Public Policy Report to

Submarines for Australia

Insight Economics

Public Policy Corporate Strategy

Australia's Future Submarine

Getting This Key Capability Right

September 2017

Insight Economics Pty Ltd

ACN:141 097 565

ABN: 29 627 712 906

Cover: *Collins* class submarine HMAS *Sheean* at anchor in Darwin Harbour with diesel generators running, Exercise KAKADU, September 2016.

CONTENTS

GLOSSARY OF ACRONYMS

A2/AD	Anti-access/area denial
ADF	Australian Defence Force
ADFA	Australian Defence Force Academy (University of NSW)
AEW&C	Airborne early warning and control aircraft
AIP	Air independent propulsion
AO	Area of operations
ANAO	Australian National Audit Office
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ASC	Australian Submarine Corporation
ASW	Anti-submarine warfare
ASuW	Anti-surface ship warfare
AWD	Air warfare destroyer
ASPI	Australian Strategic Policy Institute
C3	Command, control and communications
CAD/CAM	Computer assisted design/computer assisted manufacture
CAPEX	Capital expenditure
CEP	Competitive Evaluation Process
CMS	Combat management system
DCNS	Direction des Constructions Navales Services
DMO	Defence Matériel Organisation
EEZ	Exclusive economic zone
FCD	Full cycle docking
FSM	Future submarine
FSP	Future Submarine Project
GDP	Gross Domestic Product
IP	Intellectual property
ISR	Intelligence, surveillance and reconnaissance
LOTE	Life of type extension
MOTS	Military off-the-shelf
MPA	Maritime patrol aircraft
NPV	Net present value
PLAN	People's Liberation Army Navy (China)
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RFT	Request for tender
RN	Royal Navy (UK)
ROV	Remotely operated vehicle
SF	Special forces
Shortfin Barracuda	Shortfin Barracuda
SLOC	Sea lines of communication
SSBN	Ballistic missile nuclear submarine
SSGN	Guided missile nuclear submarine
SSK	Conventionally powered attack submarine
SSN	Nuclear powered attack submarine
SUBFOR	Submarine Force (Australia)
T&E	Test and evaluation
tkMS	thyssenkrupp Marine Systems
TLAM	Tomahawk land attack missile
UAV	Unmanned aerial vehicle
UUC	Usage and upkeep cycle
UUV	Unmanned underwater vehicle
USN	United States Navy
VLS	Vertical launch system

PREFACE

By Gary Johnston, Submarines for Australia

It was not without considerable forethought that I decided to commission Insight Economics to produce an analysis of the decision by the Australian Government to select the French firm Naval Group to make Australia's future submarines. After all, why would a businessman, with no previous links to military matters have any basis to criticise this decision?

Actually, that motivation turned out to be easy!

For some time now, my business associates and I have been concerned about the failure of Defence acquisitions and the waste of taxpayers' money associated with that. About 20 years ago, for example, the government decided to acquire Seasprite helicopters for the *Anzac* frigates. One of the fundamental flaws in the SeaSprite purchase was the attempt to build a custom solution to our perceived ASW helicopter needs. This procedure – in industry parlance – is to build an 'orphan' rather than take the safe (but perhaps less than ideal) route of buying a proven off-the-shelf helicopter, generally at a fixed price.

The result was that $1.4 billion was spent over eight years with absolutely no result – not even a single helicopter. All that money, which could have been used to build two new fully equipped teaching hospitals, was completely wasted. Not only that, but the frigates were left without an ASW helicopter for about half their lives, leaving a major capability gap in Australia's defences.

So when the Government announced the decision to make another custom piece of military hardware, this time at the eye-watering price of $50 billion, the alarm bells rang.

The submarine acquisition is far bigger and more important than the SeaSprites and if anything goes wrong the consequences could be huge. In a period where our part of the world is becoming a more dangerous place, we could be left with no submarine capability at all for a decade or more.

As numerous Senate inquiries have pointed out, Defence doesn't understand how to deal with risk when making investment decisions. When analysing alternative options for investment in military hardware, they need to involve people who are totally independent from the process, people with a financial or commercial background who understand how to generate better outcomes with an appropriate adjustment for risk. Of course, Defence would still have a role, but mainly as military and technical advisers.

The people at Insight Economics have produced this independent report in a thoughtful, balanced way. I urge you to read this document and draw your own conclusions. It is not (of course) the last word on the matter, but it just may help to get the debate back into a rational position and (hopefully) get us some submarines to protect us before we have none left.

For further information on Gary Johnston check www.submarinesforaustralia.com.au for details.

FOREWORD

The origins of this report lie in widespread concern in the Australian community in general, and among defence experts, economists and public policy specialists in particular, following the government's announcement that Australia's future submarine would be the French designed Shortfin Barracuda. Since this may well be the largest public investment in Australia's history, these concerns are legitimate and need to be addressed.

The main concerns are the:

- Suitability of the proposed acquisition having regard to the most likely strategic risks facing Australia
- Cost of the proposed acquisition
- Lack of competition and consequent loss of control over future costs
- Extended delivery timeframe with the acute danger of a capability gap
- Associated need for a comprehensive, costly life extension of the *Collins* class
- Significant risks (economic, strategic, technical and industrial) arising from the selection of an untested bespoke design for a very large submarine.

In December 2016, a concerned individual, Mr Gary Johnston (*Submarines for Australia*), commissioned Insight Economics to prepare an independent report on the FSM acquisition. The report would include an analysis of the cost and risks of the project and, if necessary, propose an alternative approach to the acquisition.

The expertise of the principals of Insight Economics lies in economics and public policy. When they formerly worked in government, all four Directors of Insight Economics had significant experience in industry policy – Dr David Charles was Secretary of the federal Industry Department – and have subsequently worked extensively in that domain in the private sector, including in the naval shipbuilding industry. Dr Michael Keating spent eleven years, including five years as Chair, as a member of the senior officials group that coordinated the advice provided to the National Security Committee of Cabinet.

While strategic issues and the technical characteristics of the new submarine are obviously of major importance and are addressed extensively in the report, they have to be considered within a more holistic critical appraisal of a very substantial public investment in military capability. The objective of such an investment should be to provide an adequate defence against the most likely and most potent threats facing Australia at least cost and on the shortest practical schedule while taking full account of the welfare of service personnel. In this respect, we place a high level of importance on assessing the risks involved (and seeing that risk mitigation strategies are incorporated) in this acquisition process. Apart from technical and safety risks, these include strategic, economic and industrial productivity risks, all three areas in which we consider Insight Economics has considerable expertise.

If the issue is framed in terms of the cost-effectiveness of a very substantial public investment, rather than solely in the narrow framework of the technical capability of the various platforms under consideration, we believe that economic and public policy specialists can make a considerable contribution to defence procurement and complement the technical expertise deployed within Defence. As David Mortimer reported in his review of defence procurement in 2008:

> "Defence is well-served with specialist advice on the performance and operational employment of military equipment. Less well developed is its appreciation of the commercial and technical risk associated with military equipment acquisitions. Consistent with this, a number of submissions to the Review suggested that Defence has often pursued a unique Australian solution, or modified an existing solution, without appropriate understanding of the attendant risks to cost, schedule and delivery. It is important that this be avoided in the future. While project requirements must ultimately reflect the demands of operational performance, they need to be tempered by the realities of cost, risk and what the market can deliver off-the-shelf and otherwise. Unless

> this is done, informed decisions about the appropriate mix of cost, schedule, risk and capability are impossible."[1]

Since we acknowledge our limited expertise in the technological attributes of contemporary submarines, we have not attempted to work on this project in an economists' vacuum. We are particularly grateful for having had the opportunity to discuss these issues with senior officials at the Department of Defence, including the head of the SEA 1000 programme, Rear Admiral Greg Sammut, AM CSC RAN. In order to complement our skills in producing this report, we have consulted many experts, several of whom have formerly held senior positions in the Department of Defence.

Throughout this study we have worked closely with two defence specialists who have provided expert advice and reviewed earlier drafts of this report:

- Professor Hugh White AO, Strategic and Defence Studies Centre at the Australian National University, who, in our view, has an unparalleled reputation in Australia for his expertise in defence strategy and force structure. Hugh White was formerly a Deputy Secretary in the Department of Defence where he made a substantial contribution to the 2000 White Paper.
- Rear Admiral (retired) Chris Stanford CB, Royal Navy, a highly experienced former anti-submarine warfare commander who also led on defining and agreeing the joint requirement for an Anglo-French 'Future Frigate' which became the Type 45 destroyer. He also produced a detailed report for Ministers on the UK's submarine operational capability in advance of the entry into service of the *Astute* class.

We have benefited greatly from consultations with a number of engineering experts, including Dr Keith Joiner CSC of ADFA (previously the head of Test and Evaluation in Defence), Dr Simon Reay Atkinson (Centre for International security Studies, University of Sydney) and Mr Keith Snell of SMA Pty Ltd (whose earlier career included 21 years in Defence as an electrical engineer engaged in naval systems and ship/submarine project management and construction). We have also had extensive discussions with a number of defence experts, including Dr Andrew Davies and Dr Mark Thomson at the Australian Strategic Policy Institute (ASPI). As well as having had discussions with defence industry specialists, we have also benefited greatly from the views of former RAN personnel, including two former commanding officers of submarines. We have particularly enjoyed lively discussions with Rear Admiral (retired) Peter Briggs AO, CSC, a former head of the New Submarine Capability Team.

We are greatly appreciative of the assistance and advice provided by all these individuals. Nevertheless, none of them bear any responsibility for the views put forward in this report, and any fault for errors or omissions remains with the principal author, Jon Stanford of Insight Economics.

The report is structured as follows:

- Chapter 1 contains a brief discussion of the importance of submarines in the ADF's order of battle
- In Chapter 2 some overarching issues around defence procurement are discussed, including the relative merits of off-the-shelf versus bespoke acquisitions and the risks involved
- Chapter 3 contains a review of the acquisition process that the government has followed with respect to the FSM
- In Chapter 4 we discuss the economic risks in the project

[1] Mortimer, David (2008), *Going to the Next Level: Report of the Defence Procurement and Sustainment Review,* Department of Defence, Canberra, page 17.

- An evaluation of the strategic risks around the FSM acquisition is contained in Chapter 5
- Chapter 6 contains an analysis of the technical risks in the proposed Shortfin Barracuda acquisition and also in the need to extend the life of the *Collins* class submarines
- Industrial risks are evaluated in Chapter 7
- In Chapter 8 we propose an alternative way forward.

At the beginning of the report an Executive Summary and Conclusions are presented.

EXECUTIVE SUMMARY AND CONCLUSIONS

This independent report by Insight Economics, sponsored by Mr Gary Johnston (*Submarines for Australia*), presents an analysis of the government's decision on the acquisition of twelve future submarines (FSM) for the Royal Australian Navy under the SEA 1000 programme. In preparing this report, we have benefited from extensive discussions with a large number of experts in the areas of strategic analysis, submarine capability and operations, engineering and defence industry.

In April 2016, the government announced that the French company DCNS (now 'Naval Group') had been selected as Australia's partner to design Australia's FSM, the Shortfin Barracuda. Including a life extension for the *Collins* class submarines, the cost of SEA 1000, at around $60 billion in 2016 prices, is extremely high, while the risks around the programme are very substantial.

After evaluating the government's decision and while not seeking to disrupt current contractual arrangements, we propose a way forward that involves significantly lower costs and risks.

Strategic requirement for the future submarine

Since the decision was made to acquire six *Collins* class submarines in the 1980s, the Asia Pacific region, once regarded as a 'strategic backwater', has moved to centre stage as the United States, since 1945 the undisputed hegemon in the region, has increasingly been challenged by the rising power of China. In recognition of Australia's changing strategic circumstances, the 2009 Defence White Paper stated that the Navy's submarine force would be doubled in size to 12, to be delivered from the early-2020s.

For a middle power like Australia, with a relatively small population and the world's third largest economic zone to defend, a powerful submarine force is a critical element in the ADF's order of battle. The lethal power of submarines and their ability to operate covertly means that they can provide a credible deterrent for a middle power while also acting as an effective force multiplier in support of asymmetric warfare.

The question, therefore, is not whether the Navy needs to renew its submarine capability, but what would be the most appropriate type of submarine for the RAN and how many we need. The answer to these questions inevitably requires the balancing of a variety of considerations so that some trade-offs in terms of different types of capability may be required. But this assessment of purpose must in turn be based on an analysis of the nature of the possible strategic threats to Australia, and their relative likelihood and importance.

The capability requirements for the FSM were first set out in the 2009 Defence White Paper. Derived from evolving Defence thinking over the previous decade, these were highly ambitious. Beyond the traditional roles of defence of Australia and intelligence gathering, the requirement included, for example, the capacity to undertake 'strategic strike', perhaps unilaterally, against a 'major adversary'. Many experts regarded the 2009 capability requirement as a mission statement for a nuclear submarine (SSN) rather than a conventionally powered, diesel-electric boat (SSK).

Our view is that the capability requirement for the FSM was overly ambitious and that any attempt to satisfy it with a SSK of a new and untested design,

apart from being excessively expensive, would inevitably risk compromising the Submarine Force's ability to discharge its most essential operational tasks. In keeping with decades of Australian defence policy, the ADF's most important role, and plainly the highest priority role for our Submarine Force, is to be able to conduct independent operations in the defence of Australia and its closer neighbours. The priority for self-reliant defence will certainly be no lower in the strategic settings we seem likely to face over coming decades than it has been in the past, and arguably will be very much higher. Further, the circumstances in which Australia may stand alone are those in which the capabilities of our own submarines would be most important to us.

In that case, and in an era when surface ships will become increasingly vulnerable to new weapons such as anti-ship ballistic missiles and hypersonic cruise missiles, the most important task for Australian submarines would be to enforce anti-access and area denial (A2/AD), particularly around the sea lines of communications (SLOCs) to Australia's north. Sea denial is the critical element in preventing an invasion of Australia, which otherwise, with our relatively modest land forces, we could not expect to defeat. As the Australian Strategic Policy Institute (ASPI) has stated, "our main and indeed sole maritime operational objective in a major power war would not be sea control but sea denial".

In any conflict, this task, of effectively prosecuting sea denial by patrolling the SLOCs and sinking hostile warships and submarines, would require a strong force of submarines. Very limited submarine resources, if any, would be available for other missions with a lower priority, such as land attack operations 'up threat' in the South China Sea or north Asia. For example, even with a force of 12 submarines the RAN would be doing well to have four boats in their areas of operations (AOs) at any one time. This is likely to be an inadequate force for prosecuting sea denial. The same ASPI report suggests that a minimum of 24 submarines would be required to enforce sea denial effectively in Australia's northern approaches.

The *Collins* class has a range of around 12,000 nautical miles and an endurance of up to 70 days at sea, and the requirement for the FSM is similar. This long range and high endurance reflects a major problem facing Australia's Submarine Force, namely the lengthy transits required between the base at HMAS *Stirling* near Fremantle and the AOs to Australia's north. Total transit times can be around four weeks, so that including time on patrol, a single mission for a RAN submarine may last between seven and ten weeks, with almost all of that time spent submerged. A *Collins* class submarine generally carries a crew of 48, compared with a complement of 185 on an *Anzac* frigate, a similar sized but perhaps less complex platform. Intelligence, surveillance and reconnaissance (ISR) missions, which provide Australia with valuable coin in the 'Five Eyes' intelligence sharing arrangements, are intensive. Fatigue becomes a problem. While establishing a forward base could help address this issue, Defence is generally opposed to offshore bases mainly because of their vulnerability in any conflict and the resources required for their defence.

Apart from capability ambitions, however, long transits are another reason why there is a view among some in Defence that Australia requires nuclear powered submarines. The present assumption is that, in any major conflict, Australian conventional submarines will mainly be used in coalition operations in which their capability in the relatively shallow waters of the

littoral zones would provide a valuable complement to the US Navy's all-nuclear submarine force. In addition, the costs of operating and sustaining SSNs would be daunting for an economy of our size – Britain has seven and France has six. One recent estimate suggests the whole of life costs are four to six times greater for a SSN than a SSK. Within the ADF's requirements for a balanced force structure, this would mean that acquiring more than six SSNs would be unlikely. Taking account of the routine maintenance cycle, only two boats would be on patrol at any time. Despite the greater capability of SSNs, this would not constitute an adequate force to undertake essential operational tasks and, in any conflict, enforce effective sea denial.

In any case, particularly for a country without a nuclear industry, there are significant barriers to acquiring nuclear submarines. Apart from onerous training requirements in a nation that produces no nuclear engineers, it would take at least 15 years to establish the required hard and soft infrastructure and the regulatory framework to operate SSNs. Without a strong bipartisan political commitment to nuclear submarines, such a policy seems impractical, at least while the US remains fully engaged in the region.

Acquisition options and the hierarchy of risk

As is true of many countries around the world, Australia has a chequered record in its acquisitions of military hardware. If anything, Defence procurement performance has deteriorated in the twenty-first century, where there has been a succession of high profile failed acquisitions. An oft-quoted example is the Super Seasprite helicopter, where $1.4 billion was expended for precisely no result. Even this substantially understates the cost, since it fails to account for the fact that the Navy's *Anzac* frigates were left without an essential airborne anti-submarine capability for most of their lives.

A number of expert investigations and Parliamentary reports on military procurement have concluded that Defence repeatedly proposes over-ambitious capability requirements that push against or beyond the barriers of currently available technologies. A consistent conclusion of these reports is that Defence should only seek to acquire a platform that goes beyond what is available as a military off-the-shelf (MOTS) solution if the ADF genuinely has a unique capability requirement. Another conclusion is that Defence should always undertake a competitive process to ensure that it achieves value for money and should always include a MOTS option in the process.

The government's decision on Australia's largest ever defence acquisition, the FSM, needs to be considered within this context. Arguably, submarines are the most complex military platforms in existence and the steady drumbeat of technological advance means that they are becoming more complex all the time. It is a sobering thought that the greatest breakthrough in submarine technology in recent times, the first nuclear-powered submarine, was delivered in a time frame that contemporary navies can only envy. Under the guiding hand of Admiral Hyman G. Rickover, the USS *Nautilus* was authorised in 1951 and undertook her maiden voyage less than four years later.

Modern submarine projects, mainly using established technologies, regularly overrun their delivery schedules by considerably more than the four years it took to build the revolutionary *Nautilus*. Generally, so as to minimise risk, most new submarine classes are evolved from existing designs. Very few nations invest in *ab initio* designs of submarines and those that do often

experience major problems. For example, the latest British SSN, the *Astute* used the same reactor as the previous class but was constructed in a shipyard that had not built a submarine for a long time and was delivered five years late and substantially over budget. The first Spanish S-80 submarine was originally intended for delivery in 2011 but had a serious design flaw and is now expected to be delivered in 2021 – probably without an AIP system, which was seen as a key capability. Even Russia, which has a highly successful record in submarine design and construction, is having major problems with its new Lada class boats. The lead submarine of the class, the *St Petersburg*, underwent sea trials in 2005 but is yet to become fully operational.

A clear danger for Australia is that, once again, we may have failed to pay heed to the painful acquisition lessons of the past. About ten years ago the RAN conceived a need for a very large submarine with habitability standards consistent with a long endurance and the ability to carry a substantial payload to north Asia. In 2014, the then Defence Minister proposed a requirement for a long-range submarine with "a comparable capability to a nuclear submarine but with diesel–electric motors". Since this concept of a SSK with the same capabilities as a SSN is essentially oxymoronic, there was a high risk the FSM would fall between two stools and not be best suited to meeting Australia's essential strategic needs.

Four options were initially considered for the FSM:

- A MOTS acquisition
- A MOTS submarine modified to meet the RAN's requirements (MMOTS)
- An evolved *Collins* class design
- An *ab initio*, developmental design.

These four options represent an escalating level of risk. The first two least risky options were discarded because Defence considered that, with lengthy transits and far distant AOs in North Asia, no MOTS-based boat could offer the required endurance while meeting contemporary standards of habitability. This conclusion is contestable, particularly if only essential capability requirements are specified and if ancillary approaches, such as forward basing, are considered. Defence also ruled out an evolved *Collins* class. In view of the fact that *Collins* is now performing very well and an evolutionary approach to submarine development is regarded globally as a lower risk option, this decision also is contentious. As a result of these choices, only the most risky option possible, a new bespoke design, remained on the table.

Acquisition decision: the Competitive Evaluation Process

Following an attempt to procure *Sōryū* class submarines on a MOTS basis from Japan, in 2015 the Abbott government established a 'competitive evaluation process' (CEP) to select a design partner for the FSM. Three submarine builders, Naval Group (France), tkMS (Germany) and Mitsubishi (Japan) were invited to develop pre-design concepts for a submarine that could deliver the Navy's ambitious capability requirement.

Defence selected Naval Group as its sole design partner based on its concept submarine, the Shortfin Barracuda, an *ab initio,* developmental design, based on the nuclear-powered Barracuda (*Suffren* class) submarine that has

yet to put to sea. Delivery would be from the early 2030s to 2050. Neither of the game changing technologies for SSKs, air-independent propulsion (AIP) and Lithium-Ion batteries, was included. [#]

Why has Defence gone down this path and elected not to take the customary and far less risky next step of funding the top two or three contenders to proceed to the project definition stage (PDS) and competitive tenders? One theory was that the French contender was a Trojan horse and that the nuclear-powered *Suffren* will emerge, like a *deus ex machina,* at some point down the track. The government has denied this and, given the practical and political constraints, it would be a difficult policy reversal that would also require a very long lead time. But noting that the objective of the CEP was to select a partner rather than a submarine, only by selecting Naval Group from the three contenders could Australia procure an *option* to acquire a SSN later if circumstances changed. For example, the strategic environment might deteriorate ('America First') or the design for the Shortfin Barracuda may turn out to be unsatisfactory or unworkable.

Putting the SSN theory to one side, we believe that over the last decade the RAN's preferred strategy has been effectively to design its own ideal submarine. We understand that in the early years Defence will provide half of the FSM design team, which only serves to reinforce this view. By first proposing a 'nuclear submarine with diesel-electric motors', essentially a blank canvas of a platform with the nuclear-related components stripped out, only Naval Group offered the Navy the opportunity to pursue this ambition to the fullest extent. Yet the project appears already to have changed significantly from the time of the announcement in April 2016. What started as an unlikely conventional version of the nuclear-powered Barracuda then became a completely new design and latest reports suggest it has now become an evolved version of Naval Group's export SSK, the Scorpène. If so, this would represent an heroic (and consequently risky) evolution, since the submarine that the RAN favours would be over twice the size of the Scorpène, and therefore very different.

A major drawback of the CEP is that because the objective of the process was ostensibly to select a design partner for Defence rather than a platform, none of the safeguards that have carefully been constructed around Defence acquisitions following earlier failures came into play. The hurdles established by the Kinnaird and Mortimer reports were not relevant. There was no competitive process, where two or three contenders would vie with each other to produce a PDS and then, at least in the past, offer a fixed price for delivery of a platform. There was no MOTS option to be used as a benchmark against which Defence's preferred solution should be assessed in terms of capability, schedule and value for money. Finally, it appears there was very little Cabinet consideration of this enormous investment. While the National Security Committee of Cabinet met five times to consider the air warfare destroyer acquisition, which was basically a MMOTS platform,

[#] AIP allows a submarine to remain fully submerged for up to three weeks without having to snort (snorkel) at shallow depth. Lithium-Ion batteries have a higher energy density than lead-acid cells and can be recharged in a shorter time as well as providing greater submerged endurance. Both these technologies reduce a conventional submarine's indiscretion ratio, that is the amount of time it spends near the surface snorting (running its diesels to recharge batteries) in any 24 hours, when it is most liable to be detected.

Ministers had only a very limited time around the Anzac day long weekend to consider Defence's much more complex, costly and risky FSM proposal.

Perhaps the most disturbing issue, however, is that the process eliminates all further competitive pressure after April 2016. With merely a pre-design concept for the FSM, Defence currently has only a non-binding cost estimate and a delivery date that, from a strategic perspective, already appears to be unacceptable. Despite the excessive budget for the project, the risks are extremely high. Going forward with just one design has resulted in Defence gifting to Naval Group almost complete market power over capability, price and delivery. Should the design turn out to be inadequate or unworkable, the implications for Australia's future submarine capability would be dire. Unlike military aircraft or artillery, submarines cannot be acquired expeditiously to fill an unexpected capability gap. There are therefore two sets of concerns that we think need to be addressed:

1. The excessive cost of the FSM project and the risks involved, and
2. An unacceptable future capability gap in Australia's submarine fleet because of the delay in the new submarines becoming operational, delays which may well increase.

These two sets of concerns are inter-related and are discussed successively below.

Excessive whole of life cost of the FSM

The headline cost of the FSM project, excluding the combat system, is $50 billion in what Defence calls 'future dollars'. While this estimate is somewhat opaque, ASPI has calculated the acquisition cost of the FSM at around $40 billion at 2016 prices, or over $3 billion per boat. Including the combat system ($6 billion) and the reported cost of the possible *Collins* class LOTE ($15 billion), the acquisition budget for the FSM is around $60 billion at 2016 prices. By comparison, most diesel-electric submarines cost less than $1 billion, although admittedly these are all much smaller than the Shortfin Barracuda. The unit cost of Japan's most recent *Sōryū* class submarine, a relatively large platform about the same size as *Collins*, was around $750 million.

Of course, whole of life costs are also very important and, with only six units, the *Collins* class, for which Australia has parent navy responsibilities, has been egregiously expensive to maintain. The rule of thumb for whole of life sustainment costs is to multiply the acquisition cost by three. This gives a total cost estimate, including FSM acquisition, combat system, through-life sustainment and a possible *Collins* LOTE of $180 billion at 2016 prices. This seems a very excessive, if not unacceptable, price to pay for the capability offered by twelve conventionally powered submarines.

Excessive risks

Apart from the excessive cost of the Shortfin Barracuda, the project comes with risks that are extremely high. These risks are analysed under four headings.

Strategic risks. By far the most important risk around the FSM is that, because of the delivery schedule and the probability of further delay, from the early 2030s Australia will be left with a submarine capability that is either seriously inadequate or, in the worst case, non-existent for several years. This capability gap is analysed in more detail below. A second issue is

whether, in light of nature of the strategic threats facing Australia, we are procuring the best available submarine capability. Because of its size and likely relatively high indiscretion ratio, Australia may be acquiring a submarine less well-suited to essential operations where a high degree of stealth, agility and the ability to operate in shallow waters will be required. Because of the high unit costs of these very large submarines, it is also likely that an appropriately sized fleet will be deemed unaffordable.

Economic risks. Not only is Australia paying far too much for twelve conventional submarines, but there is a high probability, based on previous experience with large, developmental military projects, that the cost will blow out by up to 50 per cent and the schedule will be delayed accordingly. Defence's decision to eliminate all further competition from the process effectively increases these risks substantially. This could mean that Navy will be able to acquire fewer submarines than are currently budgeted or that other Defence programmes will need to be cut.

Technical risks. Engineering experts consider the technical risks around the Shortfin Barracuda to be high. It will be a very large conventional submarine and the engineering challenges are formidable. Most surprisingly, the present concept design does not incorporate modern batteries or AIP, considered by most experts as essential in a future operational environment where submarine detection technologies will have improved significantly. China is installing seabed acoustic sensors in the South China Sea and its latest anti-submarine helicopters are believed to be able to detect a snort mast at up to 70 kms range. In addition, a bespoke design such as this needs to be subjected to extensive preview test and evaluation of its most important systems, an area where little progress appears to be occurring.

Industrial risks. In the 2016 White Paper it was stated that the FSM would be built in Australia only if it could be done "without compromising capability, cost or the project schedule". This sensible policy was rapidly abandoned. RAND has found that building warships in Australia costs 30 to 40 per cent more than overseas. The air warfare destroyers project will deliver three ships three years late and at three times the cost of an overseas build. There are also major industrial risks to the project because Australian industry has not built a submarine for fifteen years. The corporate memory as well as the remnants of the management and workforce with submarine building experience all reside in ASC, yet Naval Group is setting up a new facility to build the submarines. When a very experienced British shipbuilder started work on the *Astute* SSN, it also had not built a submarine for many years and much of the experienced workforce had been lost. The submarine was delivered five years late and greatly over budget.

The Future Capability Gap

The most immediate and possibly the biggest risk flowing from the decision to acquire the Shortfin Barracuda – a submarine that is yet to be designed, let alone built – is the inevitable long schedule for its delivery. Even on the best possible scenario where everything goes according to present plans, the first Shortfin Barracuda becomes operational only in 2033, while the *Collins* Class submarines are scheduled to be progressively withdrawn at the age of 30, between 2026 and 2033. Even then, under these very benign circumstances where everything goes according to plan, the Navy will have only one submarine in 2034 and perhaps four by 2040. This capability is clearly inadequate.

An alternative and more likely scenario, however, is that, in line with other developmental submarine projects around the world, the cost and schedule of the FSM blows out significantly. In that case the number of new submarines to be acquired could be reduced perhaps to eight, with the first entering service in 2040. Apart from the increased threat to national security from this substantial capability gap, the Submarine Force would then suffer increasingly from a lack of well-trained and effective personnel, and its capabilities would need to be re-built out into the 2050s. At the same time, the number of platforms would be clearly inadequate.

By comparison, the 2009 Defence White Paper proposed a doubling of Australia's fleet of submarines, with most of these new submarines to be in the water by the early 2030s. Since 2009, the security environment in the Asia Pacific has become more threatening. It is unlikely to improve over the next two decades and a prudent government would prepare for the situation to get considerably worse. One possibility, flagged as remote in 2009, is that Australia could become involved in a conflict with a major adversary without the support of the United States. Submarines are some of the best assets available for a middle power to prosecute asymmetric warfare. Thus Australia now needs a greater submarine capability than was envisaged in 2009.

The most urgent imperative for the government, therefore, is to address the high probability of a future capability gap in Australia's Submarine Force. There are essentially two options:

1. A life of type extension (LOTE) of the *Collins* Class submarine, or
2. Acquire a fleet of new MMOTS submarines

These options are explored below.

Option 1: Collins *class life extension*

The *Collins* class was designed for a thirty-year life. On that basis, the six submarines will reach the end of their effective lives between 2026 and 2033, when the first FSM is scheduled to enter service. In fact, if there were any slippage at all in the delivery of the FSM, the *Collins* class would need to operate into the 2040s. If the *Collins* submarines were to be used to fill the expected future capability gap they would need a comprehensive life extension This raises major technical and financial issues.

First, from a technical perspective it is not feasible to upgrade the capability of a 1980s platform design like *Collins* to contemporary standards, particularly to the minimum level that will be required in the Asia Pacific in the 2030s, let alone the 2040s. Australia's unilateral project to extend the life of its US-designed FFG-7 frigates provides a salutary warning of the problems involved in putting new wine into old bottles. As reported in *Defense Industry Daily*, "FFG-7 updates were problematic, thanks to very little reserved space for growth, and the inflexible, proprietary electronics of the time. Indeed, they were so problematic that the US Navy gave up on the idea of upgrades to face new communications realities and advanced missile threats." Nevertheless, Australia went ahead with the LOTE. The project blew out by up to seven years and only four of the six ships could be upgraded within the budget, with the end result being that the upgraded FFGs could only "perform the full range of naval duties to varying levels in low to medium threat environments".

