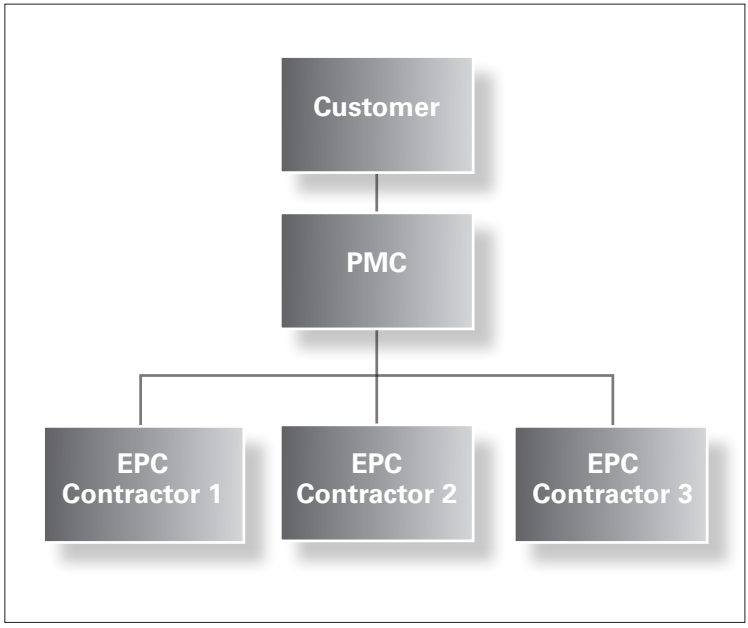


Figure A2. Typical Project Management Contract Program Structure

This is a flexible, industry-inclusive, model that enables the assured delivery of value-for-money program outcomes through the adoption of an array of different contracting strategies at different levels within the program hierarchy and at different program phases. In this way, competition can be sought where and when appropriate as a means for placing risk and delivering value through lump-sum pricing for elements of work or material/equipment systems, whilst, for example, sole sourcing other elements having more developmental risk during early program phases on a cost-reimbursable basis. As for Engineering, Procurement and Construction Management, contracts are normally placed directly with others by the customer on the "customer's paper".

For complex programs, it is acknowledged that program management, engineering integration and physical consolidation of

asset subsystems and components may require different skill sets, so the latter two capabilities are normally contracted separately, by the integrated Program Management Office.

Attributes of a Suitable Acquisition Model for SEA 1000

A Collaborative Defence-Industry Approach

Just as for the development of the Air Warfare Destroyer Alliance, bespoke program organisational, commercial and contractual arrangements need to be thoroughly workshopped in order to develop the optimal structure that enables the appropriate engagement of broader industry capability and placement of risk. Whatever the acquisition model developed for SEA 1000, there will be some common challenges and desired attributes. These will include a need for:

- a high level of Defence Organisation visibility and input,
- harnessing extensive resources and expertise from both Defence and industry;
- close collaboration between the Defence Organisation and industry, requiring cultural alignment, integration, and shared objectives and risk;
- the ability to manage global procurement of both services and systems;
- complex technical integration at the Boat-Level throughout the design, procurement and construction phases;
- flexibility and compatibility with the need to accommodate technology insertions over the life of the program; and
- adaptability to migrate to a suitable in service support regime utilising selected participants and capabilities, either those already existing or more suitable alternatives.

Figure A2 illustrates a Program Management Contracting /Delivery Partner construct.

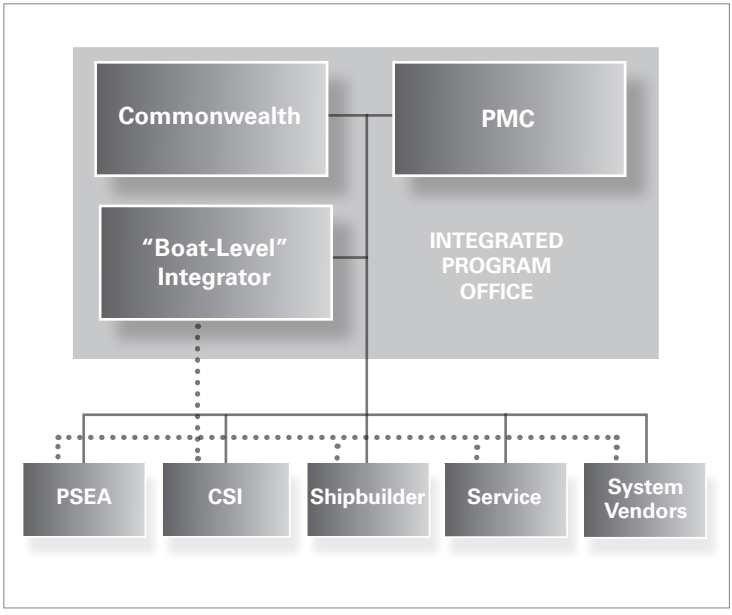


Figure A3 Integrated Program Office

Boat-Level Integration

Past naval shipbuilding acquisition programs have all involved the services of a Combat Systems Integrator to specify and manage the interfaces between the suite of weapons systems and sensors, procured either directly by the prime contractor or by/through the Combat Systems Integrator on the prime contractor's behalf. Separately, the prime contractor has engaged the original parent ship designer to evolve what has generally been a bespoke design derivative to meet the Navy's needs.