A LOTE for a submarine would be much more complex and risky than for a surface warship. One aspect is that the hull would need to be strengthened and re-certified for deep diving. This alone can cost $1 billion per boat, or by itself more than the acquisition cost of a new, advanced MOTS submarine with a thirty-year life. Even in 2008, the Submarine Institute of Australia (SIA) stated that it is not "an option to extend *Collins* since … the capability gap between the 1987 specification and contemporary needs is increasing. … The *Collins* class currently lacks any design margins (space, ship stability, power, cooling etc.) to sustain significant capability enhancements to meet the increasingly demanding environment and new requirements." A decade later, with rapid advances in the capability of regional submarine fleets, these arguments are even more compelling.

Secondly, we understand the cost of extending the life of *Collins* for ten years is around $15 billion, nearly ten times the cost of the FFG-7 LOTE and equivalent to acquiring more than 15 new MOTS submarines. In terms of the moderately enhanced capability that at best could be provided, which would not include AIP, and the very high technical risks, this cannot represent value for money for an additional ten years' life, particularly if the upgraded boats cannot safely be sent into harm's way. To quote the SIA again from 2008, "a life extension programme is therefore likely to be a poor return on investment. It is a distraction and will result in a serious capability gap."

Option 2: Acquisition of new MMOTS submarines

We consider that a better alternative to the Collins LOTE would be to take action now to acquire a new fleet of MMOTS submarines. To address Defence's concern with the capacity of smaller MOTS submarines to undertake the lengthy patrols required by the RAN, we also propose the acquisition of a submarine tender that could be forward based.

Given Australia's present circumstances and the strategic outlook, there is a recent precedent for this. By 2007, it had become clear that a life extension of the RAAF's fleet of F-111 fighter-bombers as planned would not be technically feasible. It was also evident that the F-35 joint strike fighter, designed to succeed both the F-111 and Australia's F/A-18 'Classic' Hornets, would be delayed. With the probability of a capability gap in Australia's air defence, then Defence Minister Brendan Nelson took prompt action, with no competitive process, to order 24 Super Hornet MOTS aircraft to fill the gap. This was followed by further orders when the Rudd government came to power. These actions were heavily criticised by some at the time. They are not criticised now. Unlike military aircraft, however, it is not possible to procure new submarines within a short timeframe. Modifying a submarine's design and then building it necessarily takes time. It is therefore necessary to take action now.

Accordingly, we propose that while continuing the design phase for the Shortfin Barracuda with Naval Group as contracted, the government should not proceed with the planned LOTE of the *Collins* class. While *Collins* should be equipped with updated sonars and communications systems as currently being undertaken, the comprehensive LOTE is too costly and risky and could make the capacity problem worse. There are more efficient and cost-effective ways available to address a capability gap than by undertaking a *Collins* LOTE.

If action had been taken a few years ago, perhaps the best way forward would have been to build an evolved version of the *Collins* class. Most

nations with a national submarine capability adopt an evolutionary approach to procuring new submarines. But this opportunity effectively passed in 2013 when the government shut down ASC's design house, Deep Blue Tech. The risks around resuscitating Collins Mark II now are, in our view, too great to be confident of avoiding a capability gap in the timeframe available to us.

The inescapable conclusion is that the only way to be confident of bridging the looming capability gap is to acquire a submarine based on a MOTS platform.

In practical terms, there is no such thing as a purely MOTS submarine. They are always modified in some way, if only to meet the standards of the nation acquiring them. But most modern MOTS submarines, especially those designed for global markets, have the flexibility in their design to allow for modifications desired by different customers. In practical terms, the only two competitors for an Australian MMOTS platform would be the Naval Group Scorpène and the German Type 212 (tkMS), the two submarines that recently competed for a Norwegian acquisition. The Navy has already rejected the Japanese *Sōryū* and the Swedish A26 is not yet operational and so cannot be classified as being off-the-shelf.

While in principle, the best approach for acquiring a modified MMOTS submarine would be to invite these two contractors to prepare a PDS and fixed price tender, in Australia's present situation there are some practical problems in this approach. The main issue is that the government has entered into a strategic partnership with the French government and Naval Group to develop its future submarines. In addition, if the Government has a strong preference for building the MMOTS submarines in Adelaide, and a non-French submarine were selected, there could be problems with introducing a third design and construction approach for submarines. With Naval Group establishing a facility to build submarines in Adelaide and supplying companies qualifying on the French Dassault CAD system, these problems would be avoided if the French Scorpène were chosen for the new MMOTS submarines. In addition, the Shortfin Barracuda will be derived in large part from the Scorpène and will have many common components, leading to scale advantages and benefits for the supply chain. Apart from these industrial benefits, with Australia's submarines coming from the same family, training will be greatly simplified.

Yet while these issues would clearly place Naval Group in a highly advantageous position, the government-to-government agreement does not require Australia to build to a French design if that design turns out to be unsatisfactory or too expensive. In the case of the Scorpène, there is also the issue that comprehensive classified data on its performance were leaked to the media in 2016. Naval Group would need to show that effective action had been taken to nullify the effects of this security breach. It would also be highly desirable to impose some competitive pressure on Naval Group to ensure that Australia gets the best capability that can be provided in a MMOTS package, at the right price in a fixed price contract and within an acceptable delivery timeframe. As we have stated in our report, Naval Group has had a patchy record in delivering the Scorpène outside France.

Therefore, while aware of the difficulties, our proposal is for the government to invite both Naval Group and tkMS to prepare a funded PDS and fixed price tender for building their MMOTS submarines for the RAN. Ideally, apart from the need to meet Australian standards, required modifications should be kept to a minimum. They would include additional fuel tanks to

allow for an extended range of up to 10,000 nautical miles with an additional three weeks' endurance on AIP. In order to sustain the required high levels of interoperability with the US Navy, an advanced US communications suite would need to be integrated with the boats' combat systems. The contenders should prepare fixed price tenders for building the submarines in both Australia and overseas. They would need to be delivered between 2026 and 2034.

Even though the development of the PDS would be funded by Defence, it may be that tkMS will decline this invitation to compete with Naval Group, which is the government's submarine design partner and has the advantage of having established a shipbuilding position in Adelaide. In that case, the fall back position with Naval Group would be a negotiation on price, delivery and a satisfactory resolution of the security issues relating to the performance of the Scorpène. The approximate cost of the Scorpène in various markets is in the public domain and presumably Naval Group would recognise the benefits of providing a mutually satisfactory outcome at this early stage in what could be a long partnership.

This solution is not ideal but it does have some advantages. Importantly, it requires no change to existing policy since it only replaces the proposed *Collins* LOTE, on which we understand no decision has been taken, with a cheaper, far less risky and more effective option. If the new submarines were built in Adelaide it would relieve pressure on the Valley of Death, which currently is giving rise to unfortunate decisions such as constructing the first two OPVs in Adelaide and the rest in Perth, and developing new facilities for building the future frigates before the designer and contractor have been chosen. Instead, if the process began this year, construction of the new submarines could commence in 2020 and more sensible arrangements could be put in place for the surface ship acquisitions, particularly allowing ASC/Austal participation.

There is an important second element to our proposed way forward. The RAN has generally been opposed to acquiring MOTS submarines for reasons that are understandable. With submarine missions of up to ten weeks, including total transit times of four weeks, the Submarine Force's operations tend to be much longer than those undertaken by the European navies that use the submarines that would be available as a MMOTS acquisition for Australia. RAN crews are subject to a greater workload over a longer period, thereby requiring higher standards of habitability than can be accommodated in a small MMOTS platform. Also the payloads of MMOTS boats are smaller, thereby reducing effectiveness on a long patrol. These are legitimate concerns about MMOTS submarines for the RAN and they need to be addressed.

We also propose, therefore, that the government should acquire a submarine tender. Such a vessel, possibly of around 6,000 to 8,000 tonnes displacement, would act as a 'mother ship' for the submarine fleet and, during peacetime at least, could be forward-based offshore at an Australian territory such as Christmas Island or Cocos Keeling, right on the doorstep of the Submarine Force's AOs. This would greatly reduce transit times as well as compensating for the reduced payload of smaller platforms by providing the opportunity to re-fuel, re-arm and re-provision the submarines. It would also address the fatigue problem by allowing for replacement crews after a patrol, on a fly-in, fly-out basis. By having more submarines on station at any time, together with an enhanced ability to operate in either the Pacific or

the Indian Ocean, a mobile forward base could also effectively act as a force multiplier. In a situation of extreme threat, the tender could be withdrawn to the mainland.

Supported by a tender, the MMOTS submarines would have several advantages over an upgraded *Collins* class. They would have AIP and therefore be able to remain submerged for up to three weeks on patrol where they would be far less liable to detection. They would have smaller crews who would respond positively to much shorter missions and the better lifestyle provided by access to a 'mother ship' in a tropical location and fly in, fly out operations. In terms of value for money, compared with a cost of $15 billion for a *Collins* ten-year life extension with a poor outcome in terms of capability, the MMOTS submarines plus tender should cost less than $10 billion for an advanced submarine capability with a 30-year life. They should also have lower sustainment costs. The investment case is strong.

The submarine tender would also provide significant benefits beyond sustaining the new submarines boats. It could be designed in Australia, probably with an overseas design partner. As a single unit, a local build would be unlikely to be economic, but as with the LHDs, the ship could be fitted out in Australia. It would also provide valuable service in different roles, such as a command ship and humanitarian operations.

Another benefit of this approach is that, down the track, the six MMOTS submarines under construction would provide a valuable insurance policy in the event that the eventual design of the Shortfin Barracuda was unsatisfactory, was delayed or did not provide value for money. These issues could be considered in the context of the review proposed in the 2016 Defence White Paper:

> During the long life of the new submarines, the rapid rate of technological change and ongoing evolution of Australia's strategic circumstances will continue. As part of the rolling acquisition program, a review based on strategic circumstances at the time, and developments in submarine technology, will be conducted in the late 2020s to consider whether the configuration of the submarines remains suitable or whether consideration of other specifications should commence.

This review could consider various options around building further flights of MMOTS submarines, switching to the Shortfin Barracuda or even setting in train the lengthy process required to acquire SSNs, presumably of the *Suffren* class. If the nuclear option were favoured at that time, a further six MMOTS boats could be ordered in order to provide the necessary capability while establishing the hard and soft infrastructure required for the eventual operation and sustainment of SSNs.

CONCLUSIONS

In Australia's biggest ever Defence project, the excessive cost of the Shortfin Barracuda and the risks surrounding it cast significant doubt on the credibility of its selection. By pursuing a developmental *ab initio* design, much larger than any conventional submarine built by any western country since the Second World War and not undertaking a PDS or subjecting it to competition or other safeguards, the government is ignoring all the lessons painfully learned from the Defence acquisition failures of the past two decades.

There is a very significant risk that the cost and time taken for the Shortfin Barracuda to become operational will blow out. The tgechnikcal and industrial risks are high. No submarine has been built in Australia for fifteen years. It is quite possible, based on other submarine projects round the world such as the British *Astute*, that there will be only one new submarine operational by 2040, when HMAS *Collins* will be 44 years old, and very limited capability, if any, through the 2030s. That in turn means that the most important and immediate risk in the FSM programme is of a substantial capability gap. If this occurred it would not only have a substantial impact on the viability of the Submarine Force over an extended period of time but also very serious implications for the defence of Australia when our strategic circumstances may well have deteriorated.

To avoid this capability gap, it has been proposed that the *Collins* class submarines will need to undergo a costly and risky life of type extension so that the Submarine Force can maintain some capability into the 2030s and perhaps beyond. This is estimated to cost $15 billion for an additional ten years of life and, as with upgrades to 1980s platforms more generally, it comes with a significant risk that it will not be effective. Instead, we propose that a better alternative would be to acquire an evolved version of a MOTS submarine, built at a fixed price and modified for Australian conditions and requirements. Furthermore, to avoid long and fatiguing transits, this fleet of smaller submarines would be serviced by a tender ship that could operate much closer to the submarines' area of operations. This option should cost under $10 billion for a 30-year life; much less than the *Collins* LOTE option and for a submarine that would have a longer life and be less at risk of detection. Importantly, this approach would also offer an insurance policy if the Shortfin Barracuda programme failed, in that more of the MMOTS boats could be acquired. A *Collins* LOTE would not offer this very important benefit.

This is by no means a perfect solution but the future journey has to start from where we are now. Governments of both persuasions are responsible for the predicament in which we now find ourselves. In 2009, the Rudd/Gillard governments talked a good game in terms of acquiring 12 advanced submarines and then did virtually nothing over the following four years to begin the acquisition process. The Abbott and Turnbull governments approved a grossly inflated acquisition budget for the submarines, established a flawed process that resulted in the costliest and most risky acquisition approach possible over an unacceptable timeframe, and then, for political reasons, stated that the submarines must all be built in Adelaide regardless of cost. It is now up to the government to take urgent action both to address the issue of the capability gap and to provide insurance against the possible failure or unacceptable cost of the Shortfin Barracuda project.

CHAPTER 1
Background

"Command of the sea in the future unquestionably lies beneath rather than above the surface."

John Keegan, *The Price of Admiralty*, 1988.

This report explores the issues around the acquisition of the Royal Australian Navy's future submarine (FSM) under the SEA 1000 program, with a particular focus on its costs and risks. The report does not question in any way the assumption that Australia requires a strong submarine capability. The questions are around the efficiency and cost effectiveness of the government's approach to acquiring that capability, as well as the significant risks involved.

Australia's exclusive economic zone (EEZ) is the third largest in the world.[2] Given its relatively small population and middle power status, Australia faces a daunting task in ensuring the security of its extensive coast line and many seaport towns and cities in what has become a challenging strategic environment. Submarines are a very important element in the Australian Defence Force's (ADF's) force structure. They are very attractive assets for smaller and medium-sized naval powers because of their capacity to conduct asymmetric warfare and their benefits as a force multiplier. Professor James Goldrick's views on the importance of submarines in the ADF are shown in Exhibit 1.1.

EXHIBIT 1.1: PROJECTING UNCERTAINTY – SUBMARINES IN FORCE STRUCTURE

"Among the long-standing priorities in Australia's defence strategy are protecting critical lines of trade and communication for essential national transport and military operations, and denying the use of the sea to a potential adversary.

Because of their unique characteristics, submarines will play an essential role in these endeavours. Their ability to restrict the actions of any would-be aggressor in the maritime domain remains unmatched. And despite the rate of technological change, they are unlikely to be challenged for at least a generation.

Submarines have the ability to operate covertly for extended periods and to attack with devastating lethality without warning. This means they can create uncertainty in the mind of an adversary about where they are and whether it is safe to sail ships or submarines. And the larger the submarine force, the greater that uncertainty.

Their stealth has a pre-conflict value too. In times of tension, such uncertainty can be a vital inhibitor to a would-be aggressor. Submarines can also be used to gather information about other countries' capabilities or intentions, providing early warning of an attack.

Submarines can also be used for strike missions, including inserting special forces ashore to target enemy facilities. Submarines equipped with land-attack missiles can also be an effective means to target onshore facilities and this capability may be an option for Australia in the future."

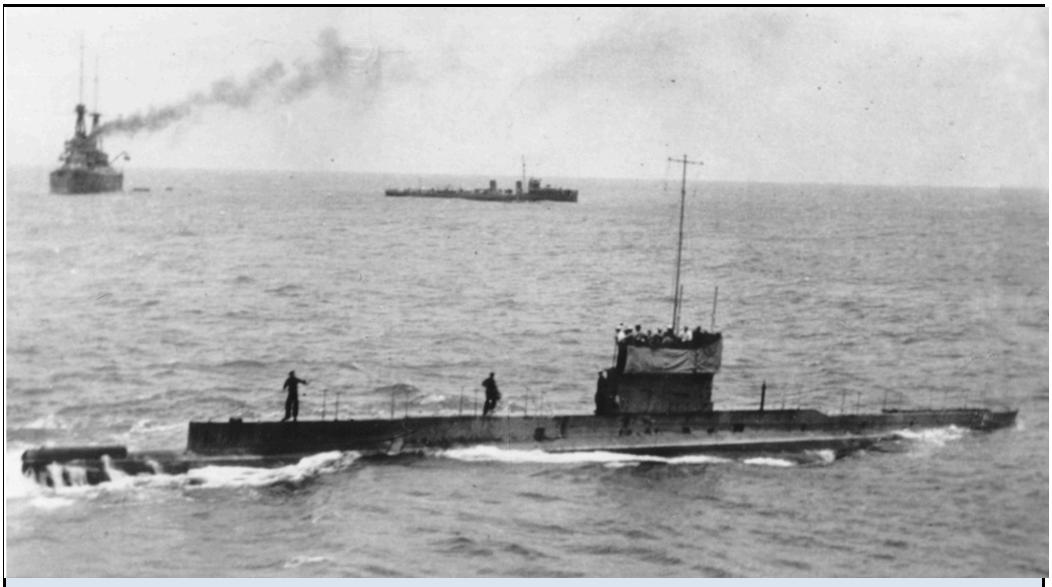
Source: Goldrick, James (2016), "Why does Australia need submarines at all?",* The Conversation, 28 April, *https://theconversation.com/why-does-australia-need-submarines-at-all-5857.

From the earliest colonial days, Australian governments have recognised the importance of sea power in ensuring the community's security against the incursions of other nations. For example, the government of Victoria acquired the state-of-the-art ironclad battleship, HMVS *Cerberus*, launched in 1868, from Britain as a deterrent to

[2] The Basement Geographer, http://basementgeographer.com/exclusive-economic-zones-how-some-countries-are-a-lot-larger-than-they-appear/

Russia. In the early years of the Commonwealth, major steps were taken to acquire a small but potent navy. Before the First World War, the nascent RAN acquired, *inter alia*, a capital ship, the battle-cruiser HMAS *Australia*, as well as two submarines of the most modern contemporary design (see Exhibit 1.2 below). Partly as a result of its historical security arrangements with 'great and powerful friends', first Britain and then the US, the RAN has always been a blue water navy capable, at least to a limited degree, of extending a global reach.

EXHIBIT 1.2: ORIGINS OF AUSTRALIA'S SUBMARINE FORCE



At the outbreak of the First World War, the RAN was small but potent. As shown in the photograph, the fleet included a Dreadnought battle-cruiser, HMAS *Australia* (top left), and two submarines, with *AE1* in the foreground.

At first, the British navy was ambivalent about submarines. In 1901, Admiral Sir Arthur Wilson, Controller of the Royal Navy, stated that "submarines are underhand, unfair and damned un-English". Despite these strictures, the British soon developed excellent submarine technology and the E class submarines (790 tonnes submerged displacement), using the latest diesel-electric propulsion, were arguably the best in the world in 1914. Their reliability was attested by the fact that *AE1* and *AE2* sailed from the UK (with occasional periods under tow) to Sydney with only few minor mechanical problems. Comfort must have been at a premium since E class submarines boasted only one bunk, rotated between the three officers, and one toilet. At the time, this was the longest voyage ever undertaken by a submarine. *AE1* was lost with all hands near Rabaul in the early stages of the war. *AE2* achieved considerable renown in 1915 by being the first Allied submarine to succeed in penetrating the Dardanelles, before being scuttled under fire. These were the only operational losses of RAN vessels in World War 1.

Source: Australian Strategic Policy Institute (ASPI) and Insight Economics

In its history since Federation, the RAN has only operated three classes of submarines, all with diesel-electric propulsion. Although Britain provided some surplus submarines to Australia after the First World War, the Australian government decided that they could not afford to operate submarines in the inter-war period. This was a mistake; had the US not entered the war in 1941, submarines would have been essential to an independent capacity to repel a Japanese attack.

With the exception of the Royal Navy's deployment of T-boats to Garden Island after World War II, Australia had a long hiatus in submarine operations before acquiring six *Oberon* class boats off-the-shelf from the UK in the 1960s and 1970s. Later, in order to maintain their regional superiority, the RAN undertook an extensive mid-life upgrade of the *Oberons*, installing

overseas state-of-the-art systems and weapons, including the American Mark 48 heavyweight torpedo and UGM-84 Harpoon missile. When these very successful submarines needed to be replaced, Australia's traditional suppliers of defence platforms, the US and the UK, were developing nuclear submarine fleets. At the same time, Australia's vulnerability to reliance on other countries, even a close ally like the UK, to sustain its vital submarine capability was highlighted in the 1982 Falklands War, when Britain curtailed the release of some supplies of spare parts for non-Royal Navy *Oberon* class boats.

The Hawke government, with Defence Minister Kim Beazley in the lead, then took the bold decision to build the RAN's next submarines in Australia to an overseas design. After an extensive competition, a Swedish design was selected for what was then the largest conventional submarine in the world, based on a considerably smaller but proven boat operated by the Swedish navy.

The *Collins* class was essentially a bespoke design undertaken in Sweden and built in Australia, which had never even assembled an off-the-shelf submarine before, let alone built a new design from scratch. Despite political debate and media point-scoring, neutral observers regard the construction of the submarines as successful, with both ASC and a large network of local suppliers performing well overtime. Yet much went wrong with the submarines in their early years. The design of the combat system, diesel engines and propellers, for example, was flawed, and the RAN was unaccustomed to having parent navy responsibilities for a highly complex platform and associated systems. For a number of years, maintenance of the boats was seriously underfunded, availability was poor and the Collins class attained a notorious record for unreliability.

Fast forward to 2017, however, and the availability and performance of the six *Collins* submarines have improved substantially in recent years to the extent that they now meet international benchmarks. Despite the fact they are now around twenty years old, Defence advised us that the Navy regards them as being 'regionally superior'. After years of pain, Australia has achieved its goal of developing an advanced sovereign submarine capability. The key question is what the government intends to do with what is an important strategic asset that is beginning to fall behind the regional competition in terms of its capabilities.

After examining various options to replace *Collins*, Defence decided that no existing class of submarine, including an evolved *Collins*, would meet Australia's supposedly unique requirement and that another bespoke design was required. In April 2016, after a short 'competitive evaluation process' (CEP), the Australian government announced that the French company DCNS had been selected as its design partner for the FSM. The partners would spend approximately ten years designing a new, 'regionally superior' large submarine, the Shortfin Barracuda. The submarine would have conventional diesel-electric propulsion and a long range, consistent with covert blue water operations far from base.

The cost in 'future dollars' for twelve submarines was estimated at $55 billion, including the US sourced combat system. The first submarine would not be delivered until 2033, with the full fleet of twelve new submarines being available by 2050. Because delivery of the FSM would be later than previously anticipated, a life extension to the *Collins* class would be required.

CHAPTER 2

Defence procurement: a hierarchy of risks

"The last 10 per cent of performance generates one-third of the cost and two-thirds of the problems."

Norman Augustine, Under Secretary of the US Army 1975-77 and later CEO of Lockheed Martin.

2.1 Background

Every country has a history of repeated problems in Defence acquisitions. In Australia's case, we have seen major cost overruns (for example, the F-35 joint strike fighter); unacceptable delays (the air warfare destroyers); on going technical problems (the Tiger battlefield helicopter); and even complete failure and abandonment at great cost (Super Sea Sprite helicopter for the *Anzac* class destroyers).

When dealing with acquisitions that are often at the frontier of contemporary available technology, some level of failure is inevitable. The corollary of this is that there is a very substantial prize available to those countries that are able to minimise the waste and the failures in defence procurement. As suggested above, one way to do this is to accept some compromises in the desired capability in order to increase the probability that an acceptable level of operational performance will be delivered at a reasonable cost and on schedule.

Good decisions about any investment in military equipment always involve complex trade-offs between operational performance, cost, timing and risk. The nature of these trade-offs is often obscured by the idea that decisions must give absolute priority to satisfying non-negotiable operational performance 'requirements', and that the other imperatives are always secondary to meeting these requirements. But the choices are never this simple. How important any particular operational performance characteristic is, and how much it is worth 'paying' for that element of performance in cost, time and risk, depends on how it affects the equipment's capacity to deliver the intended operational and strategic outcomes.

So, for example, as we will see in the analysis that follows, the range and endurance of Australia's future submarine is a critical element of its performance, but it cannot be considered independently of the other factors. How much additional cost, risk and delay it is worth accepting to achieve a particular performance level of range and endurance depends in very specific judgments about how that performance level affects the future submarine's capacity to achieve our highest-priority operational and strategic outcomes. Often it will make more sense to accept lower performance levels to lower the unit cost so that more units can be acquired, to cut the schedule to provide the capability sooner, or to reduce the risk that the capability will not be delivered according to plan.

Conversely, it makes little sense to aim for extravagant performance levels if that results in equipment being acquired in insufficient numbers, delivered

too late or not delivered at all. Failure prudently to balance desirable performance levels against cost, schedule and risk is the underlying cause of a very large proportion of defence acquisition problems. This is the message of the quote from Norman Augustine at the start of this chapter. And most often the key decision that frames the way these trade-offs are made concerns the broad acquisition strategy to be adopted.

In response to a higher level of threat in Australia's strategic circumstances, the government has increased defence spending from about 1.5 per cent to 2 per cent in GDP. With bipartisan support, it is investing heavily in advanced military capability. New platforms, such as the P-8 Poseidon maritime patrol aircraft and the Triton unmanned aerial vehicle (UAV), will provide Australia with a capability that is at the leading edge of technology globally. At the same time the government has minimised the risks in these acquisitions by acquiring tried and tested platforms off-the-shelf from the United States.

The two most important, and most costly, capabilities currently being acquired by the ADF are the future submarine and the F-35 joint strike fighter. The F-35 is the only fifth generation stealthy fighter aircraft available in the west. Australia essentially bought a share of what was a developmental project under the overall direction of the Pentagon. While this is more risky than an off-the-shelf purchase, the risks are much lower than if Australia had decided to develop a unique platform or sought to make extensive modifications to the F-35 design. This was not necessarily a given; Australia's geography suggests that the RAAF's ideal strike fighter would probably have a significantly longer range than the F-35, two engines rather than one and two seats in the cockpit. Yet Australia clearly placed a high priority on minimising the risk in acquiring a fifth generation strike fighter.

The government has taken a radically different approach to acquiring the future submarine. Perhaps because neither the US nor the UK builds conventionally powered submarines and European boats are regarded as being too small for extended blue water operations, Australia will design and build a bespoke platform, the Shortfin Barracuda. In this Chapter, we examine the relative risks inherent in alternative approaches to procuring advanced military platforms.

2.2 A hierarchy of risks

In any major defence acquisition, four broad alternative approaches are available to the government:

- Military off-the-shelf (MOTS) purchase of an existing asset class
- Modified MOTS (MMOTS), incorporating particular Australian specifications
- A development of an existing design
- A unique, bespoke design.

Military off-the-shelf (MOTS)

The first option is a MOTS purchase, generally in Australia's case from an overseas supplier, where modifications are limited to minor changes to accord with Australian regulations and standards. This approach is usually the lowest risk option and has several advantages:

- Reduced technical risks because the platform and systems are proven in service overseas
- Low strategic risk, because the capability should have been proven and verified in parent navy reports
- Lower cost, because the assets will come off a longer production line and from a supplier who has been able to move significantly up the experience curve
- Lower economic risk, because a fixed price contract is generally feasible with penalties for late delivery
- Quicker in-service date as there is no requirement for R&D or first of class trials.

The main disadvantage of a MOTS acquisition is that the asset may not even meet Australian critical capability requirements. Many European platforms, for example, have a relatively short range because they have smaller areas of operations (AOs) than are typical for Australia and they seldom have access to the most advanced US funded technology. Other problems can arise with the ownership of intellectual property and access to source codes, restricting Australia's ability to modify and upgrade platforms over time. Some overseas companies are now offering open architecture in the systems they purvey.

According to Dr Joiner another risk in MOTs is that much of the military equipment developed in Europe has not been qualified for Australian and South-East Asian environments. European military forces have little contemporary experience of operating in extreme conditions almost unique to these regions, such as the hot-wet climate that pervades the equatorial regions and the top third of Australia, tropical rain, consecutive high-wing conditions, transport road conditions and lengths (ie, dirt, corrugations, mud and fordings), high solar-radiation and salt impingement. Particular issues for the development of the *Collins* class were Australia's marine-life growth conditions, turbidity (ie, mixed dirty water), sea-surface temperatures and salinity, affecting sensors, pumps, engines and overall corrosion.

Additional environmental qualification testing, operational trialling and accelerated-life testing are often necessary to ensure MOTS equipment can operate in Australasian extremes, usually not through redesign but through restrictions, additional maintenance and packaging design. Importantly for the submarine project, Dr Joiner also advised that such additional T&E is often not anticipated or costed by European primes, which assume read-across of their extant testing of componentry and assemblies. The primes are often not pushed to undertake such additional T&E by Australian project offices through either a lack of exposure themselves, or through deference to the primes' technical expertise.[3]

In recent years, following a number of acquisition failures and procurement reviews, Australia has perhaps been more open to MOTS solutions. For example, when an interim replacement was urgently required for the RAAF's fleet of F-111s, which were to be retired prematurely in 2010, 24 F/A-18F Super Hornets were procured on the basis of a MOTS arrangement, as subsequently were twelve follow-up EA-18G 'Growler' electronic warfare

[3] Atkinson, S. R.; Skinner, C. J.; Joiner, K. F.; Caldwell, N. H. M., 2017 (accepted), 'Awaiting the next Revolution in Naval Affairs', International Maritime Conference, Sydney, October

derivatives. The acquisition has been successful, with the aircraft performing very well on active operations in the Middle East. All of the advantages cited above are evident in the acquisition.

The term 'MOTS' can be employed somewhat loosely, however. It has been known for platforms that are in the final stages of development overseas to be represented as MOTS purchases. The risks involved in acquiring a developmental platform on the basis that it is MOTS are evident from the experience with the Tiger battlefield helicopter (Exhibit 2.1).

EXHIBIT 2.1: NOT A MOTS AFTER ALL – THE TIGER BATTLEFIELD HELICOPTER

Some assets acquired by the ADF on the basis of them being off-the-shelf purchases turn out not to be MOTS at all, but effectively still in development. One example of this is the persistent failure of the European Tiger battlefield helicopter. Although this incorporated some Australian modifications, the main problem was that it had never been proven in French or German service either. It was essentially still a developmental project and was delivered into service 'as an aircraft type more developmental than that which was originally intended by the initial requirement'.[4] As the Senate Committee points out, "in effect, ARH 1 and 2, the lead Australian helicopters, were the first of type to undergo production acceptance by any nation's Defence Force".[5]

While accepted into service in 2004, the helicopter did not receive operational certification until 2016, indeed after the White Paper earlier that year had stated that it would be replaced in the early 2020s. This meant that Australian ground troops operating in Iraq and Afghanistan were forced to rely on Allied helicopters for battlefield support and these were not always available. This suggests a failure of Defence scrutiny of the platform, and insufficient attention paid to test and evaluation at the initial stage.

As the Senate Committee stated: "Suggestions that DMO should complete the required testing activities prior to accepting aircraft and consult closely with capability managers before finalising product acceptance are patently obvious. They are not about adding processes but about establishing appropriate priorities—not cutting corners on vital test and evaluation activities; ensuring that technical advice from subject matter experts informs discussions in submissions; and involving capability managers in specifying capability, technical and operational worthiness standards and the required testing to those standards."

Source: Senate Foreign Affairs, Defence and Trade References Committee (2012), "Procurement Procedures for Defence capital projects",* Final Report, *page 51.

Modified MOTS

A MMOTS design generally represents a platform developed overseas but adapted to Australian requirements. If the changes required are manageable but essential, then a modified MOTS design can carry with it many of the advantages of procuring an established platform described above. An example of this was the acquisition of the American F-111 fighter-bomber in the 1960s, where the government mandated an extended range to meet particular Australian requirements for tactical strike capability.

While some changes to overseas designs such as this may be deemed essential, however, this has not always been the case. A significant problem for a middle power such as Australia, where most defence equipment is imported, is the temptation to mix and match platforms and systems. For example, the ADF might select a European platform as the most suitable for its requirements but then specify that American electronic and weapons systems need to be substituted for the standard equipment. Often this is

[4] ANAO (2006), Audit Report No. 36 2005-06, *Management of the Tiger Armed Reconnaissance Helicopter Project—Air 87*, May, paragraph 5.
[5] Senate Committee, paragraph 2.23.

justified on the basis of 'interoperability', which is sometimes necessary but often not and is difficult for non-defence experts to challenge.

History shows that the integration of electronic and weapons systems with platforms not designed to accommodate them can be fraught with risk and often leads to severe problems. These include escalating cost, extended delivery schedules and sometimes an inability to meet Defence's specifications. While the prime contractor may suggest at the outset of a project that this integration can readily be achieved ("well, they would say that wouldn't they"), the problems can prove to be almost insuperable.

A current example of a modified MOTS acquisition is the three *Hobart* class air warfare destroyers (AWDs) being built in Adelaide. Modifications to the Spanish F-100 *Álvaro de Bazán* design were relatively modest, but the decision to build the ships in Australia and the approach adopted by Defence to constructing them meant that some of the advantages of a MOTS acquisition were lost. The result, according to the Minister for Finance, Mathias Cormann, is that Australia is paying $3 billion per ship while similar ships overseas cost $1 billion. As well as excessive cost, the length of time taken to build the ships has also meant that they will enter service deploying some equipment that is out of date. For example, a more modern version of the AEGIS system with active rather than passive phased array radar is now available but Defence had already purchased the now superseded version.

Evolution of an existing design

Countries that have a substantial defence industry and build platforms to indigenous designs often rely on an evolution of existing or legacy designs when new capability is required. This is generally less expensive and less risky than moving to a new, *ab initio* platform design and means that an existing team of designers and engineers can work together cohesively from the get-go. It is also much easier to engage local industry, which will often already be heavily committed to supplying spare parts and otherwise supporting an existing platform.

There is also an argument put by Atkinson et. al. (2017) that there are limits to evolution of existing naval designs and that when those limits are reached, it can be prohibitively costly and difficult to repeatedly try to put contemporary additional specifications into the systems of a extant major platform when design margins of power, weight, space, computing and the like have been exhausted. Also, such evolution often misses strategic shifts in the scale of maritime systems required, reflected today in very costly 'do everything' ships rather than say networked dependence of more vessels that are each smaller and where the collective naval force may be more resilient overall to contemporary threats.[6]

With most of Australia's defence matériel either imported or built to foreign designs where we generally do not own the intellectual property, this evolutionary approach is not often open to Australia. Yet one area where it is an option is in submarines. In the 1980s the Hawke government, with Defence Minister Kim Beazley the driving force, made the decision not only

[6] Atkinson, S. R.; Skinner, C. J.; Joiner, K. F.; Caldwell, N. H. M., 2017 (accepted), 'Awaiting the next Revolution in Naval Affairs', International Maritime Conference, Sydney, October

to acquire a new submarine, larger than any other conventional boat at the time, but also to establish an independent capability in designing (if only to a limited extent), building, maintaining and upgrading submarines. To be sure, some of this capability already existed in that Australian industry had with RAN direction designed and undertaken a complex and difficult upgrade to the *Oberon* class of submarines very successfully. But the scope and breadth of the ambition, although not appreciated at the time, was almost on a nation-building scale.

Overseas, almost all new submarine programmes represent evolutions of existing ones. Where they are not (the Russian Lada and the Spanish S-80 are discussed later in this report), they often run into trouble. Under the Rudd/Gillard governments, an evolution of the *Collins* class was always an option for the FSM, and some well-regarded concept designs (and some more detailed designs) had already been undertaken by ASC's Deep Blue Tech design house. When the Abbott government came to power, however, it closed down Deep Blue and then eliminated the evolved *Collins* as an option for the FSM. In some respects this is understandable. At that time, *Collins* was still not performing well in terms of availability and operational reliability and the brand was not exactly popular.

Nevertheless, if we fast forward to 2015 with the problems with *Collins* largely overcome and the submarine being highly regarded by Navy as a 'regionally superior' boat, there was a good case for including this option in the CEP. First, this would allow Australia to take the far less risky course of selecting an evolutionary design rather than an *ab initio*, developmental concept. Secondly, having finally developed a successful sovereign submarine capability at great cost and considerable pain over two decades, from a strategic industrial perspective an evolved *Collins* would make a great deal of sense. Thirdly, a *Collins* Mark Two could be delivered about a decade earlier than an *ab initio* design with significantly lower risk. Finally, because of the local sustainment of *Collins* it has a built-in supply chain of Australian companies as well as construction infrastructure such as cradles. At the least, it could have been used as a benchmark against which to assess the other three proposals.

Bespoke design

On occasion, analysis by the Defence department has concluded that its required capability can be delivered only by a unique design. In many cases, as discussed at the beginning of this chapter, this is because of an unwillingness to make trade-offs in initial capability requirements that are over-ambitious. By making the perfect the enemy of the good, Defence can end up with an outcome that is not only less than good, but is delivered late at excessive cost.

The long history of sub-optimal defence acquisitions shows that one of the most common ways of increasing costs and risks while under-delivering on capability is to select a unique design for a new platform. This is particularly the case for a middle power like Australia, where the number of platforms to be acquired is likely to be relatively low, so that there is limited scope to exploit economies of scale, move up the experience [learning] curve and depreciate the design and engineering costs over a larger number of platforms. This applies equally to important components and systems as well as to the platform more generally. While the high costs of integrating sensor,

combat and weapons systems both together and into a new platform may be recovered over a long run, these costs may prove to be unacceptably high for a bespoke Australian design with a small production run.

In addition, while Australia's limited resources in terms of naval architects, designers, systems engineers and integrators can be supplemented from overseas, this can lead to significant difficulties in terms of ownership of proprietary intellectual property and relevant source codes. As Australia's experience with the *Collins* class submarines shows, this may create severe difficulties down the track when modifications or upgrades are required.

Other countries, particularly when they require new capability in as short a time frame as possible and are concerned about costs and risks, tend to avoid bespoke designs of submarines. Norway, for example, was considering scrapping its small submarine force, but more recently has been concerned about the rapid build-up of new submarines in Russia's Northern Fleet. Consequently, the government decided to acquire four new submarines and ran a competition between Naval Group's Scorpène submarine (France) and the tkMS Type 212 (Germany), with an announcement in February 2017 that the Type 212 had been selected. The Norwegian Defence Ministry "said the submarines will be based on the 212-class subs already in service in Germany and Italy. Basing the submarines on an existing design will allow Norway to avoid an extensive development project as well as the risks involved in such an undertaking."[7] Other than its long coastline, Norway's geography is quite different to Australia's, as are its strategic circumstances, yet the aversion to a developmental project is nevertheless interesting.

Bespoke designs are not limited to new platform acquisitions. Delays in acquiring new capability to replace existing assets can also lead to bespoke upgrades being undertaken. For example, when the *Perth* class destroyers were approaching the end of their lives in the 1990s, a decision was taken to give Australia's six *Adelaide* (FFG-7) class frigates a bespoke upgrade so as to provide a fleet area air defence capability. This was in a situation where Australia did not have parent navy responsibility for the FFG-7s (they were American ships). But "FFG-7 updates were problematic, thanks to very little reserved space for growth, and the inflexible, proprietary electronics of the time. Indeed, they were so problematic that the US Navy gave up on the idea of upgrades to face new communications realities and advanced missile threats."[8]

Although the cost of the FFG upgrade is not entirely clear, it seems to have been of the order of $1.6 billion. One whistle blower reported that the outcome was that, because of a raft of problems with the systems, the four upgraded ships had a lesser capability than they had before the upgrade. Eventually it was reported that the ships "can perform the full range of naval duties to varying levels in low to medium threat environments".[9]

As one Defence insider suggested, "if you offer a politician the choice between a major upgrade or an off-the-shelf replacement, they'll always go

[7] Hoffman, Lars (2017), "Norway joins forces with Germany to procure new submarines", *Defence News*, February 3, http://www.defensenews.com/articles/norway-joins-forces-with-germany-to-procure-new-submarines

[8] *Defense Industry Daily* (2014), "Australia's Hazard(ous) Frigate Upgrades: Done at Last", http://www.defenseindustrydaily.com/australias-hazardous-frigate-upgrade-04586/

[9] *Ibid*.

for the upgrade, no matter what the relative costs and benefits are. Upgrades create jobs."

Beware the chameleon

Reviews of Defence acquisitions such as the annual major project reports by Defence and the ANAO, the 2012 Senate Inquiry into Defence Procurement and the 2016 ANAO audit into Defence Test and Evaluation, suggest that the boundaries within this taxonomy of MOTS, modified MOTS, evolution and bespoke acquisitions can become blurred. A proposed acquisition that started life as a mildly modified MOTS can, over time, end up as a highly risky bespoke design. Moreover, Ministers and officials risk being chameleons in the use of these categories to advance their acquisitions without proper scrutiny or testing. While essential for the purpose of risk reduction, these processes can be dismissed as bringing about unnecessary delays.

For example, a project proposal may initially be labelled as a MOTS acquisition, and therefore low-risk in order to get approval to proceed direct to solicitation. Then in the tender processes specifications are added that effectively modify major systems in the design (modified MOTS). Then when delays occur in contracted development, the project claims an evolutionary status to facilitate additional funding and schedule and then further modifications can effectively create a bespoke design.

There is a risk that this has already occurred with the future submarine, where early on Defence was told to rule-out bespoke designs as cost-prohibitive. Defence then argued that all proposals being called for would be modified MOTS, or at worst evolutionary designs by credible design companies. Finally, in defence of the FSM's long schedules and significant costs, it is now acknowledged that the FSM is, in fact, a bespoke design.

Some of the reasons such chameleon characteristics occur in Defence, more so than in other agencies, are:

- Major acquisition schedules are often so long that by the time problems occur individuals are rarely remembered, let alone held accountable.
- The Government can generally be relied upon to provide the largesse to bail out projects in interests of national security.
- There is always a proportion even of military officers who believe it unlikely the assets will ever be required to be employed in Australia's defence.
- Defence can trade on high public esteem for the ADF's operational performance so as to excuse poor project management,
- Defence primes have high profit margins, advertise and lobby well and rarely disclose any problems, real or potential, that could affect their relationship with Defence.
- Despite some integration, individual services and even elements within them compete vigorously for funding; one common strategy is to pursue early and on-going funding through every acquisition avenue that becomes available.

The net result of such approaches is often over-commitment too early, with little or no independent assessment, certainly nothing beyond paper-based

critiques that can usually be deflected with conjecture. Since nearly all defence acquisitions are finally decided and announced by government, politicians become both a part of the problem and, as perhaps was shown in the FSM announcement, can be held to premature commitments that often should not have been made. Really big acquisitions like SEA 1000, run across successive Governments over time, each being encouraged by officials to over commit. Proposals to counteract harmful incentives in Defence acquisitions in the U.S. are put forward by Smith et. al. (2016).[10]

2.3 Pitfalls of a bespoke design: the *Collins* class

In relation to the FSM, the most relevant example of a bespoke solution to Australia's capability requirement was the decision taken in the 1980s to acquire six *Collins* class submarines.

The RAN's preceding and very successful *Oberon* class of submarines was a MOTS purchase from the UK, coming off a production run of 27 boats. Of 2,400 tonnes submerged displacement, the *Oberons* had a range of over 10,000 nautical miles and undertook a significant number of covert intelligence, surveillance and reconnaissance (ISR) operations, including some a long way from base. A major mid-life upgrade was implemented successfully by Australian industry..

When the *Oberon* submarines needed to be replaced, the Navy, dominated by surface ship specialists, showed little enthusiasm for spending any of its constrained acquisition budget on new submarines. After that hurdle had been overcome, an investigation was made into the possibility of acquiring nuclear submarines:

> "In its first year [1982], the project team considered purchasing a nuclear submarine from the United States, United Kingdom, or France. The United States was unwilling to sell its nuclear technology, and the United Kingdom was unable to do so because of its commitments to the United States.
>
> France, however, was willing to sell *Rubis*-class submarines. Estimated to cost about 1.7 times the cost of a French conventional submarine, the *Rubis* submarine was perceived by Australian authorities to have several drawbacks, the most important of which was that Australia would have to rely on France for maintenance and support and would therefore be involved in a situation similar to its unpopular dependence on Britain with the *Oberons*. In addition, the costs of overhauling and refuelling a nuclear submarine would be very high. Also, developing the infrastructure necessary to support a nuclear ship would be extremely expensive given existing budget limitations. The Australians decided not to pursue the nuclear submarine option due to the cost of infrastructure and support and to political sensitivities concerning nuclear power."[11]

Despite the success of the British built *Oberon* class, the government decided that the next class of submarine should be built in Australia, both to create a sovereign capability and to reduce maintenance costs. As the RAND Corporation pointed out:

[10] Smith, N. C.; White, E.D.; Ritschel, J. D.; & Thal, A. E. (2016), 'Counteracting Harmful Incentives in DoD Acquisition through Test and Evaluation and Oversight', *The ITEA Journal of Test and Evaluation*; 37: pp. 218-226

[11] RAND Corporation (2011), *Learning from Experience*, Lessons from Australia's *Collins* Submarine Program, http://www.rand.org/content/dam/rand/pubs/monographs/2011/RAND_MG1128.4.pdf, page 7.

> "The RAN depended on overseas suppliers for 85-90 per cent of the support for the *Oberon* class subs, and the refits (which took place every five years) cost up to 76 per cent of the vessels' original purchase price. Due to the number of problems with refits, Australia began to once again consider developing an organic capacity to construct submarines to replace the *Oberons* as they began to decommission in the 1990s.[12]

After a lengthy selection process, in which a German design was initially recommended by the Review Board as the best proposal overall, the Swedish Kockums Type 471 proposal was eventually selected. This was an enlarged version of an existing small submarine, but incorporating the Australian requirements it essentially became a new design. Compared to the *Oberons*, the Type 471 was shorter, but about 40 per cent larger in terms of displacement. It had a heavier weapons payload, but a similar range to the *Oberon* class.

The *Collins* project was always going to be highly risky because:

- Designing and building submarines is one of the most complex activities known to humans and Australia had never built a submarine before
- Rather than choosing an established MOTS design, Defence selected what was fundamentally an *ab initio*, bespoke design
- The ambition to build a world-beating submarine, in areas such as the combat system, pushed contemporary technologies beyond their limits
- Defence did not recognise the need to undertake substantial testing and evaluation (T&E) of the submarines, both in preview and during construction
- The shipyard was new and no vessel of any significant size had ever been built in South Australia before.

As frequently occurs with *ab initio* projects, there were a number of fundamental problems with the design. The requirement for the combat system was over ambitious in terms of contemporary technology:

> In hindsight, the technology for integrating the combat system was not sufficiently developed to be viable for the *Collins* class; the necessary computing power and system architecture were not available until ten years later. In addition, the resulting combat system design was unnecessarily integrated. The resulting design was extremely complex and nearly impossible to develop.[13]

The original combat system never performed and had to be abandoned at considerable cost. Despite a German system designed for conventional submarines (SSKs) being preferred as a result of a competitive tender for a replacement combat system, for 'alliance reasons' the government selected the American AN/BGY-1 system designed for large nuclear submarines and not power-poor SSKs. It was only in 2016, 22 years after the first submarine was completed, that all six boats had an operational combat system. But the problems with the submarines went way beyond the combat system. The diesel engines have never been satisfactory; according to a former commander of Collins class submarines, "they are quite possibly the least

[12] *Ibid*, page 5.
[13] *Ibid*, page 13.

reliable diesel engines ever built".[14] Early on, there was both a significant radiated noise problem and issues with cavitation. The original propellers needed to be replaced (Exhibit 2.2).

EXHIBIT 2.2: OPERATIONAL PROBLEMS WITH THE COLLINS CLASS

Once the *Collins* had been delivered, she continued to be fraught with delays and problems. The diesel engines had been a problem since the beginning, and remain so today. Although multiple tests were done on the Hedemora diesel engine, the team failed to test it in salt water. The fuel system in any diesel submarine requires water to be added over time to compensate for the weight of the fuel burned. The key is to design a fuel system that precludes this water from reaching the engines. *Collins* had a complex fuel system that allowed water to enter the engine, partly a result of a faulty design. Swedish submarines have short patrols in calm, relatively fresh, water. When a similar design was used in the salty, open water in which Australian submarines operate, water was sucked into the engine. Salt water is more corrosive than fresh water, which exacerbated the problem. The crews and maintenance team were unprepared for this problem. Moreover, it has affected the ships' endurance, because the crew now must leave 30 per cent of the fuel in the tank to prevent water contamination.

The diesel engines have been unreliable and problematic. Between the initial delivery of HMAS *Collins* and October 1998, there were more than 75 recorded defects against the diesel engine. Some of the problems stemmed from the water-contaminated fuel, but poor design modifications, poor quality control, and poor subcontractor backup were also to blame. Repairing these problems has not only affected cost and schedule, they have also hindered the performance of the ship and eaten into the operational time of the submarine.

Noise levels also proved to be a problem. First, the requirements for noise were not well laid out in the contract, perhaps because of a lack of technical understanding of noise issues. The operators wanted the boat to go faster at a quieter signature, but the contract was not changed. Adding to the problem was the lack of tools to measure submarine noise. Finally, in 1996 the RAN reported that the noise ranges were higher than expected, but there were arguments on whether the tests were accurate enough. The noise problems came from several factors—the flow of water over the hull, the shape of the casing, and cavitation from the propeller.

The propellers proved to be an additional problem. In 1998, the propellers started to develop fatigue cracks. Sonaston, the material used for the propellers, proved to be too brittle for boats operating in an open-ocean environment. At one point, a propeller blade was fractured three-quarters of the way through the root.

Other serious problems the *Collins* experienced were vibration on the periscopes, unreliable communication masts, and a poor propeller shaft seal. All these problems accumulated, and the schedule delays continued to affect the following ships throughout the program.

Source: **RAND Corporation (2011), *Op. Cit,*, page 7.**

A major problem with the *Collins* class has been the high cost of sustaining a unique and complex asset, particularly when there are only six platforms employing a large number of bespoke components. These problems were exacerbated by the IP issues discussed above. Compared with other SSKs and even SSNs around the world, the sustainment costs of *Collins* are high.

Perhaps the major source of the problems with the *Collins* class, however, has been a long running dispute over the ownership of the intellectual property embodied in the submarines. When the Australian government bought out Kockums' share of ASC, this issue was never satisfactorily resolved, leading to a substantial lack of Australian capability to undertake modifications or even some basic repairs to the boats. Dr Andrew Davies of ASPI, in providing evidence recently to the Parliamentary Treaties

[14] *Source: Harrap, James (2012), "Reflections of a* Collins *submarine captain", http://www.asiapacificdefencereporter.com/articles/226/Reflections-of-a-Collins-Submarine-Captain*

Committee, drew attention to the problems regarding IP and the *Collins* class as an example of what not to do in the future (Exhibit 2.3).

EXHIBIT 2.3: INTELLECTUAL PROPERTY ISSUES WITH THE *COLLINS* CLASS

"The difficulties we had in developing an indigenous capability to support the Swedish designed Collins submarines, which contributed to the fleet becoming essentially moribund for a period in the late 2000s, should provide ample incentive to not repeat that experience. The Collins program provides some excellent lessons in how not to deal with an international partner in a submarine build. There was a substantial falling out between Australia and Sweden over intellectual property issues, which went as far as to land the two parties in the Federal Court in 2001. The issue was ultimately resolved, and the Australian and Swedish defence ministers produced a joint communiqué on 2013 on the subject of intellectual property rights for submarine design and technology. But it was a good illustration of the pitfalls of collaboration on sensitive defence technologies.

The clear causes regarding obligations for the supply and ownership of intellectual property in the treaty we are discussing today should go a long way to avoiding that sort of problem in the future submarine project. But it is worth understanding the background to the Collins IP dispute, because it is pertinent to the treaty we are talking about today. In 1998-99 cracking problems were discovered in the Collins propellers, and the Commonwealth shipped two units to the United States for analysis and advice. Propeller configuration is one of the crown jewels of submarine design, and Kockums took court action in 2001 when another propeller was to be shipped, resulting in the unedifying spectacle of the ship carrying the article being held off the US coast while the court action was resolved. The court found in favour of the Commonwealth, but a substantial reason for the decision was that the harm to Kockums' position had already been done by an earlier shipment, which was hardly the basis for a trust- based relationship between the parties involved."

Source: Davies, Andrew (2017), Evidence to the Joint Standing Committee on Treaties, Australian Parliament, 14 March, page 10.

It seems clear that Defence took some time to understand that sustaining an 'orphan' platform for which it had parent navy responsibilities involved high costs and higher risks. Initially, Defence only allocated to each submarine little more than half the maintenance budget for an *Anzac* class frigate, which were less complex than *Collins*, had far fewer bespoke parts and for which the RAN did not have parent navy responsibility. There were obvious issues regarding a lack of a satisfactory inventory of spare parts. Maintenance was also inadequate, with the number of breakdowns at sea being unacceptably high at a time when arguably the level of engineering skills in the navy was also at a historically low level.

In general the Navy's experience with *Collins* for at least the first fifteen years was not a happy one. The boats' performance was well below expectations and it was a long time before they were declared fit for operations. Until recently operational availability has been quite unacceptably low. In some years only one boat was available, perhaps only for limited operations. For years, it was a rare event for a *Collins* boat to complete a full patrol without breaking down. The boats became both a focal point for political point-scoring and a source of good copy for the media – the label "dud subs" was difficult to shake. This was unfortunate from at least two perspectives. First, the deterrent value of a submarine is a major part of its *raison d'être* and when its capability is widely ridiculed its operational credibility is severely diminished. Secondly, it becomes difficult to recruit the highly motivated and accomplished people required to crew a submarine when both its reputation and performance are well below par.

While the submarine builder attracted much of the blame for the problems with *Collins*, to a significant degree this is unjust. Considering all the challenges, ASC did a good job in constructing the boats, which came in close

to budget. To be sure, the delivery schedule blew out, with the first boat being about 18 months late. The quality of ASC's welding, for example, was markedly superior to the Swedish performance. The final submarine, which had to incorporate modifications as a result of trials with the earlier boats, was 41 months late.

Coles Review

In 2011, when availability and maintenance issues with the *Collins* class were approaching crisis point, John Coles from the UK was commissioned to review the *Collins* class sustainment programme, since when he has produced five reports. The good news is that, particularly since the IP issues were sorted out in 2013, the performance of the *Collins* class has improved markedly. Three submarines are now available for operations more than 90 per cent of the time. According to the fifth Coles report, published in May 2016, "the Review Team has noted a remarkable improvement in the capability to successfully manage the sustainment of the Collins submarines. The establishment of a collegiate, collaborative and well-functioning Enterprise has been foundational to rectifying legacy Collins sustainment issues. The performance achieved is approaching that required for a strategic system."

According to the Coles report, "areas of note are:

- Improvements in submarine availability, which is now nearing the international benchmark
- Significant reductions in maintenance overruns, now better than the international benchmark
- Significant reductions in days lost to defects, now better than the international benchmark."

The extent of these improvements is shown in Exhibit 2.4 below. According to Coles, "the Review Team has observed improvements to planning, productivity, inventory investment, and performance monitoring. These have contributed significantly to the reduction in maintenance time necessary to achieve the two-year Full Cycle Docking (FCD) required under the new 10+2 Usage and Upkeep Cycle (UUC). Planned maintenance durations will move to benchmark levels under the 10+2 UUC. These performance improvements have put the Enterprise in the position to achieve benchmark performance by mid-2017."[15]

According to the General Manager of Operations at ASC, productivity improvements in maintaining *Collins* have been very substantial: "Our maintenance program has gone from taking 1.2 million man hours for a full cycle [docking] to 780,000 between 2014 and 2016. We don't know any shipyard that has done what we have done."[16]

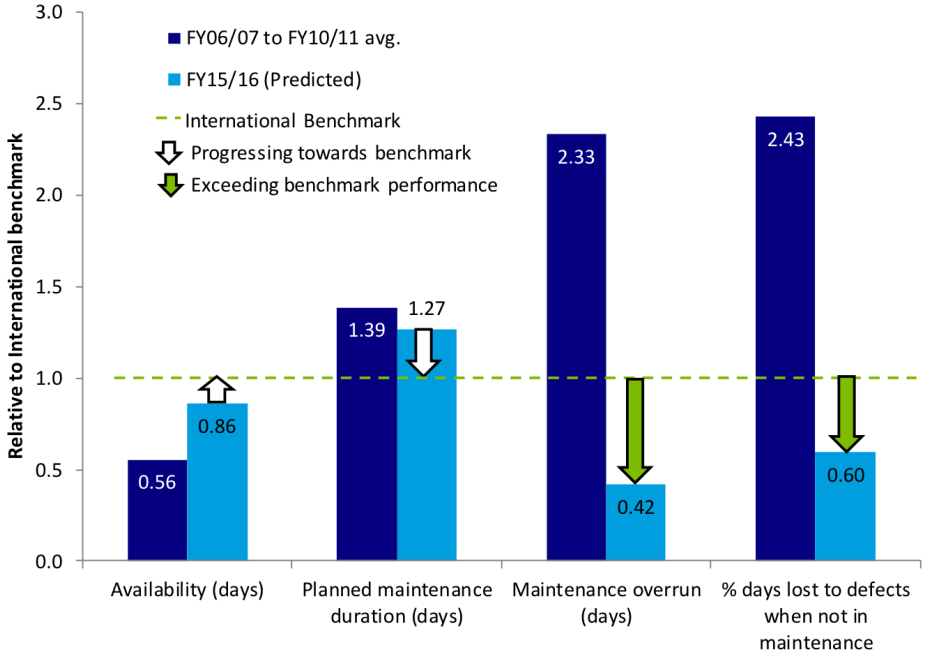
Our meeting with Defence suggested that the *Collins* class submarines are now performing very well and, indeed, are regarded as providing a 'regionally superior' capability. They are being sustained to the standard of

[15] Coles, John (2016), Collins *Class Beyond Benchmark Review*, Department of Defence, Canberra, May, page 2.

[16] http://www.adelaidenow.com.au/lifestyle/sa-lifestyle/collins-class-submarines-received-criticism-but-theyve-built-up-loyal-fans/news-story/8235e7f5d2749dda42122bd5bfa43898

international benchmarks and their availability meets Navy's requirements. Unfortunately, this is not widely understood. Good news does not often make for good copy.

EXHIBIT 2.4: COLLINS PERFORMANCE COMPARED TO INTERNATIONAL BENCHMARKS



Source: Coles, John (2016), Collins class Beyond Benchmark Review op. cit, page 3.

2.4 Mortimer Report

Soon after the Rudd government came to power, the Parliamentary Secretary for Defence Procurement, Greg Combet, commissioned David Mortimer AO to undertake a Defence Procurement and Sustainment Review [the Mortimer Report].

Perhaps the most important contribution of the Mortimer Report was to highlight the major costs and risks associated with a bespoke design rather than a military off-the-shelf (MOTS) solution:

> Experience shows that setting requirements beyond that of off-the-shelf equipment generates disproportionately large increases to the cost, schedule and risk of projects. Some of the reasons for this are easy to identify. For a small purchaser like Australia, the cost of modifying or developing new systems is invariably spread across a small production run. In contrast, off-the-shelf purchases bring the benefit of larger economies of scale. Even more important, off-the-shelf purchases avoid the considerable risks to cost and schedule inherent in developing new weapons systems.[17]

While the capability benefits of either Australian modifications to a MOTS design or a bespoke design are relatively small, the impact on costs, schedule and risk can be substantial in the extreme. Submissions to the review supported this point, for example one from IBM:

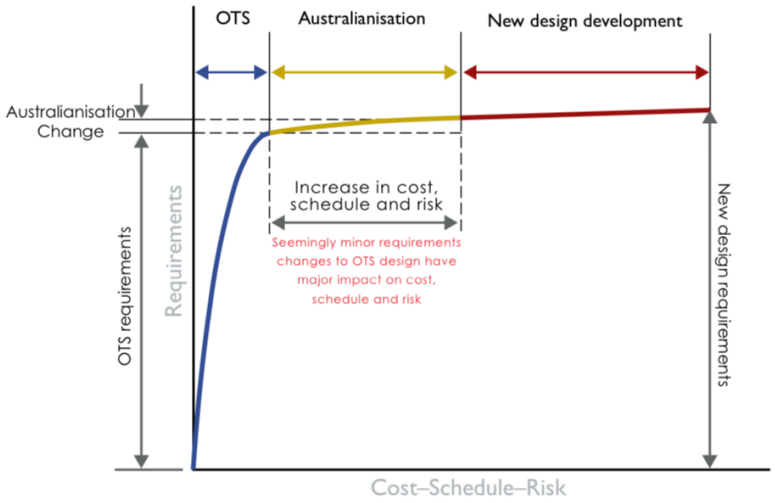
> The increased utilisation of [off-the-shelf equipment] is an imperative for Defence, DMO and the major Defence Primes to ensure that capability can be delivered in a prompt, cost effective

[17] Mortimer, David (2008), *op. cit,* page 18.

> and open manner. Most militaries have drawn similar conclusions that they can't afford the cost, time and risk in managing custom development of bespoke solutions. In Australia's case, with small fleet sizes, this is even more relevant. In addition, the custom approaches are the antithesis of [Network Centric Warfare] where interoperability is paramount.[18]

Exhibit 2.5, taken from the Mortimer Report, illustrates this point.

EXHIBIT 2.5: BEYOND MOTS – IMPACT ON COST, SCHEDULE AND RISK



Source: Mortimer Report, page 18.