The concept of the Platform Systems Engineering Agent has been put forward in order to establish an on-going, in-country Design Authority for the Class. Whether or not the role of Design Authority resides with the original ship designer or alternatively with a

Platform Systems Engineering Agent, there remains a dichotomy in having separate Platform and Combat System Design Authorities (the later role being part of the Combat Systems Integrator).

It has invariably fallen, almost by default, to the prime contractor to undertake the overall integration of the platform and combat systems at the ship-level in order to achieve the contracted performance specification. This is not only from the engineering perspective, through the ship designer and Combat Systems Integrator, but additionally through the physical consolidation of systems and equipment at the shipyard. This has necessitated close control (usually through establishment and ownership by the prime contractor) of the shipyard and its associated requisite experienced workforce.

For submarines in particular, the boat-level integration task (both engineering and physical) is critical. This is particularly in terms of the need to apply a consistent philosophy and implementation of the associated "science" of EMI/EMC, shock and vibration isolation, and acoustic and magnetic signature management throughout the design, procurement and construction phases.

ABOUT THE KOKODA FOUNDATION

Purpose

The Kokoda Foundation has been established as an independent, not-for-profit think tank to research, and foster innovative thinking on, Australia's future security challenges. The foundation's priorities are:

- To conduct quality research on security issues commissioned by public and private sector organisations.
- To foster innovative thinking on Australia's future security challenges.
- To publish quality papers (The Kokoda Papers) on issues relevant to Australia's security challenges.
- To develop Security Challenges as the leading refereed journal in the field.
- To encourage and, where appropriate, mentor a new generation of advanced strategic thinkers.
- Encourage research contributions by current and retired senior officials, business people and others with relevant expertise.

Membership

The Kokoda Foundation offers corporate, full and student memberships to those with an interest in Australia's future security challenges. Membership provides first-release access to the *Kokoda Papers* and the refereed journal, *Security Challenges*, and invitations to Foundation events. More details are available on the Kokoda Foundation website or by calling +61 2 6295 1555.

http://www.kokodafoundation.org/

Kokoda Paper No 17, January 2012

Sub Judice: Australia's Future Submarine

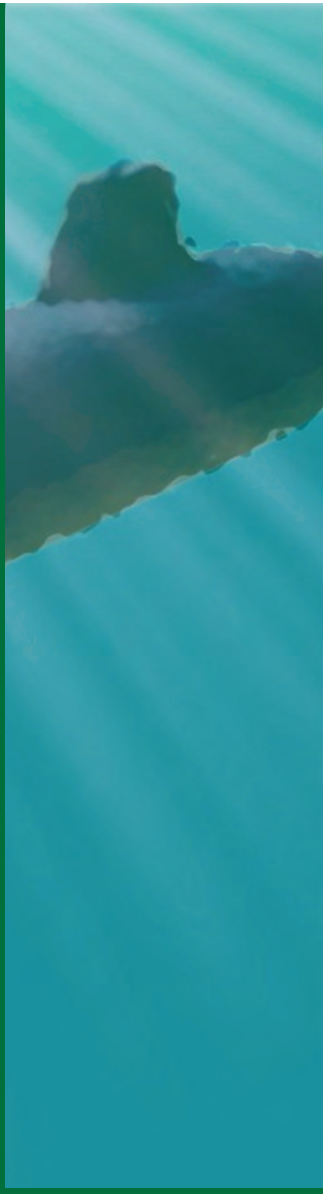
Since the Second World War, Australia's strategic geography has helped insulate it from the ambitions of regional competitors and the centres of great power conflict. But the influence of geography is not static. The benefits have accrued from Australia's membership of a dominant maritime alliance and through access to technologies that have helped maintain a capability edge in the maritime domain.

In the 21st Century new powers are rising and deploying new asymmetrical military technologies that threaten to weaken some of the advantages of geography and technology on which Australia has traditionally relied. There are developments underway which may progressively erode the freedom of movement of Australian and allied naval forces and maritime trade.

To meet these challenges during the decades ahead, Australia will require a reinvigorated strategy and investment in force elements that are not only potent, but also survivable in an increasingly complex and potentially dangerous maritime environment.

Submarines and their operations will be central to any viable strategy. They may be the only force structure elements capable of persistent operations in a maritime region that is fundamental to Australia's interests.

The purpose of this Kokoda study has been to assess how best to deliver a submarine capable of meeting a unique requirement for range, endurance and stealth, able to operate over the vast distances inherent in Australia's strategic geography and to exploit the depth that it affords.



Kokoda Foundation

About the Kokoda Foundation

The Kokoda Foundation has been established as an independent, not-for-profit think tank to research, and foster innovative thinking on, Australia's future security challenges. Visit our website at www.kokodafoundation.org

ISSN 1833-0185