Norman Augustine, who at one time occupied a senior position in acquisition at the Pentagon before becoming head of Lockheed Martin, produced a series of "laws" relating to defence industry and procurement. The analysis contained in the Mortimer Report supports one of 'Augustine's Laws', namely the 'law of insatiable appetites', which states that "the last ten per cent of performance generates one-third of the cost and two-thirds of the problems".[19] In a study of 81 major defence projects, Augustine also found that final costs exceeded pre-R&D estimates by an average of 52 per cent.[20] Apart from the impact on cost, the outcome of an Australianised or bespoke design can be that the theoretical additional capability benefits arising from the design are never delivered. The main implication of the likely significant schedule delay is that the ADF is forced to continue to use obsolescent or obsolete equipment or even none at all. This leads to a significant capability gap until the new assets are eventually delivered.

As a result of its analysis, the Mortimer Report recommended that:

> Any decisions to move beyond the requirements of an off-the-shelf solution must be based on a rigorous cost-benefit analysis of the additional capability sought against the cost and risk of doing so. This analysis must be clearly communicated to Government so that it is informed for decision-making purposes.[21]

[18] *Ibid, page 9.*

[19] Augustine, Norman R (1983), *Augustine's Laws – an irreverent guide to traps, puzzles and quandaries of the defence business and other complex undertakings*, American Institute of Aeronautics and Astronautics, New York.

[20] Davies, Andrew (2012), "ASPI recommends: Augustine's Laws", *The Strategist,* ASPI, 24 July.

[21] *Ibid, page 20.*

2.5 Senate Report on Defence Procurement

The 2012 Senate Committee report on defence procurement has been quoted before in this report and will be quoted again. It was the result of an exhaustive process and examined in detail a number of acquisition failures in the recent past, as well as Defence's processes and approach to acquisitions more generally. For the purposes of this Chapter, the report's conclusions on Defence's approach to risk are particularly instructive: [22]

> The committee finds that the current management structure in Defence has produced an organisation that lacks a robust risk regime: an organisation where its personnel are insensitive or unresponsive to risk, where no one owns risk and is incapable of learning lessons from past mistakes. In brief, Defence is currently an organisation that cannot anticipate, understand or manage risk—a fundamental flaw in an organisation that undertakes large-scale and complex projects that are in essence engineering operations. Importantly, this failure to own risk and to learn lessons is not a process problem—it is clearly a weakness deep within the organisation that permeates outwards and effectively precludes people from taking responsibility and being accountable

2.6 Implications

The main implication of this analysis is that Australian governments should be extremely cautious in approving Defence proposals to acquire major military assets that go beyond a modified off-the-shelf purchase or an evolutionary design. While Australia does have a genuine need to acquire bespoke assets in some cases – the Wedgetail acquisition may be a case in point – these are extremely rare. The same is true of 'Australianisation', particularly when this requires the replacement of electronic systems designed to work with a particular platform by others that Defence may prefer.

The risks to cost, schedules and performance inherent in both 'Australianised' modifications to off-the-shelf equipment and, on a much greater scale, bespoke acquisitions, are high. As Mortimer recommended "any decisions to move beyond the requirements of an off-the-shelf solution must be based on a rigorous cost-benefit analysis of the additional capability sought against the cost and risk of doing so".

Rightly or wrongly, the Navy has decided that no MOTS solution for the FSM is feasible. The requirement is for a submarine with a long range and high endurance and the other nations with similar requirements, such as the US, UK and France, only operate nuclear submarines. Other European navies operate closer to base and have small, brown water submarines, deemed unsuitable for Australia's purposes. The RAN's view is debatable, but even if we accept it this is not necessarily an argument in favour of a highly risky, *ab initio* design.

In this context, it is important to draw the right conclusions from Australia's experience with the *Collins* class submarines. The extent of the commitment and resources required to establish a national submarine capability was clearly underestimated at the time the decision was taken and for a long time thereafter. This underestimation included the importance of on-going Land-

[22] Senate Foreign Affairs, Defence and Trade References Committee (2012), *Procurement Procedures for Defence capital projects,* Final Report, page 249.

Based Test Sites (LBTSs) to address the problems of obsolescence.[23] The choice of what was essentially an *ab initio*, bespoke design increased the risk profile of the project very substantially. Defence significantly underestimated the costs and obligations inherent in assuming parent navy responsibilities for sustaining a new, unique and highly complex platform.

Nevertheless, inadequate recognition is given to ASC's performance in building a new class of submarine in Australia. Few of the problems with the *Collins* class should be laid at the shipbuilder's door. *Collins* is now performing very well and Australia has, finally, established a credible national submarine capability. In that context, the decision not to build on the *Collins* design to evolve an advanced new platform in favour of commissioning another unique, *ab initio* design, is a highly risky approach that ignores the lessons of the past. If anything of the *Collins* history is complicit in the discarding of its evolution, it is again the failure to build comprehensive LBTSs. If these test sites existed, they would provide an existential early de-risk for the future submarine.[24]

Finally, the Senate Committee deserves the last word in a Chapter on risk:

> The inability of Defence to learn from past mishaps is a particularly salient point. Defence may well argue that the failures noted in this report are drawn from history: but if it cannot or will not apply lessons from previous projects to current and future ones then it is destined to repeat them. Learning lessons is not only about keeping a risk register or a data base—that is simply a process—it about those lessons becoming part of the corporate knowledge.[25]

[23] Coles, J., P. Greenfield, and A. Fisher. 2012. Study into the Business of Sustaining Australia's Strategic Collins Class Submarine Capability. Canberra: Department of Defence.

[24] Joiner, K.F., and S. Reay Atkinson, Australia's Future Submarine: shaping early adaptive designs through test and evaluation. Australian Journal of Multi-Disciplinary Engineering (AJMDE), 2016. Vol 11, No. 2, 16 Nov: Presented at Submarine Institute of Australia 8th Annual Conference, 14-16 Nov.

[25] Senate Foreign Affairs, Defence and Trade References Committee (2012), *op. cit.,* page 250.

CHAPTER 3

Acquisition process for the FSM

"We learn from history that we do not learn from history."

Georg Wilhelm Friedrich Hegel.

3.1 Background

Throughout the lengthy process between the requirement for the FSM being stated in 2009 and the announcement of the design partner seven years later, there were four changes of government, including a change from the ALP to the Coalition in 2013. There were also a number of changes in Defence Ministers as well as Secretaries of Defence and Prime Minister and Cabinet. In part as a consequence of this, we are advised that the parameters around the project gradually changed, to the extent that the FSM ended up wearing the guise of the chameleon described in the previous Chapter.

We understand that initially the acquisition team was told to rule out bespoke designs as cost-prohibitive. As well as acquiring advanced submarine capability, the emphasis would be on value for money and submarines would only be built in Adelaide if it were cost-effective to do so. In accordance with this, Defence then argued that all proposals being called for would be modified MOTS, or at worst evolutionary designs by credible design companies. Then, over time, as different Ministers and senior officials brought new perspectives to the issue, the MOTS options were first withdrawn, followed by the evolution of the *Collins* class. By a process of elimination the chameleon had exchanged the modest appearance of the MMOTS boat for the much more extravagant skin of a big, *ab initio* submarine. At the same time, while the debate took place between advocates of MMOTS and those in favour of acquiring nuclear submarines, the SEA 1000 programme stealthily emerged with an extravagant budget of $56 billion including the combat system.

3.2 The capability requirement

It had long been assumed that Australia's six *Collins* class submarines would eventually be replaced by a similar number of new boats when the time came for them to be paid off. Serious thinking both inside Defence and in the wider submarine community about the kind of submarine that would be selected, and how many should be acquired, only began around 2004. The results of this work were not reflected in formal government policy until 2009, when the Rudd Government's Defence White Paper announced plans to acquire 12 new submarines to replace the six *Collins* class, and set an ambitious set of capability benchmarks for the new boats.

The Rudd Government's decision to expand both the number and the capability of the future submarines reflected a significant re-evaluation of Australia's strategic circumstances in the 2009 White Paper. This re-evaluation was driven by the rise of China, and the emerging challenge that China posed to the stable US-led order in the Western Pacific, which had been the foundation of Australia's security ever since the end of Vietnam War. In the post-Vietnam era it had been possible for Australia to plan its

defences on the assumption that its forces would not need to operate against those of a major Asian power like China. Already in the 2000 White Paper it was recognized this assumption was not as secure as it had been, but by 2009 it was evident that it could no longer be sustained over the long timeframes involved in major capability development. It was recognized that as strategic rivalries between major powers escalated, the long-term risks of Australia being drawn into a major power conflict, either in support of our allies or in our own defence, were likely to increase.
Developments since 2009 have only reinforced these broad conclusions.

This meant that Australia had to rethink its capability plans to take account of a higher risk of involvement in more intense conflict than had hitherto been contemplated. This was especially true for Australia's maritime forces, which were clearly going to be the most significant in any Australian contribution to a major power war. Accordingly, the 2009 White Paper announced two major enhancements in Australia's naval capability plans – the replacement of the 8 ANZAC class frigates with much larger and more capable warships, and the major expansion and enhancement of the submarine capability.

As background for the capability requirement to 2030, the government proposed a future strategic environment in which, as well as operating in the approaches to Australia and patrolling SLOCs, the ADF might conceivably be required to project Australia's military power in maritime South East Asia:

> It is conceivable that, over the long period covered by this White Paper, we might have to contend with major power adversaries operating in our approaches - in the most drastic circumstance, as a consequence of a wider conflict in the Asia-Pacific region. In such a circumstance, it is not a current defence planning assumption that Australia would be involved in such a conflict on its own. But we do assume that, except in the case of nuclear attack, Australia has to provide for its own local defence needs without relying on the combat forces of other countries. The Government considered such contingencies because although they are unlikely, they are not so remote as to be beyond contemplation. …In such circumstances, in order to defend ourselves we might also have to selectively project military power beyond the primary operational environment described in this White Paper, for instance in maritime Southeast Asia.[26]

It soon becomes clear from the 2009 White Paper that the new submarine would discharge a number of power projection roles, including the insertion of special forces and even strategic strike against a 'major adversary' far from base:

> The Future Submarine will be capable of a range of tasks such as anti-ship and anti-submarine warfare; strategic strike; mine detection and mine-laying operations; intelligence collection; supporting special forces (including infiltration and exfiltration missions); and gathering battlespace data in support of operations. Long transits and potentially short-notice contingencies in our 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 our strategic approaches and in operational areas.[27]

Defending Australia in the Asia Pacific Century was more explicit than are most White Papers and some governments in our region expressed various degrees of concern as a result.

[26] Australian Government (2009), *Defending Australia in the Asia Pacific Century*, Defence White Paper, Canberra, page 65.
[27] *Ibid*, page 70.

In defining the role of the FSM, the unclassified version of the 2016 White Paper returned to the traditional more diplomatic style:

> The key capabilities of the future submarine will include: anti-submarine warfare; anti-surface warfare; intelligence, surveillance and reconnaissance; and support to special operations."[28]

While there is no mention here of "selectively project[ing] military power beyond the primary operational environment … for instance in maritime Southeast Asia", there is no reason to believe that since 2009 the government's ambitions for future submarine capabilities have diminished in any way. The requirement is still for twelve large submarines (there had been speculation prior to the release of the 2016 White Paper that the number may have been reduced), with a very long range, a high level of mobility [speed] on transit, and the ability to undertake lengthy patrols of at least 70 days. Particularly because of the requirement for rapid transits and power projection effectively into the South China Sea, this was widely regarded as a job description for a nuclear submarine (SSN).

Importantly, the FSM will be required to employ the US AN/BYG-1 combat system that, being designed for a large SSN with enormous electricity generating capacity, is both power hungry and has a large physical footprint. Unlike *Collins*, which struggles to accommodate the AN/BYG-1 system, it is understood that the FSM will also be required to accommodate the various associated command and control (C2) sub-systems that are found on an advanced US SSN. In terms of the weapons payload, apart from having the capacity to carry heavyweight Mk-48 Mod7 CBASS torpedoes, mines and Harpoon anti-ship missiles, they will also have the capability to deploy the Tomahawk Land Attack Missile (TLAM).[29]

In summary, the characteristics desired by the RAN for the FSM are that it should:

- Be at least the size of the *Collins* class submarine, with a submerged displacement of 3,400 tonnes or greater
- Be able to make rapid transits and remain on patrol for at least 70 days
- Have submerged endurance greater than two weeks
- Have an underwater speed of at least 20 knots
- Embody heavy and power-hungry US systems not designed for conventional submarines
- Deploy a substantial weapons payload, with torpedoes, mines, anti-surface ship missiles and land attack cruise missiles
- Include a diver lockout chamber for special forces (SF)
- Consider desirable features, including a bay for despatching and recovering unmanned underwater vehicles (UUVs) and a dry dock shelter.

This would allow the FSM to undertake the following operations:

- Intelligence, surveillance and reconnaissance (ISR)

[28] Australian Government (2016), *Defence White Paper*, Canberra, page 92.
[29] Sam Goldsmith (2015), "SEA 1000: Design Options for the Royal Australian Navy's Future Submarine", Australian Naval Institute, http://navalinstitute.com.au/sea-1000-design-options-for-rans-future-submarine-2/, page 20.

- Anti-submarine warfare (ASW)
- Anti-surface ship warfare (ASuW)
- Land attack
- Covert special forces operations (SF).[30]

It is interesting that, following the announcement of the choice of the Shortfin Barracuda as Australia's future submarine, a recent statement by Rear Admiral Greg Sammut, the head of the SEA 1000 programme, identified the key roles for the FSM as follows:

- Anti-submarine warfare
- Anti-surface warfare
- Intelligence, Surveillance and Reconnaissance
- Support to special operations.[31]

These roles reflect the conventional objectives of submarine warfare and would be part of the mission statement of almost any country's submarine force. Notably, there is no allusion to a power projection role, perhaps exercised by land attack (strategic strike) against a "major adversary". Assuming these are Defence's priority capability requirements for the FSM and depending on the required areas of operations, *prima facie* they could all be undertaken by a MOTS submarine, modified so as to extend its range.

3.3 Options for acquiring the FSM

Leading up to the 2009 White Paper, ASC's design house, Deep Blue Tech (DBT), employed a substantial team of naval architects and engineers to come up with a number of concept designs, including a new *Collins* class, for the next generation of Australian submarines. This ambitious approach arose from two main conclusions that Defence had already reached regarding the FSM. First of all, given the size of Australia's economic zone and long transit times to areas of operations (AOs), Defence considered that Australia had a unique requirement for a conventional submarine that no MOTS boat then in existence or on the drawing board seemed likely to be able to meet. Secondly, the Deep Blue designs suggested that the capability required by Navy could be provided by a bespoke design but, just as *Collins* was the world's largest conventional submarine when it was launched, the FSM would also have to be a large boat. Overall, it appears that a strong conviction arose within Defence that the best approach would be for the FSM to be designed in Australia.

The requirement for twelve advanced submarines was announced in the 2009 White Paper, about two years after Defence had commenced work on the FSM capability. The intention was that the acquisition process would begin immediately with the first new submarine becoming available to replace the first of the *Collins* class in the mid-2020s, when it would reach the end of its planned 30-year life. Yet very little seems to have been done following the 2009 announcement, at least in part because there was disagreement between those who wanted to pursue an Australian design and those who considered it much preferable to follow the lower risk approach of

[30] Ibid, pages 18-20.
[31] Sammut (2016), *op. cit.*, Slide 2.

a modified MOTS boat. It was not until 2012, three years after the FSM was proposed, that Defence identified the four obvious options for acquiring the submarines:

1. A MOTS purchase of an existing submarine design
2. A MMOTS purchase, with some changes to the design to address particular Australian requirements, such as the integration of US systems into a European design of SSK
3. An evolved *Collins* class design
4. A new design, aimed at satisfying Australia's ambitious capability requirement.

MOTS and MMOTS options

Later, when the 2013 White Paper was released, it became clear that the advocates of an Australian evolutionary or bespoke design had prevailed. The Gillard government announced that the two MOTS options had been withdrawn from further consideration "in favour of focusing resources on progressing an 'evolved Collins' and new design options that are likely to best meet Australia's future strategic and capability requirements". At the same time the government announced that a study of the service life of the *Collins* class suggested it could be extended for one service life for the fleet (about seven years).[32] It also announced that the American AN/BYG-1 combat system represented the benchmark system for the new submarine.

Although this was a major decision that, at a stroke, multiplied the costs and risks in the acquisition, no clear reason was given for discarding the MOTS and MMOTS options. One view is that once the AN/BYG-1 tactical control system – designed for American SSNs and described "as a hot, heavy, hungry system" – had been selected for the FSM, both MOTS and modified MOTS designs were eliminated because of the large physical footprint of AN/BYG-1 and its associated sub-systems and its hunger for electrical power.

Other views are that the MOTS options were ruled out based on supposed inadequate range and endurance. In 2014, the nature of Australia's unique requirement was spelt out by Rear Admiral (Retd.) Peter Briggs in evidence to a Senate Committee:[33]

> "We are the only submarine navy in the world that steams a submarine halfway around the world and then expects it to go on patrol and, when it is finished, to come back. It is a huge driver. The transit requirements will determine the size of the submarine. The ability to cover 3,000 miles of open ocean, some of it under other people's surveillance, to do it quickly with good mobility and to arrive in a patrol area without having been spotted and to do your job is absolutely critical to the success of the submarine and no-one else has the geography or the problems that we are dealing with."

While this is a strong argument for a unique submarine with long endurance, it is not clear that any serious analysis was done of alternative approaches such as forward basing or a submarine tender ship with fly in, fly out crewing. One reason for this was that at that time the resources boom had depleted the Navy's submariner ranks to such an extent that it was

[32] Australian Strategic Policy Institute (2016), *The Cost of Defence: ASPI Defence Budget Brief, 2016-17*, Canberra, pages 214-215.
[33] Australian Senate (2014), Economics References Committee, *Future of Australia's naval shipbuilding industry, Future Submarines*, November, page 67

considered that moving submariners and their families to a remote base in the north was not a practical option. If such reasons are true, they reflect a failure to think laterally and to evaluate options like forward basing with fly-in and fly-out, as used in the mining industry, relative to the very high developmental and ultimately strategic costs of a bespoke design.

Evolved Collins *class*

It is widely accepted that an evolutionary approach to submarine design and construction is far less risky than developing a new, revolutionary design. For Australia, with a nascent national submarine capability, it would seem particularly important from a strategic perspective to build on an established design that is well understood and to utilise an existing chain of tried and tested suppliers.

According to the Australian National Audit Office (ANAO), in 2014, "Defence engaged an external review to determine the viability of enhancing the Collins design. The external review concluded that an enhanced Collins design would require the same budget, schedule and contingency as a new design, and would have significant engineering constraints such as hull diameter. On this basis, Defence determined that a new design was the preferred option for the Future Submarine."[34] The issue of the hull diameter was put to us as a major reason why an evolved Collins was not feasible. A number of witnesses put this view to a Senate committee in 2014, including Professor Goran Roos who suggested that "an evolved Collins, was doomed from the start, because the pressure hull diameter was constrained to the current 7.8 metres. He explained that this constraint 'required the hull to be stretched and this would limit a future growth path because you can only stretch a submarine so far before it becomes hydro-dynamically inefficient'."[35]

We have been unable to discover any further information on the external review that was the basis for discarding Option Three, the evolved *Collins* class. While accepting that the diameter of the hull would have needed to be increased, engineering experts we have consulted do not see this as an insuperable obstacle. Apart from the prospect of a lower risk, our discussions with experts in Adelaide, who were familiar with the evolved *Collins* program, suggested not only would the cost of *Collins* Mark Two be lower than the Shortfin Barracuda, but it could be in the water seven years earlier.

Nevertheless, with the evolved Collins option having been discarded, the risks in the FSM acquisition were now being increased very substantially. Not only would Australia pay a good deal more for its submarines, but the risks to capability and delivery were much higher. Oddly, there was very little analysis in the media of the sudden escalation in the risk profile of the FSM. Most of the comment was around the politics of building the boats in Adelaide.

[34] ANAO (2017), Report No.48 2016–17 Future Submarine—Competitive Evaluation Process, April, page 20

[35] Australian Senate (2014), Economics References Committee, *Future of Australia's Naval Shipbuilding Industry: Future Submarines*, page 79

3.4 The Competitive Evaluation Process (CEP)

When the Abbott government came to power in 2013, all options were put back on the table. After what it regarded as years of drift, the new government clearly saw the replacement of *Collins* as a matter of urgency. It appears that, while exploring the possibility of acquiring SSNs in the longer-term, the Prime Minister was disposed in favour of a MOTS solution, namely to acquire six *Sōryū* class submarines off the shelf from Japan. This approach was derailed by two factors. First, a MOTS purchase from Japan would require the government to break an election commitment to build the FSM in Adelaide. Secondly, there was no great enthusiasm in the Navy for the *Sōryū*, which was viewed as having too short a range for deployments from Fleet Base West (HMAS *Stirling*) and, because of its design characteristics, could not readily be modified so as to extend its range. In addition, despite having AIP the *Sōryū* was viewed by the RAN as not representing a significant advance over the *Collins* class in terms of technology and capability.

At a conference convened by ASPI in September 2014, the then Minister for Defence, David Johnston, said that the government's four primary objectives for the FSM were to:

1. "Deliver an enduring regionally dominant superior conventional submarine capability
2. Ensure that our new submarine capability is affordable, and that is a very important part of the whole programme
3. Ensure Australia is able to sustain a superior conventional submarine capability into the foreseeable future in a cost-effective way
4. Avoid, of course, a submarine capability gap."

In this context, the Minister stated that "ideally, we are seeking a comparable capability to a nuclear submarine with diesel–electric motors inside".[36] Of course, no such submarine exists but it seems that the Minister meant that the government wanted to procure an SSK incorporating as much of the capability of an SSN as could be delivered with existing non-nuclear technologies.

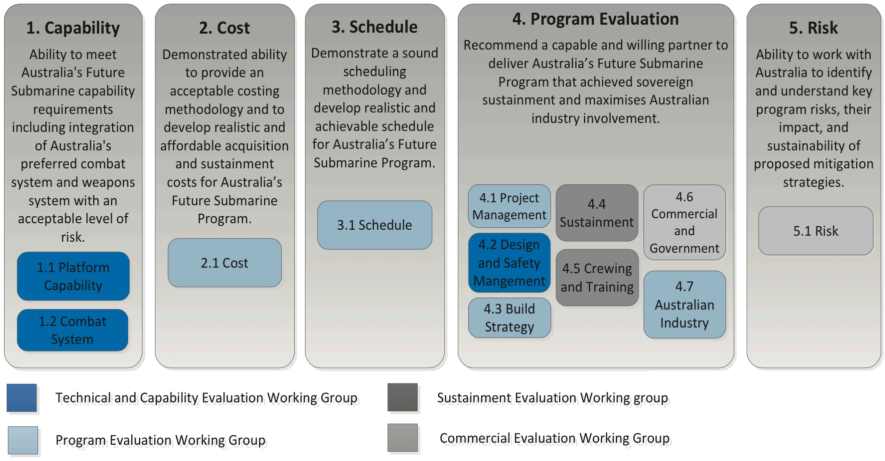
In early 2015, a new Minister for Defence, Kevin Andrews, announced that a 'competitive evaluation process' (CEP) would be established to select a design partner for the FSM. Under the CEP, and in accordance with the criteria summarised in Exhibit 3.1, submarine builders from France (DCNS), Germany (tkMS) and Japan (Ministry of Defence, supported by Mitsubishi Heavy Industries and Kawasaki Heavy Industries) were invited to propose:

- Pre-concept designs based on meeting Australian capability requirements
- Options for design and build overseas, in Australia, and/or a hybrid approach
- Rough order of magnitude costs and schedule for each option

[36] Australian Strategic Policy Institute (2014), *The Submarine Choice*, Conference Proceedings, September, page 10.

- Positions on key commercial issues, for example intellectual property rights and the ability to use and disclose technical data.

EXHIBIT 3.1: COMPETITIVE EVALUATION CRITERIA UNDER THE CEP



***Source: ANAO (2017), op. cit.*, page 24**

On the basis of the CEP, the Minister for Defence wrote to the Prime Minister on 19 April 2016 to recommend that, subject to some commercial issues around IP still to be negotiated, the French shipbuilder DCNS should be selected as the single design partner to proceed to the next stage of project definition and initial design. The design concept put forward by DCNS, the Shortfin Barracuda, was for a conventional submarine of over 90 metres in length with a submerged displacement of over 5,000 tonnes. While based on the platform of the nuclear-powered Barracuda (*Suffren*) class, in all material respects it would be a new developmental design concept. It would take approximately ten years to complete the detailed design and, according to Defence's current schedule, the first boat would enter service in 2032-33.[37].

3.5 Problems with the CEP

The CEP represented a new process for Defence. Inevitably with a new process in such a complex area, particularly one that had not been subject to very much prior design and evaluation within Defence, some problems arose. With a similar process currently being used for the SEA 5000 (Future Frigate) and SEA 1180 (Offshore Patrol Vessel) acquisitions, one observer has suggested that some of the problems are significant and have not been addressed.[38]

Concerns about the CEP were expressed before the result was known, for example Wylie suggested in January 2016:

> Australia's hairy chested handling of the CEP to date stands to compromise its ability to make an informed selection of an international partner for our future submarines. That's partly due to asymmetries in the information available to, on one hand, the

[37] Sammut, Rear Admiral Greg (2016), "The Future Submarine Program", Presentation to the 8th SIA Biennial Conference, 15 November, Slide 8.

[38] Morrison, Aidan (2017), "Future Frigates Industry Briefing: talk to the hand because the face is gagged",, ASPI, *The Strategist*, 18 January, https://www.aspistrategist.org.au/future-frigates-industry-briefing-talk-hand-face-gagged/

> Australian defence customer and to, on the other, those candidate suppliers the customer has invited to participate in the CEP. Looking further downstream, those information asymmetries are exacerbated by the developmental nature of our future submarines. Neither defence customer nor selected supplier can anticipate every development in the future submarine project and negotiate, ex ante, contingent provisions in the contracts that will satisfactorily cover unexpected design and production challenges that occur ex post.[39]

It is also useful at this stage to refer back to the August 2012 report of the Senate Committee on Defence procurement, referred to earlier in this study. The Committee had some sage words of advice on the SEA 1000 project. The report was highly critical of Defence's acquisition record and singled out a number of major problems, including an insufficient understanding of risk, a propensity to select highly risky developmental platforms, a reluctance to undertake preview T&E and an inclination to ignore expert advice. The Committee was sufficiently animated by its findings to single out SEA 1000 for specific recommendations, stating that it was "very concerned about the current unease expressed by a number of defence analysts regarding decisions already taken on the 12 new submarines".[40] The Committee's recommendations on SEA 1000 are shown in Exhibit 3.2.

EXHIBIT 3.2: SENATE COMMITTEE RECOMMENDATIONS ON SEA 1000 (2012)

"Because this project is still at an early stage, and based on the RAND study, the Coles Report, independent defence analysts and the past performance of major Defence acquisition projects, the committee recommends that government and Defence start work immediately to:

- ensure that the program is directly managed by Chief of Navy supported by the ASC and DMO where relevant, the scientific community and the public— support must be both external to the program and internal within the navy and submarine community
- avoid early lock-in through premature weapons systems choices
- ensure that the capability sought is available and minimises developmental risks
- take drastic action to address the serious skill shortages identified by RAND before a decision on assembly in Australia is made, regardless of type and design
- ensure that the program is open and transparent—full disclosure throughout the program is necessary to obtain government, industry and public support
- involve experienced people in key management positions—this requires a strategy to grow people so they are experienced in various disciplines—a top- level strategic lesson must be implemented far in advance of any specific program
- listen to technical community concerns about risk—the technical community, supplemented by outside expertise from industry and allied technology partners as necessary, should understand the state of technology and the degree to which a new design extends that technology.

The committee recommends that government and Defence respond publicly to the committee's criticisms made in this report with respect to lessons not learnt, and outline the detailed process and all the options on which current planning on submarines is taking place.

The new White Paper presents an opportunity for the government and Defence to start to provide assurances that the decisions relating to SEA 1000 are based in sound, robust and fully considered analysis."

Source: Senate Committee (2012), op. cit. pages 263-264.

It is not clear that these recommendations, highly sensible though they are, have necessarily been applied within Defence..

[39] Wylie, B. (2016), "Choosing Australia's future submarine: more haste and less speed", *The Strategist*, ASPI, 14 March, www.aspistrategist.org.au/choosing-australias-future-submarine-more-haste- and-less-speed/

[40] Senate Committee (2012), *op. cit.*, page 263.

When the outcome of the CEP became known, it highlighted a number of concerns about how the process was organised:

- There was some confusion about whether the aim of the CEP was to identify a *design partner* or a particular *design concept* for the FSM. The process seemed to be focussing on the selection of a partner, and yet the announcement was centred on the selection of a particular submarine, the Shortfin Barracuda.
- It was never entirely clear what criteria a winning bid would need to satisfy. One contender told Insight Economics, "it was meant to be an open Competitive Dialogue, but so many probity restrictions were imposed by Defence on the CEP Teams that there was no possibility of open communication about what the customer was really looking for … with proper evaluation against well defined criteria".
- It is not clear whether Defence analysed the relative risks of each proposal to any great extent and whether this was a factor in the assessment process. It is notable that under the CEP (Exhibit 3.1) contenders were required to demonstrate an "ability to work with Australia to identify and understand key program risks, their impact, and sustainability of proposed mitigation strategies". This assessment would occur, presumably, only after the contract had been awarded.
- With a tight schedule and with the three contenders not being required to propose a detailed design, there was no opportunity for preview test and evaluation (T&E) of any aspects of the three submarines on offer. This suggests that Defence will be subject to very substantial technical risks in the design and engineering of the Shortfin Barracuda with the possibility of significant cost overruns and delays in the schedule for delivery. The need for preview T&E is accentuated by the developmental nature of the platform, particularly the complexities of designing an advanced conventional submarine within a hull designed for a SSN (a world first).
- Despite the government's repeated disavowal of the nuclear option, there remains a view that some in Defence still want to retain the option of acquiring a SSN down the track. Naval Group is the only contender that builds SSNs and indeed, with the Shortfin Barracuda, did offer "a nuclear submarine with diesel engines".
- Defence advised tenderers during the process that both AIP and Lithium-Ion batteries, the two break-through technologies that have the capacity to take the capability of a SSK much closer to that of a SSN, were not seen as a priority for the FSM. Subsequently Defence has stated that AIP has not been ruled out for the Shortfin Barracuda, although it was not part of the design concept. Our advice is that AIP is unlikely to be included on account of its weight penalty (around 400 tonnes) and that advanced battery technologies have been ruled out at least for the first four boats.[41]
- There is significant concern about the ability of a French platform designer to access and integrate the highly sensitive US systems and technologies specified by Defence. This concern has subsequently

[41] Sammut (2016), *op. cit.*, Slide 6.

been heightened with the leaking of top secret data relating to France's conventional export submarine, the *Scorpène*.

- Cost and schedule concerns did not appear to play a significant part in the evaluation, with the German contender, tkMS, offering a fixed price contract for twelve submarines at under $20 billion at 2015 prices and delivery of the first boat in 2028.
- One of the risks facing the FSM down the track is the requirement for an Australian build, yet this did not seem to have been made clear until after the selection of Naval Group was announced. Ideally, the likely industrial performance of the bidders in working in Australia should have been a major consideration in evaluating the bids. For example, tkMS had given this issue significant attention, offering a transfer of digital shipyard technology to Australia and a guaranteed cost the same as construction in Germany. By contrast, the ANAO report states that Defence modelling had indicated that it would cost 15 per cent more for Naval Group to build the submarines in Australia.[42] It was not apparent that Naval Group had accorded a high priority to Australian industry involvement. Indeed, the French President greeted the announcement by stating that many thousands of jobs would be created in France in consequence and the Defence Minister announced the first two boats would be built in France.

This is not to suggest that Insight Economics necessarily favours the German or the Japanese offerings over the French. While tkMS fleshed out its proposal in public forums, we have far less information on both the Japanese and the French bids.

According to the ANAO report, the CEP required the three contenders to "demonstrate a commitment and ability to maximise Australian industry involvement through all phases of the Future Submarine Program without unduly compromising capability, cost, program schedule and risk".[43] The German proposal focussed to a large degree on industrial issues; in some ways it let the capability offered by its advanced submarine technology speak for itself. It was willing to offer a fixed price of under $20 billion, with construction in Adelaide at the same cost as in Kiel. It was also willing to transfer digital shipyard technology to Australia and assist local firms enter global supply chains. Yet it is unclear that the contenders' approach to building the submarines in Australia, including the cost premium and likely involvement of local suppliers, played a significant part in the decision.

According to well-sourced reports, the main reason for rejecting the German bid was that Defence claimed that it had identified a significant radiated noise issue from German submarines.[44] This seemed peculiar in a submarine that was yet to be designed in detail and where the problem, if indeed it existed, could presumably be rectified. It also raised the ire of both tkMS and the *Bundesmarine*, which takes great pride in the stealthy qualities of its submarines. Of greater concern is that tkMS was never provided with the opportunity to respond to Defence's concern before the CEP decision was made.

[42] ANAO (2017), *op. cit.*, page 25.
[43] *Ibid*.
[44] Stewart, Cameron (2016), "Sound of silence: why Germany lost subs bid", *The Australian*, 30 May.

The Japanese concern is quite different. For the first time since World War II, Japan was willing to engage with a foreign country to share some of its sensitive defence technology and to export advanced military equipment. On the basis of prior discussions between Prime Ministers Abbott and Abe, the Japanese bidders, rightly or wrongly, were confident that a top-level deal had been signed and sealed and was about to be delivered. While they recognised the CEP had been established, as they understood for political reasons, they had no experience of dealing with such a process.

Nevertheless, on the basis of past assurances, they believed they would emerge from the CEP with the winning bid. Indeed, on the assumption that they believed Australia had already selected the evolved *Sōryū*, they had provided Defence with a great deal of highly sensitive information on the submarine's performance that otherwise they would have kept confidential. Material damage to the relationship was done first when the Japanese bid failed and then, to rub salt in the wound, when the media in Australia published articles disparaging the quality of the *Sōryū*. to the extent of stating that "if the *Sōryū* were to fight the *Collins* today, *Collins* would kill it every time".[45]

Aside from the damage to relationships between Australia and Germany and Japan, eliminating competition at such an early stage of the procurement process is a highly risky approach. We see very substantial risks both in undertaking an *ab initio* design and in proceeding to the project definition and design phase with just one partner.

As we understand it, the main reason that Naval Group was selected is that the Barracuda platform, stripped of its nuclear reactor and much of its equipment, presents Defence with a blank canvas on which they wish to paint the ideal submarine for Australia. As discussed above, this goes back to the Deep Blue Tech developmental work and suggests that the faction within Defence that favoured an Australian design had comprehensively won the argument. For the very important initial design phase of the FSM, we understand the ratio of Australian to French naval architects and designers will be of the order of one to one.

Even if we put aside the substantial risks in an *ab initio* design, the lack of competition down the track could lead to severe difficulties for Defence in terms of capability, cost and schedule. Yet according to Defence, there are simply not the skilled resources available to design more than one class of new submarine. Nevertheless, the cost of inviting one or both of the other contenders to go to the next stage in competition with Naval Group appear to us to be dwarfed both by the overall budget for the project and by the potential benefits. The other contenders could supply their own design team with a brief to meet, as far as possible and within an acceptable cost envelope, Navy's capability requirements.

Indeed, considerable concern has been expressed about the short CEP and the outcome that eliminates all further contestability from the acquisition process. For example, and again before the outcome was known, Bergmann stated that:

[45] Staff Reporters (2016), "The submarine problem – deeper than meets the eye", *Australian Defence Magazine*, 7 April, http://www.australiandefence.com.au/news/the-submarine-problem-deeper-than-meets-the-eye

> If Defence plans to sign a production contract three years after selecting a preferred designer, they leave themselves open to enormous risks. Put simply, without commercial leverage the Commonwealth will either have to pay whatever the designer wants—or start the entire process again. ...The only way to protect against those sorts of possibilities is to have at least two bidders to choose from and maintain competitive pressure for as long as possible.[46]

The Australian National Audit Office (ANAO) clearly regards this as a problem:

> The approach taken by Defence for the Future Submarine program removes competition in the design phase, and removes incentives for the international partner (DCNS) to produce a more economical and efficient build. This places the onus on Defence to ensure that its approach to the Future Submarine's design and build phases, where final costs and schedules will be determined, returns value-for-money to the Commonwealth in the absence of a competitive process.[47]

Yet the ANAO had narrow terms of reference for this report and accepted the CEP process. Dr Keith Joiner, formerly the head of test and evaluation (T&E) at Defence and now on the staff at the University of NSW in Canberra, is critical of this and provided the following comment to Insight Economics:

> The ANAO must have been aware that when people are concerned by the CEP process, they do not mean the narrowly defined CEP process used to choose the partner, rather the totally fallacious idea that you would choose a partner without 'eliciting and assessing a full design or identifying firm cost and schedule data' via a normal tendering process that includes preview T&E. There is no reason that the reference designs could not be assessed (previewed) and reasonable cost and schedule information used to determine a value-for-money decision in a conventional tender process. Paper-based down-selects never disclose sufficiently the technological, commercial and operational risks.
>
> Finally, nowhere do people look at the ironic use of the argument of 'mature designs only' being used to kill-off an indigenous design and then using the argument 'it is a new design' to justify the long process, high cost and early down-select of Naval Group. The public are getting a story sheet at every turn and it is the *Collins* all over again. If anything can explain this self-perpetuating project style in Defence, it is the tendency every 20-40 years to get fighter pilots & fighter engineers to procure the next fighter and submariners to procure the next submarine. Contemporary acquisition reform does not get a chance.

Cabinet process

One of the major concerns around the CEP is the Cabinet process and the key question of whether Ministers had sufficient time to evaluate the complex issues around what is reported to be Australia's biggest ever Defence investment.

Under the 'two pass' system, where Defence projects are assessed twice before an acquisition decision is made, major projects are considered at least twice by the National Security Committee of Cabinet. The Mortimer report pointed out that "particularly complex projects, or those that make significant demands on national resources, have rightly been considered by Government on more than two occasions. The Air Warfare Destroyer project,

[46] Bergmann, Kym, "Australia's next generation submarine: where to now", *The Strategist*, ASPI 14 December.

[47] ANAO (2017), *op. cit.*, page 38.

for example, was considered five times."[48] The problem in the case of SEA 1000, however, was once again that under the CEP the government was selecting not a submarine, but a design partner. This meant that the usual procedures did not have to be followed, even though the outcome of the CEP was the announcement of the eventual procurement of a submarine, namely the Shortfin Barracuda.

Yet even the selection of the design partner received relatively little Cabinet consideration. Very little time elapsed between the letter from the Minister for Defence recommending DCNS to the Prime Minister on Tuesday, 19 April 2016 to the announcement on Tuesday, 26 April. Note that Monday 25 April was the Anzac Day public holiday. Within this week, half of which was weekend/holiday, the National Security Committee of Cabinet would have had to have met and approved the decision, and full Cabinet would have had to endorse this before the announcement. For a complex and substantial issue such as the future submarine, it would seem essential not only that the ten day rule for Cabinet Submissions should be observed but that a series of Submissions and Memoranda should have been put forward to allow time for agencies, particularly the coordinating departments, to evaluate and, if necessary, challenge Defence's proposal.

The key questions are:

- When was a Cabinet submission circulated for coordination comments, if at all?
- Did any department, including the coordinating departments, have any genuine opportunity to comment in depth on Defence's proposal?

In short, it is not at all clear that Ministers had anywhere near enough information, or access to an informed assessment from officials, to be able to interrogate the Minister for Defence's proposal in any great depth.

Future review

There is an enigmatic statement in the 2016 White Paper:

> During the long life of the new submarines, the rapid rate of technological change and ongoing evolution of Australia's strategic circumstances will continue. As part of the rolling acquisition program, a review based on strategic circumstances at the time, and developments in submarine technology, will be conducted in the late 2020s to consider whether the configuration of the submarines remains suitable or whether consideration of other specifications should commence.[49]

This seems peculiar, particularly in terms of timing. The detailed design for the Shortfin Barracuda is scheduled to be completed in the "late 2020s" and the construction of the first boat should then be underway. If Defence is suggesting that, after a review at that time and without a decade of prior intensive preparation, the government may decide that a nuclear submarine is required, on present policy settings the *Collins* class may be challenging Methuselah before it is replaced.

[48] Mortimer, David (2008), *op. cit,* page 14.

[49] Australian Government (2016), *Defence White Pape*r, op. cit., page 91.

3.6 Implications

The FSM acquisition is likely to be Australia's largest defence project to date. It seems important to minimise the risks in the acquisition. Yet, as was suggested in Chapter 2 of this report, a bespoke solution represents the most risky approach possible. Importantly, in seeking a "nuclear submarine with diesel engines" there is a high risk that Defence will fall between two stools.

Most importantly, the lack of contestability in the process beyond the design concept stage together with Defence's opposition to a fixed price contract leaves the government highly exposed in the relationship with Naval Group. It may well eventuate that Defence's capability requirement cannot be delivered in its entirety in a conventional submarine, in which case a *Collins* evolution or a MMOTS purchase would have made much more sense. Yet if the cost of the submarine goes up during the process and the already extended delivery schedule blows out, there will be very little that the government can do.

In the final assessment, a major concern of the outcome of the CEP is that not one of the four criteria set out by the previous Defence Minister, David Johnston, appears to have been met. First, without AIP or Lithium-Ion batteries, the FSM will likely not provide an 'enduring regionally dominant superior conventional submarine capability'. In an era of nuclear submarines becoming much more common in the Asia-Pacific, the FSM will not be a 'regionally superior submarine', to which Johnston's carefully worded criterion has been inflated by subsequent Ministers. Secondly, with the FSM being perhaps the most expensive SSK the world has ever seen, it is difficult to argue that 'the new submarine capability is affordable'. Thirdly, with the first submarine likely to enter service in 2035-40 and at great cost, it is not at all clear that the project will 'sustain a superior conventional submarine capability into the foreseeable future in a cost-effective way', especially while the rolling design, acquisition and sustainment model has not been articulated and costed properly by Defence. Fourthly, it seems highly questionable that Australia will be able to 'avoid, of course, a submarine capability gap'. The only question is how long the gap will be.

This last point is particularly significant in terms of risk. The original intention in 2007-09 was to have the first new submarine available to replace HMAS *Collins* in the mid-2020s. It now appears that in the space of ten years, the project's schedule has slipped by ten years.

The bottom line is that Defence appears to have cast aside any consideration of value for money and of risk minimisation. As a senior Defence official has been quoted as saying: "If you asked someone to devise a new submarine program with the highest risk factors at every stage, you could not have done a much better job. It will almost certainly end in tears and possibly a catastrophe".[50]

[50] Akerman, Piers (2016), "Leaks in subs should sink French project", *Daily Telegraph,* 17 September, http://www.dailytelegraph.com.au/news/opinion/piers-akerman-leaks-in-subs-should-sink-french-project/news-story/830275ecec5d76b2da914a37ee87b785

CHAPTER 4

Economic and financial risks

"It costs a lot to build bad products."

Norman Augustine, Under Secretary of the US Army 1975-77 and later CEO of Lockheed Martin.

4.1 Background

Defence has allocated $50 billion in so-called 'future dollars' to a major public investment in new submarine capability from the 2030s. In this Chapter we examine the economic and financial risks around this project.

In light of the waste of trillions of dollars on sub-optimal defence projects globally, it is not surprising that the economics of the acquisition process for advanced military systems has generated a significant literature, particularly in the United States. Yet it needs to be recognised that there are enormous uncertainties and complexities involved in defence procurement. As Ergas and Menedes have pointed out

> "The complex weapons acquisition process is afflicted by almost all of the pathologies that prevent efficient outcomes: information asymmetry, conflicting goals, non-commensurable objectives, lack of credible commitments, within government incentive problems; all superimposed with a high degree of technical complexity and uncertainty."[51]

Any examination of the evidence given by Defence to various inquiries into procurement suggests that the disciplines of financial economics are not consistently applied to major investment projects within the department. We believe that a substantial benefit could accrue if the tools of investment appraisal were rigorously applied within Defence to evaluate different options to deliver a specified level of military capability. At the very least, this would force acquisition teams to examine in great depth the different levels of risk applying to alternative options and the consequential impact on cost and delivered capability.

4.2 Addressing the economic risks

In Australia, the Department of Defence sits in a privileged position compared to other departments of state. It has a single line budget allocation. Within that overall budget, the Minister can choose to allocate funding to programmes without any significant scrutiny from other government agencies. While other departments are consulted in terms of the strategic environment and broad capability requirements, the allocation of funds between various major acquisitions, such as SEA 1000 (future submarines) AIR 6000 (F-35 joint strike fighter) and SEA 5000 (Future Frigate) lies very much within the discretion of the Minister acting on advice from the department.

In terms of individual programmes, it seems very clear that Defence could benefit by working closely with other specialist government departments,

[51] Ergas, Henry and Flavio Menezes (2004), "The Economics of Buying Complex Weapons", *Agenda*, Volume 11, No.3, Australian National University, page 262.

particularly Treasury and Finance. As reported in Chapter 1 of this report, Mortimer observed that while Defence has a great deal of technical expertise regarding the capability of various military platforms and systems, it is much less skilled in commercial analysis. It has a poor record in assessing the risks involved in various programmes and the probability that their costs and schedules will overshoot significantly, or even that the technological risks are too great and that the required capability may never be delivered. It may be that these skills are lacking in government more generally and that in order to appraise these massive investments efficiently and effectively, government may well need to recruit significant expertise from the private sector.

Australia is by no means alone in its experience of military programmes that turn out to be disasters in many respects, but perhaps mainly in terms of wasting a great deal of taxpayers' money. Hard lessons have also been learnt in the UK. In response to repeated failures, the UK government has recently established a new approach to defence procurement (Exhibit 4.1).

EXHIBIT 4.1: DEFENCE PROCUREMENT – MANAGING ECONOMIC RISKS IN THE UK

Defence Strategy, Policy, Force Structures and Equipment Programmes

In the UK, because of consistent embarrassing defence procurement failures leading to massive cost overruns, enormous delays in 'in service' dates, frequent inability to meet the operational requirement and in some cases cancellation of the project, the Single Services and even the Ministry of Defence (MOD) as a whole are no longer permitted to approve, run and deliver their own large projects, which are now subject to external appraisal, agreement and constant monitoring and holding to account by other agencies. The system has been completely overhauled in the last two years after a major review by Lord Levene.

Ministers, the UK Treasury, other government departments and Parliament are all involved at the macro level with the annual Defence Budget, spending reviews and estimates and also with the five yearly Strategic Defence and Security Reviews which itemise and review the relevant equipment programmes and define the Future Force structure. Each SDSR outlines the key elements of an affordable force structure that is to be delivered in 10 years time, based on strategic planning assumptions. The defence programme must be affordable, joined up and totally derived from policy. Overall Defence spending is monitored and controlled to make sure that it stays within the approvals set by the Treasury and by Parliament.

Equipment Programme Approvals and Delivery

At the micro level the Treasury and Cabinet Office, which jointly run the Major Projects Authority, approve all large scale or contentious projects, which will already have passed through the MOD's own internal approvals process. The MOD Investment Approvals Committee (IAC) is responsible for considering major investment proposals for expensive, complicated, innovative, risky or contentious projects, and making recommendations to ministers. Investment approvals provide assurances that the investment meets a strategic requirement, will provide value for money and is affordable within the department's financial envelope. Capability programmes are only funded against approved business cases, which look at the strategic, financial, economic, commercial and industrial risks. Major programme spending is managed using a Portfolio, Programme and Project Management (P3M) approach, common across government, using evidence-based balance of investment decisions. Given the usual financial and time overruns there is a constant analysis of cost and capability trade offs (CCTOs) to bring the project in within time and cost limits. CCTOs may of course also be demanded from projects that are themselves within budget simply because of financial pressures in other areas of Defence or elsewhere in government.

Each equipment programme has a Senior Responsible Owner who leads on all aspects of delivering a programme, accounting for cost, capability and benefit trade-offs and making sure that the business case remains valid from start to delivery, by providing consistent and reliable financial, commercial, industrial and technical information and advice. This is crucial given the length of time needed to move from concept to actual operational in service date, especially in major ship or aircraft platforms with complex integrated command, sensor and weapon systems.

Source: Stanford, Chris (2017), Communication to Insight Economics

4.3 Cost of the future submarine

It is difficult to get a clear view of how much the FSM is going to cost. We know that Defence has allocated around $50 billion (excluding the combat system) to acquiring advanced new submarine capability in the shape of twelve 'regionally superior' conventionally-powered submarines. But this allocation is expressed in 'future dollars', that is it takes account of inflation. Further, the $50 billion includes more than the acquisition cost of twelve submarines. For example, it also includes, *inter alia*, and in no particular order:

- Programme management
- Support systems
- Spares
- Land based testing facilities
- Wharves
- Maintenance facilities
- Training
- A facility in France
- On base facilities
- Funding for the Defence Science and Technology Group (DST).

Both Dr Andrew Davies and Dr Mark Thomson of ASPI have attempted to cut through the uncertainty and using modelling have separately come out with separate estimates of the acquisition cost of the FSM at just under $40 billion in 2016 prices.[52] This equates to around $3.25 billion per submarine.

EXHIBIT 4.2: COST OF FSM – COMPARISON WITH COLLINS CLASS

It is useful to understand the contract value at issue for the FSP. The media and some politicians are trying to outbid each other as to the delivery cost of 12 new ocean-going submarines. Sums of $30 to $50 billion dollars are bandied around by people with little knowledge or understanding of the scope of the work for the delivery of the FSP.

ASC delivered the six Collins class boats at roughly $5 billion Australian dollars. The lump sum price included the establishment of a new, purpose-built, shipyard near Adelaide, the design, procurement and development of the combat system and the construction of the submarine platforms. It also included the training of personnel, the development of a Logistics Management System (SIMS/SIS), and the qualifying of some 1500 Australian sub-contractors to the then current Australian AS 3901-1987 Quality Standard.

By extrapolating the contract price for the six Collins class boats it would be safe to deduce that the $50 billion price-tag the media attaches to a 12-boat FSP is way off the mark.

If the Commonwealth confirms an order for 8 + 4 long-range blue-water submarines of advanced, multi-purpose, capability, a unit cost of $1.6 billion Australian dollars in today's money and exchange rate should be a more realistic figure. This number should also hold reasonably firm if the government pursues a single-source selection process for the new submarine class provided the RAN specified operational capabilities are not required concurrently. In other words, mine-laying, ROV, and Special Forces deployments, or torpedo and rocket launching capability are not required collectively on each mission.

Source: Ohff, Hans J. (2015), Address to Submarine Institute of Australia, 17 November, page 1.

[52] See, for example, Davies, Andrew (2017), "The current cost of the future submarine", *The Strategist*, ASPI, 23 June.

Even for a 5,000 tonne submarine, this cost seems very high. The rule of thumb currently is that a conventional submarine should cost around $400,000/tonne. This is consistent with an estimate by Dr Hans Ohff, the CEO of ASC during the construction of the *Collins* class submarines, who suggested in 2015 that a unit cost of $1.6 billion for twelve blue water submarines would be reasonable (Exhibit 4.2). This was about the fixed price quoted by tkMS under the CEP for their Type 216 proposal. It should be noted, however, that the implications of Exhibit 4.2 is that the cost of the six *Collins* class boats ($5 billion) included the provision of much of the infrastructure required to produce the submarines.

Two questions arising from this are considered here. First, is the estimated acquisition cost excessive in terms of what other products are available on the global submarine market? Secondly, how should opportunity costs be treated in this process?

What does a submarine cost on the global market?

The difficulty of considering acquisition costs of different submarines using data that is in the public domain is that it is very difficult to estimate whether these costs are measured on a consistent basis. For example, they may or may not include set up costs, including some infrastructure, weapons and training.

Compared to the estimated acquisition cost of the Shortfin Barracuda of about US$2.5 billion (at September 2017 exchange rates), the Japanese *Sōryū* class submarine, a contemporary large SSK (4,200 tonnes submerged displacement), is far less expensive, with the most recent boat, commissioned in 2015, estimated to cost US$540 million.[53] Singapore has recently ordered two German Type 218 submarines (2,400 tonnes submerged) at a total programme cost of US$1.71 billion (US$855 million per boat), but it is unclear what this includes. Vietnam recently bought six of Russia's accomplished Kilo class submarines (about 3,400 tonnes submerged displacement) for around US$330 million a copy.

By comparison, the cost in FY 2016 of an American state-of-the-art *Virginia* class nuclear attack submarine, significantly larger than the FSM (circa 8,000 tonnes submerged displacement) and much more capable, is US$2.7 billion.[54] The latest British *Astute* class SSN, about the same size as the *Virginia* class, is expected to have cost around US$2.0 billion when it is delivered next year.

Of course, in comparing the costs of acquiring these submarines we need to consider the relative capability they provide. To be sure, the Shortfin Barracuda will offer a longer range than most of these other conventional submarines and, due to its size, improved habitability. It will also carry a greater weapons payload and perhaps be more versatile in the missions it can undertake. But on the other side of the ledger, according to Defence's current thinking, it will not incorporate either of the two breakthrough technologies that are currently transforming the capability of SSKs – air independent propulsion (AIP) and modern battery technologies, currently Lithium-Ion but in the future likely to include Lithium-Sulphur and other

[53] Wikipedia, https://en.wikipedia.org/wiki/Sōryū-class_submarine
[54] Wikipedia, https://en.wikipedia.org/wiki/Virginia-class_submarine

technologies currently under development. Without these, it is likely to have a significantly higher indiscretion ratio than many of these other SSKs, making it more vulnerable to detection and attack. [55]

When the first Shortfin Barracuda is delivered, probably in the late 2030s, therefore, it will struggle to justify the description of being 'regionally superior'. It will not have the capability of a SSN, many more of which will be present in the waters of the Asia-Pacific region, while some SSKs will likely have more advanced propulsion systems. Indeed, it is difficult to see that the FSM's capability will be any greater, and perhaps less, than, for example, a Type 218 submarine of the class being acquired by Singapore. Such a submarine could also readily be modified to extend its range and acquired much more quickly for around half the cost.

The other important issue to consider is that the Shortfin Barracuda is a developmental project with a highly ambitious capability requirement and thereby exposed to the significant risks discussed throughout this report. On the basis of other big developmental projects, its cost can be expected to blow out by a substantial margin. As stated in Chapter 2, Augustine's study of 81 major developmental defence projects in the US found that final costs exceeded preliminary estimates by an average of 52 per cent. If that degree of cost blow out were replicated in the FSM project, in two decades time Australia would be spending around $5 billion on each FSM, or far more than the current acquisition cost of a far more capable SSN.

It is also important to understand the total, or whole of life, cost for a submarine, which is substantially higher than the acquisition cost. In a communication to Insight Economics in July 2017, Keith Snell, an electrical engineer who had formerly worked in Naval Technical Services within Defence, stated that:

> Complex developmental military projects like the Shortfin Barracuda exhibit a very high probability of substantial cost and schedule overruns. Particularly with the elimination of competition, the main economic risk is that the base line cost and delivery of the submarines could blow out by tens of billions of dollars.
>
> If the current construction of the Shortfin Barracuda runs its course the 2016 year project estimate of $50 billion could easily grow (even with modest escalation rates between 2.5 and 3.5 per cent) to double this cost in then year dollars, with deliveries of the 12 boats commencing in the mid to late 2030s. Sustainment costs for a further 25-30 years life cycle operation, maintenance and modernisation would add a further 2-3 times to these acquisition costs.

The whole of life cost of a submarine requires an estimate of the through life sustainment costs of the boats, conventionally calculated by multiplying the acquisition cost by three. This leads to an estimate of the whole of life costs of SEA 1000 of around $180 billion, including acquisition ($40 billion), combat system ($6 billion), sustainment ($120 billion) and *Collins* life extension ($15 billion). We struggle to see how this enormous cost, accompanied by very substantial risks, can offer value for money.

[55] A submarine's indiscretion ratio is defined as the time spent on the surface or at periscope/snorting depth divided by the time it is fully submerged in any 24-hour period. Until the development of AIP, SSKs had a much higher indiscretion rate than SSNs, which led the father of the nuclear submarine, Admiral Hyman G. Rickover USN, to dismiss conventional submarines as "mere submersibles".

Opportunity cost

In discussing the opportunity cost of spending $50 billion on acquiring new submarine capability, we accept the government's decision to allocate funding equivalent to two per cent of GDP to defence. Therefore we do not need to get into a 'guns versus butter' debate; if some of the $50 billion were not directed towards the submarine, we assume it would be allocated to other defence projects within the two per cent of GDP envelope. But $50 billion is a substantial amount of money – much more than other countries are spending to acquire SSKs – and it is a quite reasonable question to inquire whether or not some of it could be allocated elsewhere.

First, of course, there are opportunity cost considerations within the government's policy of acquiring significant new submarine capability. For example, Defence may have considered:

- Within a similar budget, instead of 12 Shortfin Barracudas, acquiring 24 MMOTS submarines which, other than being available more quickly, would enable at least eight submarines, rather than four, to be patrolling their areas of operations (AOs) at any time and possibly increase submarine capability substantially.
- Acquiring a larger number of smaller submarines and committing some of the SEA 1000 funds towards acquiring a submarine tender vessel or establishing a permanent forward base closer to AOs. This would significantly reduce transit times, and allow more submarines to patrol in their AOs at any point in time.
- Acquiring two classes of submarines, one a more nimble SSK with AIP or more modern battery technology, acquired off the shelf and the other the Shortfin Barracuda.

Secondly, no information is available on how Defence arrived at the very large financial commitment for the acquisition of submarine capability within its overall budget. Clearly, significant trade-offs must be made between all kinds of matériel acquisitions for the ADF. We do not dispute that the acquisition of a strong submarine capability is desirable in light of Australia's geography, middle power status and strategic circumstances. But other assets are important too and it would be reassuring to understand how Defence makes these trade-offs and how rigorously the opportunity cost framework is applied.

Finally, the current budget for the FSM is far greater than we have seen for the Submarine Force in recent years. It will push the allocation for submarine capability from around 10 per cent of the Defence budget to closer to 20 per cent. When this starts to bite, can we expect to see kickback, not only from the Army and RAAF, but even from the surface navy? If so, this could result in a reduction in the number of submarine platforms to be acquired.

4.4 Analysing the financial risks

The main financial risk facing the FSM is that the massive investment does not deliver the required capability and the cost and delivery schedule of the project blows out. At one end of the scale, a disastrous example of this was the Seasprite helicopter intended to operate from the *Anzac* frigates. After the expenditure of $1.4 billion, not one helicopter was operational and the

whole programme was written off. Such an exercise is more than a financial calamity; it means that the ADF is left without a necessary capability for a prolonged period of time – in this case without an effective ship-borne anti-submarine helicopter for over a decade until the MOTS Seahawk Romeo was acquired.

If we consider the FSM acquisition as a major public investment whose projected return to the Australian community needs to be assessed against the costs and risks on the other side of the ledger, we can establish a more robust framework for Defence to evaluate the various options. Such a framework is used routinely not only in major private sector investments but also in developing cost-benefit studies of major public investments in physical infrastructure. We do not know if the Australian Department of Defence employs these basic financial techniques of investment appraisal; if it does, it is not evident that they play a dominant role.

Of course, while important lessons can be learned from the private sector, investing in new submarine capability for the Navy is not exactly analogous to an investment in, say, developing a major new gas field and building a LNG production facility in Western Australia. The main difference is that the returns to the community from an advanced submarine capability take the form of enhanced national security and are not measured in dollars and cents, although approximate values can be calculated. On the other hand, the costs of both types of investment can be projected, while the risks around both the costs and the pay-off can be assessed by experts in the relevant fields. In terms of the return to a Defence investment, proxy values can be assigned to each element in the capability requirement and a net present value (NPV) of the capability provided by each option can be estimated.

4.5 Contestability and competition

The already very substantial economic risks associated with the FSM project, identified above, are greatly increased by the decision to eliminate any competition beyond the 'once over lightly' competitive evaluation process.

The novel CEP approach is a process that lacks transparency and disallows contestability beyond the initial choice of a design partner. It is not clear why the government did not first issue a Request for Proposals (RFP) and then a Request for Tender (RFT) with competition occurring at each stage of the process. Perhaps the reason is that time was moving on. The 2009 White Paper stated that significant new submarine capability was required, with delivery of new submarines commencing by the mid-2020s. The then government appeared to sit on its hands for four years, at the same time reducing defence spending and making little obvious progress on the submarine acquisition.

When the Abbott government came to power Ministers seemed to move more quickly on the submarine programme, and the CEP process may have seemed like a way to make up for lost time. Nevertheless, there is a fundamental flaw in the process itself. By eliminating all competition before a detailed design has been produced, the Navy faces substantial risks. What if the eventual Naval Group design is untenable on technical grounds and cannot deliver the required capability? What if the price quoted by Naval Group, now enjoying a monopoly position, is unacceptably high? What if deep problems emerge with ownership of IP? What if the key workload is reserved for French industry and the allocation of work to competitive

Australian businesses is small, with a low local content? Whatever is done and said now, during the honeymoon stage of the relationship, it is difficult to see as time goes by why Naval Group will not increasingly have Defence over a barrel. As Bergmann has pointed out:

> "If Defence plans to sign a production contract three years after selecting a preferred designer, they leave themselves open to enormous risks. Put simply, without commercial leverage the Commonwealth will either have to pay whatever the designer wants—or start the entire process again. ...The only way to protect against those sorts of possibilities is to have at least two bidders to choose from and maintain competitive pressure for as long as possible.'"[56]

Defence made clear why it has proceeded with only one partner in information provided to the Audit Office (ANAO). In response to concerns about this lack of competition, the ANAO reported that:

> The decision to select one design partner, as opposed to two, was made on the basis that Defence did not have the technical resources to retain two partners. Defence advised the Minister for Defence, in December 2015, that:
> '[t]he concept and preliminary design is resource-intensive work and will take about three to four years to complete...This is not work that can be outsourced. It requires submarine design knowledge coupled with a firm understanding of Australia's operational requirements for the Future Submarine. These skills are in short supply internationally...and Australia should not be confident of assembling more than one Government team to work through the concept and preliminary design in a robust manner. Endeavouring to work with two international partners would dilute our capability and undermine the effort required to arrive at a sound understanding of the capability, cost range and risks of the proposed design for the Future Submarine.'[57]

Yet, o us this is not persuasive. We understand that Defence wants to design the perfect conventional submarine for Australia and that only the French proposal presented them with what was virtually a blank canvas. But confining the design process to a single offering comes with a number of significant risks. With a very lengthy design process and an absence of competition, in the early 2030s it is possible that the Shortfin Barracuda will appear to be an unattractive and expensive proposition with no obvious alternatives. By then the relevant Ministers and officials will all have moved on, accountability will not be obvious and resolving the crisis will be left to some other unfortunate who had nothing to do with the project when its process was set in stone.

The ANAO clearly regards this as a problem:

> The approach taken by Defence for the Future Submarine program removes competition in the design phase, and removes incentives for the international partner (DCNS) to produce a more economical and efficient build. This places the onus on Defence to ensure that its approach to the Future Submarine's design and build phases, where final costs and schedules will be determined, returns value-for-money to the Commonwealth in the absence of a competitive process.[58]

---

[56] Bergmann, K., (2015), "Australia's next generation submarine: where to now?", *The Strategist*, Australian Strategic Policy Institute, 14 December, http://www.aspistrategist.org.au/australias-next-generation-submarine-where-to-now/

[57] ANAO (2017), Report No.48 2016–17 *Future Submarine—Competitive Evaluation Process*, April, page 38.

[58] *Ibid*.

4.6 Implications

The proposed aggregate investment of just under $50 billion at 2016-17 prices in new submarine capability represents Australia's biggest ever defence project. The economic risks around the project are commensurately large.

Yet while it is clear that the cost of the FSM is excessive, we don't know how excessive it really is. Australia's Defence department is apparently unique around the world in using future dollars rather than expressing cost in terms of constant price dollars. Unless the objective was to obscure the true cost of new assets, it is very difficult to understand the reason for this. We consider the ASPI calculations of an acquisition cost just shy of $40 billion in 2016 prices, or over $3 billion per submarine, probably provide the best available estimate. This is a very high price to pay for a conventionally powered submarine, particularly one that will lack twenty-first century propulsion systems and will have a relatively high indiscretion ratio.

The extent to which Defence analysed other options in terms of opportunity costs is not clear. There are other options available for providing Australia with the advanced submarine capability that the Navy requires. These options may offer significantly greater value for money. For example, some off-the-shelf submarines, modified to provide a longer range and equipped with AIP, would offer a more advanced capability to the Shortfin Barracuda in certain respects and be available much sooner at a lower cost. These submarines would require smaller crews and the Navy could afford many more platforms. The endurance of the crews in these smaller submarines would be enhanced if the need for long transits was eliminated by the establishment of a forward base closer to the Submarine Force's AOs, or alternatively by the procurement of a submarine tender or mother ship.

The fundamental economic risk to the FSM is that, as has occurred in many previous defence programmes, the cost of the acquisition will blow out to unacceptable levels. Other countries face similar problems, but the risks to the FSM project are significantly increased by the elimination of competition from the post-CEP process.

Finally, the risks in Australia are also increased because Defence has a single line budget allocation and, unlike other departments of state, its programmes are not subject to close scrutiny by the main economic agencies of Treasury and Finance.

Some lessons from the UK are that government needs to:

- Design a national defence strategy, agreed across Government and, given lead times for equipment, ideally with cross party support
- Design a force structure to support the strategy within an affordable budget
- Ensure the equipment programme has realistic aims and objectives, in capability, timescales and costs
- Establish a plan to constantly monitor major programmes with cost/benefit analyses and modifications made expediently, and also if new equipment makes the current plan obsolete
- Ensure that sufficient allowance is made for through life support and personnel costs.

CHAPTER 5
Strategic risks

"The first, the supreme, the most far-reaching act of judgment that the statesman and commander have to make is to establish ... the kind of war on which they are embarking."
Carl von Clausewitz, *On War*.

5.1 Background: changing strategic circumstances

Australia's decisions about its future submarine capability must be framed by broader judgments about the way our strategic circumstances are changing. As we have seen in Chapter 3, the decision in 2009 to substantially enhance our submarine forces was made in the light of assessments at that time about major shifts in our strategic setting. Those judgments now look, if anything, too conservative. China's economic weight, diplomatic reach and military power have grown faster than was expected back then. In particular, its maritime power has grown faster, especially its capacity for Anti-Access and Area Denial (A2/AD) operations that would curtail US maritime power projection into the Western Pacific.

At the same time, America's position in Asia has come under greater pressure than had been expected. President Obama's 'Pivot to Asia' is widely seen as having failed to respond effectively to China's increasingly assertive challenge to the US role in Asia, and the election of President Trump has raised real questions about US commitment and resolve to maintain the leading role in Asia which has been the basis of Asia's security and Australia's strategic posture for so long. Geography alone means that Australia's has never been able to take US strategic support for granted in all circumstances, the way Canada for example can do. But the trends of recent years in Asia strongly suggest that we must be even more aware of the uncertainties about the US role in our security in future than we have been hitherto. That means of course that we must consider the need to rely more on our own forces and less on our allies for our security in the decades ahead.

Australia is one of the wealthiest nations in the Asia Pacific region on a per capita basis but it has a relatively small population and, in terms of numbers of military personnel, a small defence force. In global terms it regards itself as a middle power, yet if the definition of a middle power is the ability to defend itself against a great power, this is questionable. Australia has the third largest EEZ in the world and is faced with significantly greater strategic threats than many other middle powers. Canada, for example, has many similarities with Australia yet with a land border with the United States and ultimately protected by the Monroe doctrine, it faces strategic threats of a much lower order. This is reflected in its lower level of defence spending than Australia. "While Australia's GDP is about 18 per cent smaller than that of Canada, it spends considerably more on defence—US$24.0 billion this year, compared with Canada's US$14.0 billion."[59]

[59] Davies, Andrew and Christopher Cowan (2016), "Australia and Canada: different boats for different folks", *The Strategist,* ASPI, 21 December, https://www.aspistrategist.org.au/australia-canada-different-boats-different-folks/

While Australians take comfort from the US alliance for their security, it is by no means universally understood that this does not constitute a cast iron guarantee of military support even if Australia were to be attacked; the extent of the obligation is to consult and then to 'act'. On paper at least, the US provides more certain military support to Albania (under NATO) than it does to Australia under ANZUS. Accepting the consequent need for self-reliance, Australian governments have traditionally sought to maintain a technologically advanced defence force that would deter potential adversaries even in the absence of US support.

Now Australia faces changed circumstances. China is beginning to challenge the US hegemony that has existed in the Asia Pacific region for seventy years. While an accommodation between the US and China is possible, and from Australia's perspective highly desirable, it is conceivable that this competition could also lead to military conflict with deeply negative implications for Australia.

Chris Parry, a British expert on naval strategy, sees a move towards sea control and power projection on the part of China, which is "already one of the most prolific military shipbuilders in the world":

> It is clear that the Chinese are modernising rapidly and are now seeking to adopt more joint approaches to warfare, integrating all elements of fighting power within a coherent combined arms doctrine. They are not simply stuck in the groove of anti-access and area denial and look set to graduate to the more sophisticated offensive and power projection approaches favoured by Western countries. Critically, China is planning to have four aircraft carriers by 2022 – a statement of significant intent alongside their other modernisation programmes.[60]

As well as the possibility of conflicts with regional powers, as has always been accommodated in Defence planning, contemporary contingencies must now include the possibility of a conflict with a great power, however much Australia would seek to avoid it. Although Australia's part in any such conflict, were it to occur in the next few years, would presumably be in a coalition that included the United States, it is not safe to make such an assumption further into the future. The election of President Trump has only served to highlight what is still little more than a possibility, that an isolationist policy of America First will prevail in the longer term and the US will choose not to continue to project its power into the Asia-Pacific. However unlikely a US retreat 'east of Hawaii' may be, it is entirely responsible for governments to make provision for these kinds of contingencies when planning defence capability requirements into the long term and acquiring very expensive new platforms.

This is a very demanding prospect. Australians are used to seeing themselves as among Asia's most wealthy counties, but this is less and less the case. By 2050 when the last of the new submarines are now planned to enter service, PwC estimates that Australia's GDP in PPP terms will have fallen behind not just China, Japan and India, but Indonesia (then projected to be the world's 4th largest economy), South Korea, the Philippines, Vietnam, Malaysia and Thailand. To maintain the strategic weight of a middle power that can look after itself with less support from America, we will have to use our dwindling relative level of resources very carefully indeed.

[60] Parry, Chris (2014), *Super Highway: Sea Power in the 21st Century*, Elliott and Thompson Ltd, London, pages 272-3.

Submarines will be absolutely critical to any defence posture that offers Australia a reasonable chance of achieving and sustaining a position as an independent middle-power over coming decades. That is because of our position as an island continent surrounded by island neighbours. The ultimate key to our security is to be able to prevent any hostile power projecting forces toward us or our closer neighbours, and submarines, along with land-based aircraft, offer the most cost-effective way to do that.

In this Chapter we consider some strategic risks arising from the proposed FSM acquisition. The following questions are addressed:

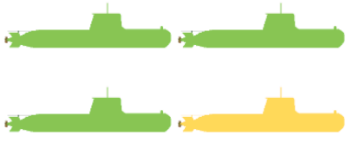
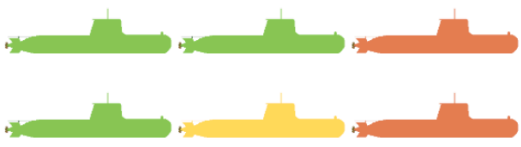
- In light of Australia's strategic circumstances, is the timeframe for the procurement of future submarine capability appropriate?
- From a strategic perspective, what particular characteristics are required in the FSM to deliver the necessary capability – for example, does the submarine need to be large and/or require a long range or extended endurance?
- Given the government's ambitious capability requirement for the FSM, does the RAN really need nuclear-powered submarines?
- Would the construction and establishment of a permanent forward base for the ADF be an appropriate response to the problem of long transit time to reach AOs and the short range of some defence assets, particularly in the RAAF?
- Are there any strategic risks arising from an association with a French submarine builder, for example in terms of a requirement to employ substantial sensitive US equipment in the FSM and the fact that France is not an ally of Australia's?

These questions are considered below.

5.2 Timeframe: can Australia wait 20 years?

Clearly, Australia needs a stronger Submarine Force. The Navy's current requirement for submarine availability is shown in Exhibit 5.1 below.

EXHIBIT 5.1: RAN REQUIREMENT FOR SUBMARINE AVAILABILITY

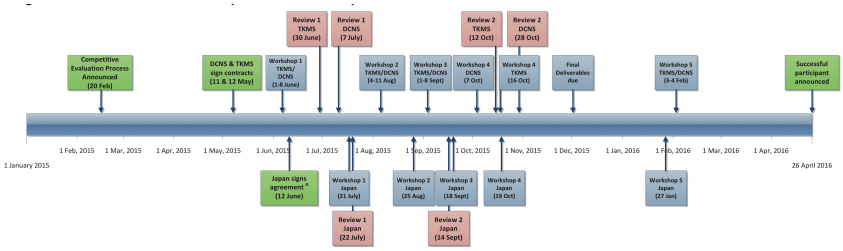
 Assured by…	Two deployable submarines consistently available.
 Underpinned by…	Four submarines in-service with the Fleet Commander. Three submarines consistently available for tasking, with one in shorter-term maintenance.
	Six submarines in the fleet. Two in long-term maintenance and upgrade.

Source: Coles, John (2016),* Collins *class Beyond Benchmark Review op. cit., page 7.

These targets are consistent with international performance benchmarks and the recent substantial improvement in the availability of the Collins class means that they are now generally being met. But the implication is that from a fleet of six submarines, although three boats may often be ready for deployment, only two are consistently available for operations. Given Australia's long transits from base to areas of operations (AOs), it is likely that only one or a maximum of two submarines will be operating in their AO at any point in time. Even with a fleet of twelve submarines, double the current size, perhaps only three or four submarines will be operating in their AOs at any point in time. Australia's submarines may be high in quality, but inevitably the quantity will be lacking. This means that with a multitude of possible objectives, Defence needs to get the operational priorities right.

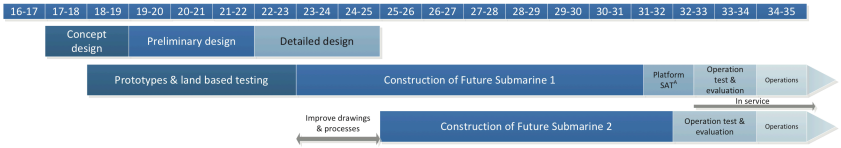
According to Defence's latest schedule as reported by the Auditor-General, the first Shortfin Barracuda submarine will be in operational service midway through 2034 (Exhibit 5.2).

EXHIBIT 5.2: INDICATIVE FUTURE SUBMARINE SCHEDULE



Note A: The relationship with Japan was governed by an inter-government agreement.
Source: ANAO analysis of Defence documents.

Figure 1.2: Future Submarine program indicative schedule



Note A: Ship Acceptance Trials (SAT).
Source: ANAO analysis of Defence Documents.

Source: ANAO (2017), op. cit , page 15

Already this appears to represent at least a year's slippage since the schedule was presented at the SIA Conference. Yet Defence must plan for the contingency that for a highly complex project like the FSM, using a bespoke design, this timetable will blow out further. On the basis of the average delay in the delivery of developmental unique and complex new military platforms, as suggested by Augustine in Chapter 2 of this report and the technical risks inherent in the Shortfin Barracuda (Chapter 5), it is plausible to suggest that 2038- 2040 may be a reasonable estimate of when the first new submarine will be completed. Of course, in order to maintain some credible submarine capability until then, the *Collins* class boats would require a comprehensive life of type extension (LOTE). Yet, as is described in Chapter 5, this involves considerable risks, with only three boats likely to be updated and the possibility of extending their lives as front-line assets beyond 2035 being highly uncertain.

The capability requirement for the ADF that resulted in the acquisition of six *Collins* class submarines reflected the strategic circumstances that obtained in the early 1980s. The Cold War was at its height, with Soviet submarine activity focussed more on the Atlantic and Arctic oceans than the Asia Pacific region. Even the beginning of the China story was in the future and the

PLAN's naval strength was small and its assets generally of poor quality. At that time, because of its technological edge, the RAN may well have been able to claim superiority over the PLAN, particularly in the context of a 'defence of Australia' conflict.

The current situation is very different. As stated by the government in May 2017, "the doubling of the submarine fleet recognises that Australia will face a more challenging maritime environment in coming years".[61] By 2030, according to the 2016 Defence White Paper, more than half of the world's submarines will be operating in the Asia-Pacific region. The White Paper states that: "By 2020 China's submarine force is likely to grow to more than 70 submarines".[62] Admittedly this total is fewer than the PLAN's complement of submarines thirty years before, but in 1990 China did not have an advanced submarine capability; Admiral Jacky Fisher might have said that most of their submarines "could neither fight nor run away". The White Paper is coy about the fact that the projected 2020 total will include up to nine modern SSNs and up to five nuclear powered ballistic missile-armed submarines. By 2020, China will also have in commission nearly 50 modern diesel attack submarines, most with AIP (see Exhibit 5.3).

EXHIBIT 5.3: CHINA'S SUBMARINE FLEET, 1990-2020

Type	1990	1995	2000	2005	2010	2015	2020
Diesel Attack	88	43	60	51	54	57-62	59-64
Nuclear Attack	4	5	5	6	6	6-8	6-9
Nuclear Ballistic	1	1	1	2	3	3-5	4-5
Total	**93**	**49**	**66**	**59**	**63**	**66-75**	**69-78**

… OF WHICH PERCENTAGE MODERN

Type	1990	1995	2000	2005	2010	2015	2020
Diesel Attack	0%	0%	7%	40%	50%	70%	75%
Nuclear Attack	0%	0%	0%	33%	33%	70%	100%

Source: US-China Economic and Security Review Commission (2014), "Chinese Navy extends its combat reach to the Indian Ocean", Staff Report, March, page 12.

In addition, Russia is strengthening its submarine force in its Pacific Fleet. In addition to SSNs based at Vladivostok, Russia has recently ordered six of the latest version of the Kilo class SSK for deployment in the Pacific. Both India and China now have nuclear submarines with the ability to launch long-range nuclear missiles. While intensively developing its indigenous nuclear submarine capability, India is also actively seeking Russian assistance in developing advanced SSNs. It already has commissioned one capable Russian SSN of the *Akula* class and is seeking to acquire more.

Already other nations in the region are responding to China's increased assertiveness by increasing military spending, with new advanced attack submarines being a particular focus for countries like Japan, India, Korea, Indonesia, Singapore and Vietnam. Many of these new submarines will be of an advanced design with modern sensor technology and AIP. "Southeast

[61] Australian Government (2017), *Naval Shipbuilding Plan*, Department of Defence, Canberra, March, page 24.
[62] *Defence White Paper (2016), op. cit.*, page 42.

Asia's newest submarines are also equipped with advanced hull-mounted active and passive sonar, anechoic tiles and modern designs for improved quieting, more effective torpedoes, and even the ability to launch anti-ship cruise missiles."[63] This is described in Exhibit 5.4.

EXHIBIT 5.4: SUBMARINE COMPETITION IN ASIA

An important aspect of the regional "arms competition" in East Asia is the gradual introduction of new classes of conventionally-powered diesel-electric submarines, which are increasingly becoming "platforms of choice" as force multipliers in diverse missions as well as against superior forces. Coupled with submarine-launched anti-ship and land-attack cruise missiles, advanced intelligence, surveillance, and reconnaissance (ISR) sensors, anti-submarine sensors and weapons, as well as new propulsion systems – such as air-independent propulsion (AIP) – these new classes of submarines have a greater capacity to remain undetected (stealth), with improved target-identification-and-attack cycle and ultimately increased mission flexibility, mobility, endurance, reach and lethality. In particular, conventional submarine modernisation and expansion has been profound in Northeast Asia. There are at least three underlying drivers that support and accelerate submarine procurement and diffusion among Asian navies:

(1) the persistent geopolitical insecurity, regional rivalry, and uncertainty stemming from the nexus of unresolved historical legacies to emergence of complex types of conflicts that broaden national defense requirements and operational needs;

(2) increased regional economic growth rates that increase the capacity to purchase cutting-edge weapons systems and accelerate force modernization programs; and

(3) the rapid technological change embedded in the globalization, consolidation, and competition of global arms markets and defense industries that have to diversify their commercial interests through export-orientated strategies and innovation – particularly aiming at Asia-Pacific markets.

However, the primary strategic driver for submarine procurement in East Asia is arguably China's ongoing qualitative military modernization.

Source: Raska, M.(2016), 'Diesel-Electric Submarine Modernization in Asia: The Role of Air-Independent Propulsion Systems', in Bitzinger, R. A. (Ed.), Emerging Critical Technologies and Security in the Asia-Pacific, pp. 91-106.

Raska goes on to report that in 2014 China marked '17 straight years of near-double digit increases in defence spending' and 'currently operates as many as 45 submarines structured in six different classes'. The growth in submarines is exponential and not contained to the economically significant, with Raska also reporting that, 'by 2018, with all six *Kilos* operational and equipped with *Klub-S* (3M-54) anti-ship cruise missiles, Vietnam's subsurface fleet could potentially represent the largest undersea force in the region.' This year Thailand and Myanmar have joined Indonesia, Malaysia and Singapore in actively seeking enhanced submarine or anti-submarine capabilities.[64] In explaining this phenomenon of submarine expansion in smaller 'defensively-orientated navies in East and Southeast Asia', Raska

[63] Bitzinger, Richard A (2016), "The myth of the submarine 'arms race' in Southeast Asia", *Asia Times*, 19 October, http://www.atimes.com/myth-submarine-arms-race-southeast-asia/

[64] Raska, M (2016) *'Diesel-Electric Submarine Modernization in Asia: The Role of Air-Independent Propulsion Systems'*, in Bitzinger, R. A. (Ed.*), Emerging Critical Technologies and Security in the Asia-Pacific,* page 94.

Maas, R., Indonesian French companies join forces for naval projects, in on-line news article, United Press International, 2017, March 31, http://www.upi.com/Defense-News/2017/03/31/Indonesian-French-companies-join-forces-for-naval-projects/9281490979577/

The Times of India, India set to export torpedoes to Myanmar, in on-line news article, 2017, March 25, http://timesofindia.indiatimes.com/india/india-set-to-export-torpedoes-to-myanmar/articleshow/57821427.cms

The Nation, 'No rush' to buy three submarines, says Prawit, in on-line news article, http://www.nationmultimedia.com/news/breakingnews/30310669

attributes this to the submarine's inherent stealth attributes enabling 'sea-denial' or 'preventing an opponent using the sea'.

In the face of this, it could be expected that the government would see the need to upgrade Australia's submarine capability in the region as rapidly as is practical. This strategic need seemed clear in the 2009 White Paper. Twelve new submarines were to be acquired, with delivery taking place from the mid-2020s. Subsequent progress in implementing this has been glacial, however, and now the Coalition government appears to have chosen the slowest possible route to acquiring new capability, with the first FSM likely not to be available until two decades hence. Contrast this with Russia, which ordered six new and advanced Kilo class submarines in 2016 with all six likely to be in service with the Pacific Fleet by 2024.

Although the *Collins* class is now providing excellent service, it was designed to have a thirty-year life. HMAS *Collins* will be thirty years old in 2026. As described in Chapter 5, a life extension to the submarines can provide only limited benefits in terms of enhanced capability; it is unlikely, for example, that AIP can be fitted, or the diesels and motor replaced. The idea that the submarines can be sent into harm's way much after the early 2030s, when the waters to Australia's north will be teeming with advanced, modern submarines, surely represents the triumph of hope over experience. We should remember that it was confidently expected that the F-111 could continue in the front line until 2020 and this turned out to be totally impractical. While new aircraft can be procured relatively quickly to fill an unforeseen capability gap, new submarines take a lot longer to acquire.

There is a material probability, therefore, that Australia will be faced with a lengthy gap in submarine capability in the 2030s. The implications of a capability gap, where no submarines could be deployed operationally, go beyond the consequences for the defence of Australia and achieving sea denial in our maritime approaches. The number of seagoing personnel would decline rapidly and, without the experience of high-end submarine operations, the skills and expertise of those who remained could be rapidly eroded, not to mention the difficulty in maintaining their morale. The need to re-build such skills and recruit, nurture and train a whole new and much larger group of submariners into the 2030s and well beyond would mean that it could be much longer before the FSM could be deployed operationally in meaningful numbers.

Perhaps most importantly, the government's long timeframe for the FSM acquisition suggests that it does not believe there is any significant possibility of Australia being involved in a major conflict in this region in the medium term. While it is by no means certain that there will be such a conflict or, if there were, that Australia would be involved, the risk is there now and it is material. Howard W. French of Columbia University and a former senior foreign correspondent with the *New York Times*, suggests that if China were to make a move to assert global dominance that would be contested by the US and its allies, that initiative would be most likely to occur in the next decade. This is because of China's uniquely serious problems with an ageing population.[65]

[65] French, Howard W. (2016), "China's Twilight Years", *The Atlantic*, June, https://www.theatlantic.com/magazine/archive/2016/06/chinas-twilight-years/480768/.

On that view, the greatest likelihood of conflict in this region is in the period leading up to 2030. Australia would want to muster more than two or three ageing submarines for operations at that time, yet even on the current, very optimistic schedule, the Shortfin Barracuda will be no more than a gleam in the Navy's eye. In terms of the present timetable for acquiring the FSM, the strategic risks are unacceptably high.

5.3 Strategic capability priorities for the FSM

Australia's new submarines will constitute a critical element in the ADF's future force structure. It is important, therefore, to understand clearly the nature of their mission; put simply, what are they for?

In this context, four operational functions are considered here:

- Intelligence, surveillance and reconnaissance (ISR)
- Sea control and sea denial
- Special Forces
- Tactical land strike

In this Section we examine the characteristics Australia's FSM requires in order to discharge these roles effectively and what the relative priorities are.

Intelligence, surveillance and reconnaissance (ISR)

Understandably, during peacetime or while at war, governments do not reveal much about their intelligence gathering operations. For the US Navy's nuclear attack submarines during peacetime, for example, more than 50 per cent of the mission tasking is reported to be in the ISR domain.[66] Because of the covert nature of their operations, submarines have a major advantage over surface ships and aircraft in terms of being able to loiter submerged off a foreign shore for lengthy periods of time and gather vital intelligence. Even very high-flying surveillance aircraft, such as the venerable Lockheed Martin U-2, can only spend a few minutes over any particular objective while being much more prone to detection. Satellites are intermittent and predictable, while being limited by orbital parameters.

According to a former Australian submariner:

> At the very technical data gathering levels, [submarines] can collect Acoustic Intelligence, Signal Intelligence – consisting of both Electronic Intelligence and Communications Intelligence – and, finally, Visual Intelligence. Submarines can position themselves to capture line of sight transmissions or observe undersea or over water tests that other assets are unable to see. Submarines fitted with multi-beam sonars or environmental instrumentation can also collect bathymetric and sea floor classification data. …
>
> At a less technical level, submarines can conduct systematic and continuous observation of a targeted area or group to monitor operations, fleet movements and patterns or to establish tactics, strengths and weaknesses and vulnerabilities of a potential opponent.
>
> Submarines are the optimum asset for detecting and observing underwater activity to establish an adversary's true submarine capability. It might not be unusual to see submarines operating in close vicinity to another country's submarine bases and operational

[66] Patrick, Rex (2011), "Not just a powerful weapon", Asia Pacific Defence Reporter, February, page 59.

areas, particularly noting the recent proliferation of modern submarines.[67]

It is not difficult to deduce that the main reason the US is keen for Australia to acquire a new generation of SSKs is not power projection but rather the contribution they would make to intelligence gathering, specifically in the area of communications electronics support measures (CESM). The advanced Kestrel CESM system fitted to the *Collins* class, for example, provides "wideband signal search, narrowband audio interception and direction finding (DF) over the HF, VHF and UHF bands".[68] ISR activities by Australian submarines can make an important contribution, and provide Australia with valuable 'coin', in the context of the "Five Eyes" intelligence sharing agreement with the US, UK, Canada and New Zealand.

In our assessment, on the basis of expert advice, the ISR role must be rated a priority for Australian submarines in the Asia Pacific. This should not be taken lightly, however; undersea ISR missions will often result in operations taking place in another country's EEZ and even in its territorial waters. This may be hazardous, even in peacetime. For obvious reasons, a veil of secrecy shields these operations from public view. But occasionally the veil is lifted, as is shown in Exhibit 5.5.

EXHIBIT 5.5: ISR – COVERT INTELLIGENCE GATHERING OPERATIONS

"Australia's submarine operations are cloaked in secrecy but some clues about the roles of the Navy's current and new submarines in an uncertain future can be gained from the extraordinary secret operations of the *Oberon* boats during the Cold War.

"*The Australian* has revealed that in 1985, HMAS *Orion* entered Cam Ranh Bay in Vietnam, the Soviet Union's largest naval base outside the USSR. Prime Minister Bob Hawke was later shown brilliantly clear footage of a Soviet Charlie Class nuclear submarine *Orion* was tailing. Unseen but just metres behind the Soviet submarine, *Orion's* crew was able to get remarkable pictures of sonar and other fittings along its hull. It may not be a coincidence that at about this time the government was considering whether or not to order a new class of submarines to succeed the *Oberon* class.

"On another occasion and in response to an American request, HMAS *Orion* waited, submerged, outside Cam Ranh Bay and this time tailed a Soviet *Kirov*-Class nuclear powered cruiser, monitoring its communications.

"A similar operation inside the Chinese port of Shanghai in late 1992 nearly went disastrously wrong. HMAS *Orion* became caught in fishing nets. After a fisherman used an axe to cut his boat free, the Australian submarine was able to escape into the open ocean.

"Years later, more top secret patrols were carried out by Australian submarines to gather intelligence about Indonesian military operations around East Timor."

Source: Goldrick, James (2016), "Why does Australia need submarines at all?",* The Conversation, 28 April, *https://theconversation.com/why-does-australia-need-submarines-at-all-5857.

What then are the characteristics required in the FSM to discharge this role effectively and with all due regard to the safety of RAN submariners? It seems that the following attributes would be highly desirable:

- A long range and endurance
- Advanced stealth characteristics
- State-of-the-art sensors, communications and electronic warfare equipment

[67] Patrick, Rex (2011), *Ibid*.

[68] Daronmont Technologies, http://www.daronmont.com.au/dartweb/index.php/projects/kestrel

- Ability to remain submerged for at least a week at a time, so as to minimise the indiscretion rate and the possibility of detection.

There would appear to be no requirement for a submarine to be of a substantial size to undertake these activities successfully. While SSNs are large but can undertake ISR activities in the littoral, they also have the ability to escape at high speed if detected. That said, they rarely operate in very shallow water close to the coastline, or enter constrained navigational channels. For a SSK, particularly when operating inshore in shallow waters, a large hull would consequently seem to be a distinct disadvantage and make detection more likely. Indeed, a relatively small SSK with an advanced AIP system would appear to have advantages over a SSN in the covert ISR role.

The conclusion must be that an advanced MMOTS submarine with the capacity to operate submerged for long periods, perhaps modified to provide a longer range, would be well suited to undertaking ISR activities for the RAN.

Sea denial

While the control of the seas and airspace in and around Australia's maritime approaches and also wherever Australian ships are present may be the ideal objective of military strategy, it is unlikely ever to be achieved. Incursions by hostile submarines or attacks by land-based or sea-launched aircraft or missiles could never be entirely avoided. The predominant operational objective of the ADF in any conflict where Australia was threatened with attack would be anti-access and area denial (A2/AD).

The main function of Australian submarines in such a conflict would be sea denial in the SLOCs to Australia's north. Several choke points in the northern approaches to Australia, including the Malacca Straits, the Sunda Strait and the Lombok Strait, are of particular importance. By patrolling these choke points and attacking hostile submarines and surface ships, Australian submarines could deny access to Australia's northern waters and deter any attack on the homeland. Of particular importance in terms of incursions by submarines – both SSKs and SSNs – is the Lombok Strait, where the waters are deeper and well suited to the covert passage of modern submarines.

However, received submarine doctrine around the world generally sees offence as the best form of defence for submarine warfare and believes the most efficient means of prosecuting sea denial is in sinking ships and submarines by interdicting them 'up threat', in particular by patrolling outside enemy bases. If not operating in coalition with the US, it may be necessary for Australian submarines to undertake sea denial operations in forward areas. For example, they could combine ISR missions with attacks on naval forces – surface ships and submarines – around fleet bases. They could also lay mines outside bases, or smart weapons that can float into the base. While SSNs would be better suited to this role in the event of a conflict with a 'major adversary', both in terms of having the speed to withdraw swiftly to safer waters and being able to return quickly if required to operate in the defence of the homeland, SSKs would also be capable of operating 'up threat' provided they had the necessary endurance and deployed technologies such as AIP that would reduce their indiscretion ratio.

In an interview in 2015, the previous Chief of Navy (2011-14), Rear Admiral Ray Griggs, defined the major operational task for the future submarine as "sinking hostile ships and submarines. In contrast, other roles such as intelligence collection, transporting special force teams and land strike using cruise missiles are very much secondary and not significant design drivers." Yet this activity was not seen as being confined to the choke points; force projection operations far from home were high on the agenda. "The area of operations seems clear. Admiral Griggs considers the South China Sea as the area of most interest."[69]

Clearly, sea denial and the ability to sink hostile ships and submarines is a vital role for the FSM. What characteristics are required for it to be fully effective in the sea denial role? We suggest:

- A long range and endurance
- Advanced stealth characteristics
- State-of-the-art sensors, communications and electronic warfare intercept equipment, integrated with a sophisticated command system that can interface with shore based intelligence systems and data links
- A capacity to carry a substantial payload of state-of-the-art torpedoes, mines and anti-ship missiles
- Ability to remain submerged for at least a week at a time, so as to minimise the indiscretion rate and the possibility of detection.

Once again, there is no requirement for a unique large submarine in order to discharge this role effectively. A number of MOTS submarines are available with very advanced capabilities in sea denial. Indeed, a large SSK, particularly one without AIP and/or Lithium-Ion batteries, would be less advantageous and more prone to detection and ultimately destruction by ASW forces.

Special Forces

The ability to insert Special Forces (SF) is a capability well suited to the covert nature of a submarine's operations.

Special Forces can complement the submarine's ISR activities in peacetime, although this is obviously a highly risky activity, not least in diplomatic terms. In any conflict, SF can provide ISR data and forward air control. They can also attack military emplacements and undertake various sabotage operations.

Although some SSNs provide accommodation for large numbers of SF troops (around 100 in some cases), SSKs are incapable of deploying such large numbers while on patrol. SF do not need to be accommodated, however, for the duration of a submarine's patrol as it is possible to embark troops by parachute or rappelling from helicopters. They can be deployed from the submarine via diver lockouts, rubber boats or, in the case of Israeli submarines at least, by being launched through enlarged torpedo tubes. It is

[69] Peter Layton (2015), "Australia's next submarine – will it be the Soryu", *Defence Today,* Vol 11, No 4, page 8.

difficult to think of many wartime situations, however, where SF could be deployed to an Australian submarine operating 'up threat'.

Landing SF from an Australian submarine would seem to be a more likely activity in the context of conflict with a regional power rather than a 'major adversary'. Given relative priorities, it would appear to be very inadvisable to move away from a MOTS solution solely on the grounds of being able to accommodate more SF. This is particularly the case now that Australia has deployed a significant amphibious, power projection capability in the shape of the *Canberra* class LHDs.

Most MOTS submarines have the capability to deploy Special Forces. The German derivatives of the Type 212, for example, have flexible modules that can provide a range of optional additions depending on the mission. These include additional fuel; accommodation for SF; unmanned vehicles; or additional stowage for mines, torpedoes or land attack missiles.

The requirement for SF capability does not provide any reason to acquire a large, bespoke submarine. Indeed, SSKs can have advantages over SSNs in terms of SF deployment and smaller SSKs are better able to operate undetected in the littoral.

Tactical land strike

In the 2009 White Paper, where the requirement for twelve new submarines first appeared, one of the government's specified capabilities was that of 'strategic strike' against a 'major adversary'. Although this has not been repeated in subsequent White Papers it is not clear that official thinking has changed since 2009. The requirement appears overly ambitious for a middle power such as Australia, without nuclear weapons and without the capacity to undertake a land campaign of any intensity. Indeed long range strategic strike is a capability possessed only by perhaps four major powers with on going operations in the Asia Pacific region – the US, Russia, China and India. In terms of military capability they are in a different class to Australia, for example they all possess nuclear weapons and they all deploy ballistic missile-armed nuclear submarines (SSBNs).

Putting strategic strike to one side, tactical land attack using cruise missiles constitutes an important capability for modern submarines, both nuclear boats and SSKs. Since the first Gulf War, submarines have been increasingly involved in tactical land strike activities, although exclusively to date in the Middle East and North Africa. Until recently, most attacks had been from nuclear-powered submarines, with American and British boats using the US Tomahawk Land Attack Missile (TLAM). In December 2016, however, the Russian improved Kilo class submarine *Rostov-na-Donu*, a diesel-electric boat, launched Kalibur land-attack missiles against Islamic State.[70]

A SSK would be unlikely to carry more than 10 or 12 cruise missiles. This can be compared with four 18,000 tonne US *Ohio* class submarines which have been converted to carry 154 TLAMs that can be launched within six minutes. Although these SSGNs will be retired in the medium term, the next batch of Virginia class SSNs will be designed to carry a greater payload of TLAMs.

[70] Mizokami, Kyle (2016), "The Kilo class submarine: why Russia's enemies fear 'the Black Hole'", *The National Interest*, 23 October, http://nationalinterest.org/blog/the-kilo-class-submarine-why-russias-enemies-fear-the-black-18140

Tactical land strike using cruise missiles is generally used early in a military campaign to disable command and control systems as well as military bases, intelligence centres, key infrastructure and production facilities. Submarines can utilise their covert advantages in being able to launch missiles from close to the enemy coast, with a consequent greater ability to penetrate inland, but they suffer the disadvantage of long transit times so that the main targets may already have been taken out by air attack by the time a SSK arrives on station.

Submarines can launch land attack missiles either through a vertical launch system (VLS) or through torpedo tubes. A VLS system has a significant physical footprint and is unable to be reloaded while at sea. Israel provides an example of a country where the land attack capability is an important one and yet utilises its *Dolphin* class SSKs (derived from the German Type 212 design) to deliver the weapons through special extra large torpedo tubes. Whether the Israeli capability is tactical or strategic is a moot point; their cruise missiles are said to be capable of being armed with nuclear warheads.

While a tactical land strike capability is probably a lower order priority for the FSM, it could be useful in the event of conflict with a regional power. Yet the RAAF will also have a significant land strike capability in the near future, with Classic Hornets, Super Hornets, the F-35 joint strike fighter and the P-8 Poseidon all having this capability with the added ability to arrive much earlier on the scene than a SSK.

It is difficult to see a requirement for tactical land strike for the FSM in the event of conflict with a 'major adversary', particularly a nation equipped with nuclear weapons. If Australia were in a coalition with the US, the US Navy's SSNs and SSGNs would not require support from the RAN's modestly-armed SSKs for tactical land strike. If Australia were involved in such a conflict not in partnership with the US, the priority for RAN submarines would be sea denial. Firing a few conventional TLAMs at a great power under those circumstances would be akin to kicking over the hornets' nest.

While agreeing that a land strike capability would be useful for the FSM, particularly in a conflict with a regional power, it is challenging to suggest that it merits a high priority. It would be very difficult, if not impossible, to mount an argument for developing an *ad initio* design specifically to deliver this capability. According to one ex-RAN submariner, "One thing is certain; the requirement for land strike does not force us down a risky and costly own-design submarine program. A MOTS or modified MOTS submarine can also do the job."[71]

What are the strategic priorities for FSM capability?

In the 2009 Defence White Paper, the government proposed an ambitious role for the FSM. But we need to understand the limited nature of Australia's resources. As suggested above, even with 12 submarines in the fleet (which on present reckoning we will not see until 2050) it is difficult to see how more than four at any time could be on patrol in their AOs. This partly reflects maintenance schedules, which are now at or approaching international standards, but also the long transits required from Fleet Base West near Fremantle to, say, the choke points in the Indonesian archipelago.

[71] Patrick, Rex (2011), "Submarine Tactical Land Strike", *Asia Pacific Defence Reporter*, June, page 32.

The main operational priority for these submarines would be sea denial. As Dr Andrew Davies of ASPI has stated, "our main and indeed sole maritime operational objective in a major power war would not be sea control but sea denial". In an interview in 2015, the previous Chief of Navy (2011-14), Rear Admiral Ray Griggs, defined the major operational task for the future submarine as "sinking hostile ships and submarines. In contrast, other roles such as intelligence collection, transporting special force teams and land strike using cruise missiles are very much secondary and not significant design drivers."[72]

As a former RAN submarine commander has suggested:

> Many of the arguments supporting the unique requirements for our future submarine focus on long duration patrols, extended ranges, and lengthy covert ocean transits. Whilst a scenario can be created to necessitate this, you can't let one extreme and hypothetical situation define the reality of our future. I do not believe an SSK significantly larger than Collins is possible, much less a good idea. There will always be some missions that can't be achieved; let's focus our solution on the ones which can.[73]

In similar vein, a strategic policy expert, Dr Benjamin Schreer proposed in 2014:

> We might be thus better off leaving the increasingly crowded undersea space off the Chinese mainland to our US ally whose nuclear submarines are faster and better armed. Moreover, expect non-nuclear submarines of partner nations like Japan, South Korea or Vietnam to also operate in this space given their geographic proximity to China. As Peter Jennings argued at our conference, Australia should consider adopting a more modest assessment as to how far 'up threat' our submarines should operate in the future. In my view, this implies a focus on operations in the Eastern Indian Ocean and maritime chokepoints in the Indonesian archipelago.[74]

Schreer's view is entirely consistent with the 'concentric circles' concept of Australian interests and strategic objectives, first put forward in the 2000 Defence White Paper and accepted by successive governments ever since. In short, this argues that while in any conflict forward operations in, say, the South China Sea may make sense from a military perspective, in strategic terms less distant areas of interest, such as the archipelagic choke points, would be accorded a higher priority. Even with a fleet of 12 submarines, taking account of availability and transit times, relatively few RAN submarines would be available for the priority task of patrolling these vital choke points in the SLOCs to the north of Australia.

In the event of a conflict, therefore, it is difficult to see that any Australian submarines would be available for, say, power projection missions in the South China Sea. Perhaps this is too pessimistic and one submarine may be available for one mission 'up threat' at some time. If so, it seems idiosyncratic, to say the least, to base the design of Australia's future submarines on this single contingency and to delay the acquisition process for over a decade so as to ensure that the FSM has the additional capability of power projection against a major adversary. All the other capability

[72] Peter Layton (2015), "Australia's next submarine – will it be the Soryu", *Defence Today,* Vol 11, No 4, page 8.

[73] Harrap, James (2012), "Reflections of a *Collins* submarine captain", *Asia Pacific Defence Reporter*, 3 May, http://www.asiapacificdefencereporter.com/articles/226/Reflections-of-a-Collins-Submarine-Captain

[74] Schreer, Benjamin (2014), *The Strategist*, ASPI, 24 April.

requirements discussed in this section of the report could be undertaken by a MMOTS submarine provided it had sufficient endurance.

5.4 Does the RAN need nuclear submarines?

The capability requirement for the FSM represents a very ambitious and perhaps impossible requirement for an existing design of SSK. Defence states that the all-encompassing nature of the requirement is why Australia needs a bespoke submarine. But in fact, this is not a unique requirement. Western nations such as the US, UK and France would have a similar blue water requirement for their submarine forces. The problem is that those three countries only operate SSNs.

Although new technologies such as AIP and more efficient batteries have enhanced the capabilities of SSKs, nuclear-powered submarines still have considerable advantages. These include sustained high speed, which reduces transit times, allows them to keep up with and attack fast surface ships and gives the submarine a better chance of eluding hostile forces. They also have the ability to remain submerged for long periods of time, limited only by the endurance of the crew. Although they need to come to relatively shallow depths, where they are more vulnerable to detection, from time to time in order to communicate, their indiscretion ratio is much lower than a SSK, which every few days needs to raise a snorkel or snort above the surface in order to re-charge its batteries.

Advanced SSKs, on the other hand, have the advantage of being quieter than SSNs while submerged and this, combined with their generally smaller physical footprint, makes them more difficult to detect. SSKs are well suited to ISR activities and sea denial in brown water, the littoral and SLOC choke points. In these roles, the development of AIP and modern battery technologies have brought the capability of a SSK closer to that of a SSN. Added to this is a SSK's ability to loiter in relatively shallow water for extended periods of time and deploy their passive sonars where they are virtually undetectable.

SSNs are more suited to long-range, blue water operations where they are very effective in A2/AD operations. They are also much more effective than SSKs in power projection missions, where their greater weapons payload and high speed provides substantial advantages, not least in terms of survivability. It is incontrovertible that there are missions where the Barracuda SSN would be much more efficient and effective, as well as achieving greater survivability, than the Shortfin version. Such missions include 'up threat' operations, such as power projection and, as Rear Admiral Briggs has put it, penetrating "high pay-off areas for submarines close to an opponent's operating bases and associated training areas".[75]

In the case of a conflict in, say, the South China Sea, it may not be prudent to send a Shortfin Barracuda submarine to attack shipping off the PLAN's Hainan Island base or to launch cruise missiles against China. The transit distance from Fremantle to Hainan Island is around 6,000 km. It is quite possible that, even in a large SSK, the crew would arrive in a fatigued state. While it may have a 'burst speed' of around 20 knots, this could not be sustained for very long. After executing an attack, therefore, an SSK could

[75] Briggs, Peter (2015), "Why Australia should build its own submarines", *The Strategist,* ASPI, January.

exit the area at only about one-third the speed of a SSN, or much less if using AIP. Compounding this disadvantage, without AIP the Shortfin Barracuda would have a relatively high indiscretion ratio that would leave it far more vulnerable to destruction. In operations such as these, if considered necessary by the government, a RAN crew would be more secure in a SSN.

The value of both SSNs and SSKs is illustrated in the context of the Falklands War in Exhibit 5.6.

EXHIBIT 5.6: SSNS AND SSKS: LESSONS FROM THE FALKLANDS WAR

Apart from isolated incidents involving submarines and land attack missions in the Middle East, the war between Britain and Argentina over the Falkland Islands in 1982 is the only post-World War II conflict in which submarines were actively involved. The Royal Navy deployed six submarines, five of them SSNs, to the South Atlantic. The RN SSNs had a long history of successful operations countering Soviet submarines in the North Atlantic and Arctic oceans. The platforms were very effective, while their crews were highly trained and in the first rank in terms of professionalism.

The Argentine Navy possessed only four diesel-electric submarines, of which two were modern German Type 209 submarines. Only one, the *San Luis* (1,285 tonnes), was available for operations in 1982. While the *San Luis* and its weapons and systems were state-of-the-art at the time, its navy's doctrine was uncertain and its crew was insufficiently trained for modern naval operations against a major power.

As is well known, the first blow was struck by the British nuclear submarine *Conqueror,* which on May 2nd sank the cruiser *General Belgrano.* As a consequence of this, the Argentine surface fleet, including its only aircraft carrier, was confined to port for the duration of the conflict. This effectively surrendered sea control to Britain, which is widely regarded as the main lesson from the war as regards the potency of submarines.

The *San Luis* undertook one continuous patrol of sixty days, however, and also had a significant impact on operations. On May 1st it attacked two British warships, *Brilliant* and *Yarmouth*, with torpedoes, but although one torpedo is thought to have struck one ship the attack failed. A similar attack on *Arrow* and *Alacrity* and another on an unidentified British submarine also failed. German and Dutch investigators after the war found that the preparation and arming of the weapons was deficient, with one sailor having accidentally reversed the polarity on the cables between the torpedoes and the submarine, preventing the weapons from taking up a proper heading.

The first point to make here is that if the *San Luis* had had a highly trained crew together with better support, it could conceivably have torpedoed a British aircraft carrier and changed the course of the war. Secondly, despite its combat ineffectiveness, the presence of the *San Luis* tied down substantial British forces. The Royal Navy had a reputation as being perhaps the best ASW force in the world. and while employing twelve ships, six submarines and over 25 helicopters, it could not locate and destroy one underperforming SSK operating with no AIP. In fact, the Task Force expended much of its anti-submarine equipment, including 50 Mk 46 torpedoes and all of its sonar buoys, in the hunt for the *San Luis* and had to be replenished by the US. The net result for the RN was only the destruction of two whales, torpedoed by HMS *Brilliant*.

Source: Harper, Lieutenant Commander Steven R., USN (1994), "Submarine Operations during the Falklands War", Paper submitted to the Faculty of the US Naval War College; Insight Economics.

If Australia were to acquire nuclear submarines in the future, a major investment would be required to establish the hard and soft infrastructure necessary to support the operations of SSNs. This would take a long time to achieve – perhaps 15 to 20 years – and would require an early political commitment as well as bipartisan support. It is clear that without such an Australian commitment to create the required infrastructure, the US would not allow Australia to acquire *Virginia* class nuclear submarines or even older *Los Angeles* class boats. Nor would the US be favourably disposed to a transfer of UK *Astute* class technology to Australia, since the American government owns significant intellectual property in that submarine.

Indeed, under the 1958 US–UK Mutual Defence Agreement, the US has the right to block the sale of submarine nuclear reactors by the United Kingdom

to any third party. In the 1980s, the US invoked this treaty to block the sale of British *Trafalgar* class SSNs to Canada, which, unlike Australia, has a nuclear industry.[76] Although Prime Minister Thatcher later reached an agreement with President Reagan to supply *Trafalgar* class submarines to Canada, by then the Cold War was over and the budget required to acquire and support SSNs was difficult to justify. In addition, even for a country with an established nuclear industry, the Canadians also became aware of the very high costs required to create and maintain the hard and soft infrastructure to operate and sustain a fleet of SSNs.

While we understand France has offered to sell Barracuda class SSNs to Australia, as they did with the *Rubis* class 35 years ago, the US may be reluctant to provide support, by allowing the transfer of sensitive American systems, for example, such as the combat system and various weapons to the platform. Nevertheless, this would not be a significant problem; the French combat system to be used in the Barracuda class, CYCOBS, is highly regarded and has been used in other French nuclear submarines. The use of the AN/BYG-1 combat system is not essential for interoperability with the USN, as is proven by the fact that submarines from a range of nations regularly operate with American submarines using different command systems (Exhibit 5.7). But it would be important to integrate a comprehensive US communications suite to ensure effective interoperability and to help avoid 'blue on blue' incidents.

EXHIBIT 5.7: BARRACUDA CLASS SSN – A GOOD FIT FOR THE RAN?

It is clear that there are elements in the capability requirement for the FSM, described in successive White Papers, that are better suited to a nuclear-powered submarine than a conventionally-powered boat. The choice of the Shortfin Barracuda suggests that the government, as the former Defence Minister stated, are still seeking a diesel-electric submarine that mimics as far as possible the capability of a SSN.

In strategic terms, taking account of its ultimate duty of care to ADF personnel not to send them into harm's way on technically inferior platforms, the government is effectively faced with a choice. Does it want to reject more dangerous missions up-threat in areas like the South China Sea, or does it want to have the flexibility to pursue then in the future? If the latter, it requires a nuclear submarine.

If it decides the RAN does require a SSN, there are several reasons why the Barracuda has some appeal. First, the other potential candidates, the US *Virginia* class and the British *Astute* class, are not available. Secondly, even if they were, the Barracuda would probably be a better fit for Australia. At 5,400 tonnes submerged it is considerably smaller and it only requires a crew of 60 (similar to *Collins*). Thirdly, although unproven as yet, the submarine promises to be highly advanced, with excellent stealth characteristics, first class sensors and advanced weapons. The noise signatures of French nuclear submarines have improved very substantially since the early days of the *Rubis* class. In addition, unlike American and British submarines, the Barracuda class will use only low enriched nuclear fuel, not the weapons grade uranium that might cause problems for Australia under the Nuclear Non-Proliferation Treaty.

Source; Insight Economics.

There are some practical reasons why nuclear submarines are not an option for Australia at this time. The main argument is that Australia has no nuclear industry and there are significant barriers, including political issues, to creating one. Every country that currently operates nuclear submarines, or (like Brazil) aspires to do so, has a civil nuclear industry. This argument can be overdone, however. As a major supplier of uranium to global markets

[76] Canada also considered the French *Rubis* class SSN, but rejected it reportedly because of its noise levels.

Australia is a player in the nuclear fuel cycle and operates a nuclear reactor at Lucas Heights. It has a well-regarded nuclear regulator, ARPANSA, which could develop the regulatory framework required to maintain and operate a fleet of SSNs – an area where the US and the UK, in particular, expend very considerable resources. As the commander of the US Pacific Fleet said recently, 'it's very, very expensive to sustain nuclear-powered vessels. There's a significant infrastructure requirement and a significant safety requirement. We spend an extraordinary amount of resources ensuring the safety of nuclear power.'[77] If it were to acquire a Barracuda class SSN, Australia could also call on French support for reactor maintenance and, every ten years or so, refuelling.

The other important issue relates to providing highly trained crews for a fleet of nuclear submarines. The RAN has been severely stretched to provide crews for even three *Collins* class submarines at one time. With the exception of the French Barracuda, most SSNs require much larger crews than SSKs. They also need intensive training; in case of an emergency, for example, each member of the crew needs to be familiar with the complex systems, many of them unique to nuclear boats, which operate in and around their station. Much of this intensive and lengthy training would need to be conducted overseas, possibly in the French language if the Barracuda were to be acquired. Drawing on a much larger workforce, the British Royal Navy, for example, is experiencing problems in providing crews for its fleet of 11 nuclear submarines, especially in training and retaining sufficient engineering ratings and qualified nuclear watchkeepers.

A key question from a strategic perspective is whether SSNs rather than advanced SSKs would be the best fit for Australia. With a small population and a very long coastline and large EEZ to defend, the main requirement is for as many effective submarines as the budget will allow. The infrastructure required to operate SSNs makes them a very expensive proposition. The Royal Navy can only afford seven of them. Rear Admiral Peter Briggs, a retired submariner, suggests that a fleet of SSNs could cost between four and six times as much as a similar number of SSKs.[78] It is hard to see Australia being able to acquire more than six. Having between two and three submarines, even SSNs, available for operations at any one time will not be sufficient in the future. While transit times would certainly be greatly reduced by a SSN, this could also be achieved by forward basing.

From a strategic perspective, a nuclear powered submarine is unquestionably an asset that can be employed for the purposes of power projection in a great power conflict. With the exception of India, the six nations that currently operate nuclear submarines constitute the permanent membership of the UN Security Council. They also all deploy nuclear weapons, including the capability to activate submarine launched ballistic missiles (SLBMs) in a second strike. As a conventionally-armed middle power, it would seem to be over ambitious for Australia to attempt to undertake power projection activities – perhaps with cruise missiles with conventional warheads – against a major adversary with the ability to retaliate with incalculably greater effect.

[77] Nicholson, Brendan (2017), "US admiral and RAN chief: nuclear submarines require massive backup," *The Strategist*, 2 August.

[78] Briggs, Peter (2016), "Nuclear propulsion for Australia's submarines?" *The Strategist*, 17 November.

Perhaps the most important consideration is that if Australia were involved in a conflict with a major power in coalition with the United States, it would not need to deploy SSNs. The US Navy has an all-nuclear submarine fleet that complements Australia's conventionally powered Submarine Force. The RAN's can deploy its SSKs for brown water operations in the littoral at least as well as the USN, whereas *Virginia* class submarines and other American assets can undertake power projection roles far better than the RAN.

This is not to say that if in the future Australia's strategic circumstances changed for the worse, for example if the US withdrew to Hawaii and even beyond, the acquisition of nuclear submarines should not be actively considered. But in that event, there would be a need for a more comprehensive national conversation about the nation's security, even including, perhaps, whether a defence arsenal of conventional weapons constituted a sufficient deterrent. As Dr Andrew Davies of ASPI suggested last year:

> Our worst case scenario is a total US disengagement from the region, including Australia. In that case a more capable ADF is a necessary response. We would need to invest in those capabilities that are capable of doing the most harm to even a capable major power. Taking them on head to head would make little sense, so we're back to asymmetric capabilities like submarines. And, ultimately, if we were feeling sufficiently threatened, we would also need to worry about a nuclear deterrent, and about robust delivery mechanisms. Submarines might be important in that respect as well.[79]

5.5 Does the ADF need a new forward base?

While we sometimes talk of the Asia Pacific region as if it is in Australia's backyard, in fact it is not. From a military perspective this has both advantages and disadvantages. The main advantage is that it makes Australia a very difficult place to invade, as the Japanese navy acknowledged in 1942. The disadvantages relate to the time it takes for ADF assets to reach their forward AOs and, in consequence, the limited time they may be able to remain on station when they do finally arrive.

The military solution to a problem of this nature is generally to establish one or more forward bases. China's militarisation of disputed islands in the South China Sea may be seen in this light. In a conflict, Australia would probably be able to utilise American forward basing facilities at Guam or perhaps share Royal Navy facilities at Singapore. However, this may not be sufficient. A forward base could also provide very useful facilities for the RAN, including not just the opportunity to refuel and re-provision submarines and surface units, but also opportunities for some shore leave and R&R.

In terms of the FSM, a forward base could significantly reduce the advantage a SSN would provide in terms of transit times. Submarines could also refuel, re-arm and re-provision, perhaps with a new submarine tender being available to provide routine maintenance or repairs. Given the necessarily cramped environment in a submarine, the opportunity for crews to stretch their legs ashore would be highly desirable. The use of a forward base may reduce the perceived need for a large submarine with a large weapons payload and also one with a very long range. It could enhance the

[79] Davies, Andrew (2016), "The deterrent value of submarines", Address to SIA Conference, ASPI, 15 November, page 5.

attractiveness of a smaller submarine with a flexible mission capability using alternative modules – for example, mines, land attack missiles, UUVs and special forces. In short, it could make a MOTS submarine a much more attractive proposition to the RAN.

There are a number of options as to where this base could be located. Christmas Island and Cocos Keeling have the advantages of being Australian territory and are well located in terms of RAN submarines' AOs. On the other hand, they have poor natural harbours and could require the construction of submarine pens, which would raise the cost of developing the base considerably. Another possibility would be for the Australian government to seek a long-term lease from PNG on Manus Island. The economic benefits to PNG, as well as the security benefits, would be substantial. Strategically, the establishment of an Australian base on Manus could be seen as a measured but robust response to China's militarisation of artificial islands in the South China Sea.

There are always some risks with forward basing. One strategic risk for a base not on Australian territory is that because of changing political imperatives in the host nation, the lease could be withdrawn. Operational risks include surveillance of the base by satellites, aircraft, drones and submarines with the ability to detect the movements of Australian military assets. The same argument, however, applies, perhaps with less force, to HMAS *Stirling* in Fremantle. Satellites and drones may monitor submarine movements and, in the event of a conflict, an adversary could position a SSN nearby to destroy any submarine setting out on patrol.

Nevertheless, we believe a better option is to acquire a submarine tender that could act as a mobile 'mother ship' for the Submarine Force. Such a ship could operate on Australian territory, such as Christmas Island and Cocos-Keeling, both of which are virtually on the doorstep of the Submarine Force's AOs. It could act as a command and support ship for submarine operations in the Indian Ocean, Pacific Ocean or North Asia. In a conflict it would not require major ADF assets to defend it because it could be withdrawn to the Australian mainland.

5.6 The French connection

Together with the F-35 joint strike fighter, the FSM acquisition is of vital importance for Australia's future security in a region where the strategic environment is increasingly uncertain. Both platforms are of overseas design and, despite the submarines scheduled to be built in Australia, both will be heavily reliant on overseas suppliers for components, including the all-important systems and weapons. Although Australia has no choice in the matter, there are always some risks involved in acquiring weapons systems from overseas. For example, during the Vietnam War, both Sweden and Switzerland placed an embargo on the sale of spare parts for defence assets previously purchased by Australia.

In the context of Naval Group's success in the CEP, it is interesting to note that France has now climbed to the top of the so-called soft power index, with soft power defined as "a measure of the ability of countries to get their

way through persuasion rather than force".[80] In May 2017, in its naval shipbuilding plan, the Australian government painted a benign picture of a long-standing close strategic relationship between Australia and France:

> Australia and France have a close and long-standing relationship, based on shared interests in contributing to the rules-based global order and strong cooperation in the Pacific. This relationship will continue into future decades including in support of the future submarine project.[81]

While welcome, this long-standing close relationship may come as something of a surprise to inhabitants of both countries. Between 1966 and 1996, France conducted about 180 nuclear tests in the South Pacific, many of them in the atmosphere, much to the displeasure of Australian governments of both political persuasions. While it is reassuring to believe that a 'rules-based global order' exists to which both Australia and France adhere, its invocation tends to invite the question of 'whose rules?' For example, the French secret service's *Opération Satanique*, the sinking of the *Rainbow Warrior* in 1985, resulting in one fatality, suggests that the congruence between French and Aussie rules, if indeed it now exists, is not necessarily long-standing. In addition, France has consistently refused to grant independence to its imperial territories in the South Pacific.

Since World War II, France has followed an independent foreign policy based, naturally enough, on its national interest. Yet France's national interest is not necessarily the same as that of Australia. France is not an ally of Australia. Unless cast iron protocols were established, in any conflict between Australia and a major adversary in the region it may be that of the three alternative suppliers in the CEP, France would be the most likely to adopt a policy less sympathetic to the security interests of Australia.

Australia's relationship with Naval Group became somewhat clouded soon after the April 2016 announcement of the choice of the Shortfin Barracuda for the RAN when there occurred a comprehensive leak of top secret information on the company's conventional Scorpène class submarine. According to a media report, the documents, marked 'Secret Scorpène India', "disclosed almost the entire combat capability of the subs, including the frequencies used to gather intelligence, the range, endurance, diving depth and survivability of the boats, their magnetic, electromagnetic and infra-red signatures, the parameters of its anti-ship missiles and, most crucially, the noise the subs make at various speeds".[82] As a consequence, India declined to take up the option to purchase three Scorpène submarines additional to the six it was already acquiring.

Despite assurances that the Shortfin Barracuda will be a different design to the Scorpène, there can be little doubt that many of the electronic systems on the boats will be similar to, or evolved versions of, those on the Scorpène, leveraging the Naval Group supply chain. This has attendant risks,

[80] Miller, Nick (2017), "Trump's America trounced by Macron's France in latest soft power rankings', *The Age*, 19 July, http://www.theage.com.au/world/trumps-america-trounced-by-macrons-france-in-latest-soft-power-rankings-20170718-gxdx84.html

[81] Australian Government (2017), *Naval Shipbuilding Plan*, *op. cit.*, page 27.

[82] Stewart, Cameron (2016), "Leak torpedoes India's $2 bn deal for more French submarines", *The Australian*, 5 September, http://www.theaustralian.com.au/national-affairs/defence/leak-torpedoes-indias-2bn-deal-for-more-french-submarines/news-story/6f9921d70c97a9c589b264c9eb5dadad

particularly in the evolving cyber warfare domain where cyber security is critically reliant on assurance of the supply chain through-life.[83]

This issue also has implications for another important strategic consideration, namely whether the US will be prepared to supply its most high-tech and sensitive systems, such as the continually evolving AN/BYG-1 combat system and associated command and control equipment, together with the Mk 48 CBASS torpedo for installation and integration with European sensors in a submarine of French origin. Although both the combat system and the torpedo are integrated with French sensors on the *Collins* platform and Defence is confident that the US authorities will agree to such integration, we cannot be certain that this will be the case in ten years time when the equipment may need to be acquired for the first FSM. We understand that approval by the US Congress is likely to be required and this is always difficult to predict, particularly over such a long timeframe. The comprehensive leak of top-secret data on the Scorpène will not have assisted in this regard.

Apart from the need to ensure cyber security, there are other aspects to the issue of how to guard closely sensitive information on the systems and capabilities of Australian defence assets. It would be idle to believe that French industry will not supply their advanced systems to other countries in the region, including some that may not be allied to or aligned with Australia. In March 2017, for example, defence companies from France and Indonesia signed a MOU to bolster ties for submarine and surface ship projects. The agreement facilitates strengthened information sharing between France's c and Indonesia's PT PAL. According to Naval Group, Indonesia seeks to bolster the naval capabilities for its armed forces with a long-term cooperation with France.[84]

5.7 Implications

The strategic environment in the Asia-Pacific region has become more dangerous in this century, with the situation having become more uncertain in the year since the decision on the strategic partner for developing the FSM was made. There are significant strategic risks around Australia's choice of a bespoke large SSK, with the first of twelve boats not scheduled to enter service until, at best, the mid-2030s.

The biggest strategic risk in the FSM acquisition is the substantial delay in delivery as a consequence of pursuing a blue sky, developmental design. There is nothing in the current strategic situation to reassure Australians that we do not need more submarines than we have now or that the requirement for new submarines to enter service from the early-2020s, as was envisaged in the 2009 White Paper, is no longer valid. Indeed, the opposite is the case. The requirement for the twelve submarines foreshadowed in that 'Force 2030' White Paper occurred when, as the White Paper suggested, "there is a broad [community] consensus that the present strategic environment is relatively benign in terms of a major military threat

[83] Alberts, C., Haller, J., Wallen, C., and Wood, C. 2017, Assessing DoD System Acquisition Supply Chain Risk Management, Crosstalk May/June 2017

[84] Maas, R., Indonesian French companies join forces for naval projects, in on-line news article, United Press International, 2017, March 31, http://www.upi.com/Defense-News/2017/03/31/Indonesian-French-companies-join-forces-for-naval-projects/9281490979577/

to Australia".[85] Eight years later, in a period when Australia has been threatened with nuclear attack, such a consensus would no longer exist and the requirement for twelve new submarines is more urgent than before.

Even with a life extension, it is difficult to see the *Collins* class submarines would be fit for front-line operations after about 2035. Yet taking account of probable delays in the delivery of the Shortfin Barracuda, we may only have one or two new submarines in service by 2040, whereas the original capability requirement was for twelve in service by the early 2030s. The current approach carries with it the acute danger of a lengthy capability gap in submarine operations, with a consequent threat both to national security and the loss of essential skills needed to operate the FSM when it eventually arrives.

Looking in detail at the main areas of operational capability required in the FSM, the main task in any conflict would be to enforce sea denial in the SLOCs to our north. The implication is that if the government is willing to allocate a lesser priority to functions such as power projection activities against a major adversary, there is no need to acquire a large submarine built to an *ab initio* design. An advanced MMOTS submarine could discharge many of the required roles better than a large SSK, particularly one lacking both AIP and Li-Ion batteries. Even if Australia does have a strategic need for a large SSK, which is open to dispute, it is difficult to see that we need twelve of them. A submarine fleet with two classes of boat would be more costly in terms of training and, perhaps, maintenance, but from a strategic perspective could make a lot of sense. There would also be substantial benefits in acquiring more platforms than 12, perhaps 18 or even 24. This would be unaffordable with such a large submarine.

While some may still harbour an ambition to acquire a SSN down the track, there would be difficulties in achieving this in the near future. Yet there is a disconnect between the capability requirement for the FSM, at least as set out in the 2009 White Paper, which reads like a mission statement for a nuclear submarine, and the decision to acquire a very large SSK apparently in a futile effort to mimic the capabilities of a SSN. The government should accept that if political considerations or more substantive reasons preclude the acquisition of a SSN, then it must temper its ambition in terms of power projection missions in AOs such as the South China Sea. Not only would such missions using a very limited number of conventional weapons likely be ineffective, but they would also put the crews at significant risk. Much better, if engaged in any coalition operations involving the US, for the US Navy to undertake operations that require SSNs and the RAN to contribute its SSK fleet for other, equally valuable, missions.

On the other hand, if the government considers that it is possible that the US will withdraw from the region and pursue an 'America First' policy then it should begin a process for of contingency planning to acquire SSNs for the RAN. The irony of seeking to acquire nuclear powered French Barracudas, which would be much more capable than the Shortfin version, is that they would probably be no more expensive in terms of the acquisition cost, would be lower risk and would be available within a shorter time frame. However, operating SSNs would be no easy task and the overall cost would be very high. If Australia were to acquire SSNs with the ability to employ them on a

[85] Australian Government (2009), *Defence White Paper*, op. cit, page 18.

sovereign basis, they would need to have highly trained RAN crews and be regulated and sustained in Australia. This would require a major political and financial commitment, with bipartisan support and, at least 15 years hard and expensive work.

Finally, many of the problems around long transit times and limited available time on station could be greatly reduced if a forward base were established. Perhaps the most effective way to establish this would be to acquire a submarine tender that could operate on Australian sovereign territory, such as Christmas Island or Cocos-Keeling.

CHAPTER 6
Technical risks

"A submarine should be as small as possible and only as large as necessary."
Hans J Ohff, former Managing Director of the Australian Submarine Corporation.

6.1 Background

In this Chapter, we explore, at a necessarily high level, the technical challenges faced by the FSM project. It seems to us that the technical risks around the project derive mainly from the desire to acquire a conventionally-powered submarine with the capability of a SSN. In a very real sense this is impossible because much of the capability of a SSN derives from its powerful and virtually inexhaustible nuclear reactor. But in pursuit of this elusive Holy Grail, the SEA 1000 project will be subject to a range of technical risks. There is a material risk that it will not deliver 100 per cent of the desired capability; that the capability it will eventually provide could equally have been delivered, more cheaply and much more expeditiously, by a MOTS boat or an evolved *Collins*; and that the technical challenges mean that the FSM project will be delivered unacceptably late or even, perhaps, not at all.

First, we look at some issues around the level of engineering expertise available within Defence so as to assess these technical risks, including by embedding a test and evaluation (T&E) regime as part of the design and construction process. Secondly, we discuss the technical risks involved by dint of choosing a unique, bespoke submarine to replace *Collins*. Thirdly, we examine the risks inherent in selecting a big platform, one that is as large as a SSN when SSKs are generally much smaller. Fourthly, we examine some of the new propulsion technologies that are transforming the operational performance of SSKs and discuss the risks of not adopting these technologies. Fifthly, we look at the risks involved in the various systems and weapons that the RAN specifies must be integrated with the new platform. Finally, we discuss some of the risks of undertaking a life of type extension of the *Collins* class, which is necessitated by the delay is acquiring the FSM.

6.2 Engineering expertise and Test & Evaluation

Loss of engineering skills in the RAN

In the process of preparing this report, a common theme in many meetings with experts was the decline in engineering expertise in the Defence department. This appears to be partly the result of budget cutbacks in the late 1990s and early 2000s, when the Naval Technical Services department, the repository of much engineering expertise, was abolished. At the same time, many civilian engineers left the ADF. Another factor was the impact of the resources boom in Australia, when skilled engineers were in short supply.

By the late 2000's it was clear that the Navy's performance was being adversely affected by a lack of technical engineering expertise. In the first half of 2010, "two-thirds of the navy's fleet were unable to operate at full

capacity at some stage … because of repairs, maintenance, crew shortages or operational restrictions."[86]

In a report by the Auditor General in 2015, it was stated that in the RAN "as at 30 June 2014, the marine technician employment category had a workforce shortfall of 23.5 per cent and the medical officer category had a workforce shortfall of 29 per cent. Defence classified these categories as 'critical'. Some of Navy's critical employment categories, particularly technical sailor, engineering and medical officer categories, have experienced sustained workforce shortfalls for over a decade."[87]

A review of the engineering problems in the Navy, chaired by retired Air Vice-Marshal Julie Hammer reported to the Chief of Navy in 2009. The review stated that navy engineering had reached a critical low point. "Many engineering reviews of the past have identified some of the same issues highlighted in this review, but solutions have not been pursued. The current situation has an urgency and criticality that cannot be overstated."[88]

The report was not released, but according to an article in *The Australian*, which acquired a copy, its findings included:

- "Navy is potentially exposed due to the poor state of engineering policy"
- Navy has failed to upgrade the skills of its engineers to prepare them "to manage the challenges of new capabilities such as air warfare destroyers, landing helicopter dock ships and new submarines"
- There is a serious morale problem among engineers: "the negative attitude of some sailors is cancerous and can quickly pervade large sectors of the fleet support unit"
- There is a serious problem with career management and navy personnel need to have higher qualifications as well as access to better training
- The number of civilian engineering and technical officers has been reduced from "many hundreds in the 1980s to a fraction of that number today"
- There should be greater recognition and promotion for engineering professionals, who are often overlooked in favour of sea command personnel. [89]

"Navy is fundamentally a technological service," the review stated. "Its war-fighting ability is critically dependent on the engineering design of its platforms and systems and the state of serviceability in which they are maintained." James Brown of the Lowy Institute concluded "this is a navy that is tactically excellent but technically bankrupt".[90]

This lack of engineering expertise, together with reportedly a culture within Defence that makes junior and middle-ranking officers unwilling to 'speak

[86] Kenny, Chris (2011), "'Cancerous' morale risks our navy fleet", *The Australian*, February 19
[87] ANAO (2014), *Recruitment and retention of Specialist Skills for Navy*, Report No. 17, 2014-15, page 12.
[88] Harmer, Deborah (2016), "'Tactically excellent but technically bankrupt': What can the Royal Navy learn from the Royal Australian Navy's engineering crisis?" *The Naval Review* (UK), Vol. 104, November, page 438.
[89] Kenny, Chris (2011) *op. cit*.
[90] *Ibid*.

truth to power', can also have a substantial negative impact on informed decision making on acquisitions such as the FSM. In 2011, another journalist reported that "in the case of Australia's navy, experts say there is a vacuum of critical voices inside the system willing to speak up and debate the key decisions that have led, through many years, to the present state of the fleet".[91]

The application of substantial engineering expertise is a critical success factor in major acquisitions, particularly where the new platform is highly developmental, such as AIR 6000 (New Air Combat Capability) or SEA 1000 (Future Submarine Program). In recent times, there has been a tendency to put 'the drivers' in charge of major acquisition projects, that is pilots or navigators in the RAAF and general list officers or submariners in the RAN. This is not in any way a criticism of the senior officers concerned who, in our experience, are highly professional and reflect great credit on the ADF. But it is quite natural that their overriding interest in the acquisition of a new defence platform is in maximising its capability; they are, understandably, less focussed on value for money or the risks that the capability cannot be achieved at a reasonable cost or in an acceptable timeframe. They may be more willing than an engineer or an accountant, for example, to make the perfect the enemy of the good.

Test and evaluation

In order to minimise the very high technical risks when developing a new defence platform, a substantial and effective test and evaluation (T&E) process needs to be an inherent part of the programme. Unfortunately, compared to the US and UK, for example, which invest in a large number of bespoke, developmental defence programmes, the emphasis placed on T&E by Australia's Department of Defence is significantly less. While this may, in part, reflect a triumph of hope over experience, a much more important factor is a lack of experience in managing big, highly risky developmental projects. Abstracting from early projects such as the CAC Boomerang aircraft in World War II, the *Collins* class submarine programme was probably the first substantial bespoke defence project ever undertaken by Australian industry.[92]

A great deal of pain and treasure could have been saved if the *Collins* class submarine been subject to a well-developed programme for effective T&E, including preview testing. Issues such as the problems with the propulsion system, diesel engines, propellers and combat system could all have been nipped in the bud and mostly rectified at a much earlier stage than occurred. As Joiner has noted, "in 2002, when five of the six boats had been built and operational release still not achieved, the Australian National Audit Office (ANAO) found test plans weren't updated, resourced or enforced, that test coordination meetings weren't being held, and that Defence was struggling

[91] Stewart, Cameron, (2011), "Navy scuppered by 'can do, make do' culture", *The Australian*, February 19.

[92] Like the *Collins* class, the Boomerang was partially derived from another platform. Never a success against Japanese Zeke fighters, one pilot claimed the Boomerang was a misnomer because it never came back.

to verify safety-critical software."[93] McIntosh and Prescott stated in a report to the Minister in 1999:

> To our surprise, deficiencies have occurred in items that should have been relatively straightforward, had testing, even along the lines of that routinely applied to merchant ships, been undertaken. ... More seriously, the structure of the contract ... has been a factor in the difficulties with, amongst others, the combat system, propeller, and periscopes. It was aggravated by the lack of insistence on all the testing required to reduce risk, notably full tank testing of hull models and early checking of more routine equipment to avoid unnecessary problems.[94]

One of the results of the problems that occurred as the result of a lack of T&E on the *Collins* class, was an awareness of the need for much greater discipline around testing on future Defence platforms. Yet, as Joiner and Atkinson have pointed out:

> At the peak of operational difficulties with the *Collins* in 1999, a Ministerial report expressed considerable frustration at the inadequacy of T&E not to have screened for technical risks earlier, including a prescient call for preview testing as part of any future selection. The ANAO confirmed the inadequacy of the Collins testing in a more detailed review published in 2002 and they ascribed the difficulty to project governance not enforcing the necessary test policy. Unfortunately, Australia's DoD at the time rejected the ANAO recommendations to improve along U.S. lines the independence and governance of such project testing, ironically arguing it did not "do" projects that warrant such rigorous oversight![95]

Nevertheless, after several other capital projects, including the Super Seasprite helicopter, that went badly awry, Defence accepted the need to apply a rigorous T&E process for future acquisitions. Yet a Senate committee report on defence procurement in 2012 found that the procedures were still not being followed to a satisfactory degree. In particular, the committee found that: "the lessons to be learned from recent projects underscore the need for improvement in test and evaluation. Such observations have particular relevance for defence projects still in the early stages of their capability development especially the need for up-front investment in research and analysis."[96] Following that report, Defence accepted the need to undertake preview T&E on all acquisitions, yet even in 2016 another Parliamentary committee reviewed an example where this had not been done.[97]

Dr Keith Joiner, formerly the Director of T&E in the Department of Defence, has set out in an article co-written with Dr Simon Reay Atkinson, the details of the T&E process that needs to be undertaken on the FSM. This is summarised in Exhibit 6.1 below.

---

[93] Joiner, Keith F. (2016), "SEA 1000: test before you buy", *The Strategist*, ASPI, 26 April

[94] McIntosh, M. K. and J.B. Prescott, (1999), *Collins Class Submarine Report*. Canberra: Department of Defence, page 6, www.defence.gov.au/minister/1999/collins.html

[95] Joiner, Keith F. and Simon Reay Atkinson (2016), "Australia's future submarine: shaping early adaptive designs through test and evaluation", *Australian Journal of Multi-Disciplinary Engineering*, forthcoming, p. 29.

[96] Senate Foreign Affairs, Defence and Trade References Committee (2012), op. cit, page 235.

[97] Joiner (2016), op. cit.

EXHIBIT 6.1: TEST AND EVALUATION FOR THE FUTURE SUBMARINE

> [An approach to T&E that addresses the risks inherent in a 'clean sheet design'] "warrants '*state-of-the-art'* land-based test sites that do the full suite of research, development, test, evaluation and through-life supply and training support. Moreover, high-level submarine design and sustainment studies in the U.S. and U.K. illustrate that all submarine systems must be represented in one of many land-based test sites, and the sites must also link to provide full submarine performance replication and direction. An example breakdown of necessary land-based test sites is: power and propulsion, command and weapons, sonar systems and noise measurement, other signature measurement and replication, submarine platform management (including life-support, maneuvering), communication (on & off platform), rescue, and autonomous vehicle and personnel. Allied naval vessels are increasing required to perform cooperative engagement with other air, land and strategic surveillance assets and for twenty years the need to link test sites of the command and weapon systems has been identified as crucial to achieving and maintaining such capability."

Source: Joiner and Atkinson (2016), op. cit, pages 22-23.

More recently, Dr Joiner has become concerned at the early lack of progress in establishing land-based test sites in Australia, which, in late 2016, Defence committed to commission in early 2019. "This is an ambitious timeline, given these facilities will be complex and that most routine new facility projects take the Defence Department between three and seven years. … A serious concern with delays in test capability is that the French designer and builder, DCNS, will soon hold sway over the project direction. It suits their commercial purposes for such test sites to be delayed, so French sites pick up the slack and all efforts at independent test capability become buried in the difficulties of foreign release and Australian deference, so as to avoid political sensitivity."[98]

In fact, the 2012 Senate committee report made explicit reference to T&E undertaken in France for the multi-role tanker aircraft (MRRT):

> It should be noted that during its visit to RAAF Edinburgh, the committee gained a greater understanding of the lack of resources and attention Defence gave to the testing and evaluation of the MRTT in France. Thus, the committee believes that another important lesson for Defence, DMO and relevant capability managers is to ensure that any overseas testing and evaluation of an acquisition is closely scrutinised by appropriately qualified and resourced Australian personnel. Such personnel should be accountable to one source of authority, i.e. the client who finally uses the product. Defence should not skimp on the resources necessary to conduct adequate and appropriate T&E activities and make it crystal clear who is responsible.[99]

In light of the comprehensive leak of data relating to the Scorpène submarine, it may be that Naval Group electronic systems are now vulnerable to cyber attack. Joiner is also concerned about progress in developing cybersecurity for the FSM:

> "Cyber is becoming the cheap first-strike weapon of choice by potential adversaries. … The future submarine's high-level requirements would undoubtedly have cyber-resilience as a key feature, but there is no evidence of this flowing through to the key cybersecurity plans like those usual at this stage in a U.S. project (i.e. Project Protection Plan). Nor is there evidence of the necessary industry engagement to establish a cyber-trusted network in time for the test sites and to scrutinize DCNS and LM [Lockheed Martin]

[98] Joiner, Keith F. (2017), "Negating the impact of the future submarine at next election", *Pearls and Irritations* blog, 13 April, http://johnmenadue.com/?p=10046

[99] Australian Senate (2012), *op. cit*., page 25.

> redesigns. Again, DCNS and LM are unlikely to be commercially motivated to adjust extant supply chains, or subject them to new scrutiny, in order to establish a robust and independent cybersecurity test framework for Australia."[100]

6.3 Technical risks and non-MOTS solutions

As discussed in Chapter 2, new bespoke designs of military platforms persistently fail to achieve their required capability. In contrast with nuclear submarines, which have the power and space to deploy virtually any capability they require, the design of a SSK is all about compromise and trade-offs. The technical risks of producing an *ab initio* design of a new submarine are extensive and profound. Most new classes of submarine are built on the basis of an evolutionary design, that is, one based on the previous class of submarine and developed to take account of new technologies and processes. The ability to use an evolutionary development process clearly reduces the technical risk significantly. The German Type 212, for example, represents a major advance on the previous Type 209 but it is recognisable as an evolution of the earlier design. Indeed, the design of German submarines has evolved from models going back 100 years.

An interesting example of evolutionary progress is also the Russian Kilo class, which has been in production since 1980. The design has evolved considerably over 35 years and the latest version (Project 636.3, Varshavyanka class) remains, in contemporary terms, a formidable weapon. The Varshavyanka class boats reach speeds of 20 knots, can dive to 300 meters and carry crews of 52 people. The submarines, which are armed with torpedoes, mines, and Kalibr 3M54 (NATO SS-N-27 Sizzler) cruise missiles, are mainly intended for anti-shipping and anti-submarine missions in relatively shallow waters."[101] At around US$400 million a copy with a building time of two years, it is relatively inexpensive, delivery is rapid, its technical risks are very low and it is fast and highly manoeuvrable with a relatively quiet acoustic signature. Having delivered six of the latest version of the Kilo to the Black Sea fleet within seven years of being ordered, in May 2016 the Russian navy ordered six of the latest Kilo class boats for the Pacific fleet.

Australia cannot acquire Kilo class submarines, but the contrast with the *Collins* class is interesting. Perhaps the third of the four options for the FSM – a 'son of *Collins*' design – was dismissed too rapidly. The RAN believes that too many of the design ideas incorporated in *Collins* reflect 1980s thinking and technology that are no longer relevant. Yet the same must be true of the Kilo class; in fact the double hull construction (also found in the *Sōryū* class) goes back to the German U-boat designs from World War II acquired by the Soviet Union in 1945.

The technical risks inherent in new submarine programmes are illustrated by recent Russian and Spanish experience (Exhibit 6.2). Russia's Lada class reflect a desire to build a new generation SSK and, in contrast to Australia's direction, for it to be smaller and more stealthy than its predecessor, the Kilo class. Having been being laid down in 1997, it would normally be expected that the first submarine, the *St Petersburg*, would now be enjoying its 15th

[100] Ibid.

[101] GlobalSecurity.org (2017), http://www.globalsecurity.org/military/world/russia/636m.htm

birthday in active service. Instead the class has been a failure to date, without incorporating some of the advanced technologies that were their *raison d'être* in the first place.

As a result of substantial errors in construction and technical problems, Spain's first S-80 submarine is likely to be delivered at least seven years later than originally intended at a much greater cost and without incorporating the AIP technology that was one of the major advanced features of the design and an essential component of the capability requirement. The Defence Ministry suggested that difficulties with new acquisitions were to be expected: "The technology challenges that these programs face during development are much more than simple calculations. All the major military programs, especially submarines, have experienced delays and often have required the support of a technology partner."[102]

EXHIBIT 6.2: TECHNICAL RISKS WITH NEW SUBMARINE DESIGNS

Russia: the Lada Class

Russia's attempt to produce a 'fourth generation' SSK, the Lada class, saw three submarines laid down between 1997 and 2006 of which none is yet in active service due to extensive technical problems. Lada had a modern hull design, was smaller than Kilo and the latest design is said to include new sensors, with fuel cell AIP also seen as a likely feature. But it has caused the Russians significant problems. The first Lada submarine, *St Petersburg*, began trials in 2005. The persistent failure of the *St Petersburg* to deliver the required capability over a six-year period caused the Lada programme to be cancelled in 2011. Shortly afterwards, however, a change of heart caused two further boats to be ordered in 2012 to a heavily revised design. Problems are said to persist and these are yet to be delivered. They will not deploy AIP.

Russia now appears to be cutting its losses and moving on to a new class of SSK, the Kalina class: "The two Lada-class Project 677 submarines will be delivered as scheduled — in 2018 and 2019," a spokesman for United Shipbuilding Corporation told RIA Novosti. "Then the construction of the new non-nuclear Kalina-class submarines will be launched."

Spain: the S-80

After a period cooperating with France on a new submarine design, Spain decided to go it alone and design and build an advanced new SSK. At around 2,300 tonnes, the S-80 would be able to carry land attack missiles as well as special forces and was designed to operate in the power projection role. In 2004, the government ordered four boats for around US$550 million each, with the first to be delivered in 2011. A two year delay ensued almost immediately due to an extended selection process for the combat system. The GFC then hit Spain particularly hard leading to a budget crisis and in 2011 further delays were announced, with the first boat to be delivered in 2015 and the last in 2018. In 2013, Navantia announced that a major miscalculation had occurred. Due to the misplacement of a decimal point, an additional 75 tonnes had been added to the submarine during construction with the result that it would not be able to re-surface after diving. The American Electric Boat Company was engaged to help design a way forward, which included a lengthening of the hull by seven metres to provide additional buoyancy. The first submarine was then scheduled to be delivered in 2018. In January 2017, however, the government announced that due to problems in developing the AIP system, the first submarine would not incorporate this technology and it was not known which of the other three boats would be fitted with AIP.

Source: http://nationalinterest.org/blog/the-buzz/revealed-russias-lethal-new-kalina-class-submarine-15544; http://o.canada.com/news/spain-builds-submarine-70-tons-too-heavy; http://www.janes.com/article/67182/spain-s-first-s-80-submarine-to-lack-aip

The technical risks of designing and building a new platform must be assessed against the estimated benefits it will provide relative to a MOTS acquisition. In the case of Spain's S-80 submarine, for example, it seems clear that the Armada would have acquired a much greater capability sooner

[102] http://www.janes.com/article/67182/spain-s-first-s-80-submarine-to-lack-aip

and at considerably less cost if they had bought a MOTS boat with AIP. If, say, an *ab initio* platform design is finally able to achieve 85 per cent of its required capability, at high cost and with significant schedule blow-outs, the risk-adjusted return from acquiring a MOTS platform which promised only 80 per cent of the requirement can be significantly higher. Of course, there is also a likelihood that the MOTS platform can deliver more than 85 per cent of the desired capability, in which case the advantage is clear cut.

6.4 Technical risks with large SSKs

When the results of the CEP were announced, it seemed clear that the intention was to take the hull of the nuclear-powered Barracuda and convert it to diesel-electric propulsion. This was always going to be a highly risky proposition. Fundamentally, there is the problem of converting a hull designed around a nuclear reactor to a completely different configuration and weight distribution that characterises a SSK. It has never been done before. There may be issues around buoyancy, trim, radiated noise and the propulsion system that would need to be resolved; perhaps a redesign of the hull would be required.

These issues are explored in more detail in Appendix 1.

Now, however, although the nuclear-powered Barracuda's hull appeared to be the basis of Naval Group's design concept for the CEP, it has become evident that the Shortfin Barracuda will be a completely new design, perhaps incorporating some of the features of the much smaller Scorpène. It will therefore be subject to all the major technical risks around *ab initio* submarine designs.

One of the main technical risks with the FSM is that Defence has decided it requires a submarine with a displacement 50 per cent greater than Collins, which also was the largest class of non-nuclear submarines in existence when it was built. As discussed below, designing a large SSK carries with it particularly difficult trade-offs and technical risks, while sending one into harm's way poses additional operational risks.

Long before the advent of nuclear submarines, navies experimented with large diesel-electric boats designed to carry big guns or aircraft and provide some capacity for power projection. Unfortunately, their lives, like that of Hobbes' ancient man, were often "nasty, brutish and short". The UK built three M class submarines at the end of World War 1, each armed with one 12-inch gun on the then relatively large displacement of 2,000 tonnes. Two of the three were lost with all hands in accidents. In the 1930s, France commissioned the *Surcouf*, a cruiser submarine of 4,375 tonnes armed with two 8-inch guns and deploying a seaplane. The *Surcouf* was despatched to Australia in 1942 but was lost *en route*, in the Gulf of Mexico, as a result of a collision with an American freighter. In World War II, Admiral Yamamoto conceived a plan to build very large submarines for the Imperial Japanese Navy with an extended range and the capacity to carry three seaplanes, with the aim of bombing American cities. Three submarines of the I-400 class were completed, displacing 6,670 tonnes submerged. They never saw action and were all captured by US forces in 1945 and subsequently destroyed. Designing, constructing and manning these leviathans diverted much needed resources from other projects essential to Japan's war effort.

Apart from their strategic ineffectiveness, these classes of large submarines were generally regarded as being unsuccessful from a technical perspective.

While being easier to detect on account of their physical and acoustic footprints, their diving time was slow, they were ponderous while submerged and lacked manoeuvrability. The *Surcouf* rolled heavily while on the surface and proved very difficult to trim when submerged. The I-400 was very unwieldy and easy for ASW forces to detect. In return, its effectiveness in terms of land attack was very limited.

Nowadays large conventional submarines such as the proposed Shortfin Barracuda are rare among the navies of the world. At 3,400 tonnes (submerged), HMAS *Collins*, when commissioned was the largest operational diesel electric submarine in the world. In general, SSKs are substantially smaller. For example, two of the biggest selling export submarines at present, the German Type 214 and the French *Scorpène*, have submerged displacements of 1,860 tonnes and 2,000 tonnes respectively. The highly successful Russian Kilo class, with a submerged displacement of between 3,000 and 4,000 tonnes depending on the version, is bigger, but its successor, the Lada class, was designed to be smaller at 2,700 tonnes.

Nuclear-powered submarines tend to be large. Part of the reason for this is the size of the nuclear propulsion plant. In the British *Astute* class of SSNs (7,800 tonnes submerged), for example, all the space aft of the sail is taken up by the nuclear reactor and associated machinery and equipment. Another reason is that nuclear boats have effectively an unlimited supply of electricity so they can afford to be both large and lavish in terms of equipment. The sensors, combat systems, command and control systems, as well as the complement of weapons can all safely have a greater weight and physical footprint than would be required on a SSK. In addition, having a high 'hotel load' is no problem either and so large galleys and even some recreational facilities for the crew can also readily be accommodated.

The former head of ASC, Dr Hans Ohff, comes from the German tradition of submarine design, which, as he suggests, aims to pack the maximum destructive power into as small and as covert a platform as possible. This is as much in the interests of survivability as anything else. Ohff points out that large SSKs need more and more power to achieve the same speed as small ones: "'as the size and power of a submarine increase', argues the government's DST Group correctly, 'the gains made in range, speed and endurance diminish'. The maxim: '*as small as possible and as big as is necessary'* holds firm for all naval submarine designs, but particularly for diesel-electric boats." [103]

As one Australian submariner said in 2012 in regard to the SEA 1000 acquisition "what we must always keep in mind is that we cannot build a mini- SSN. The requisite power to size ratio does not increase in a linear manner as the size of the submarine increases, but in an exponential manner."[104] Doubling a submarine's speed, for example, increases energy consumption by a factor of eight, which suggests that a high speed burst in a large submarine would have to be very short to avoid running down the batteries completely. Apart from being considerably easier to detect on account of their size in an ocean that is becoming increasingly transparent, the other problems with large SSKs are that they are less nimble and less

[103] Ohff, Hans J (2017), "Australia's future submarine: a Class with no equals", *The Strategist, ASPI*, 16 January, *https://www.aspistrategist.org.au/australias-future-submarine-class-no-equals/*

[104] Miles, Glen (2012), "Australia's Future Submarine Capability; an integrated plan for success", *Journal of the Australian Naval Institute*, Issue 143, March, page 23.

manoeuvrable, so that they lose many of their advantages in terms of working in the shallow waters of the littoral.

The Barracuda SSN, for example, has a nuclear power plant producing 50MW, thereby providing virtually unlimited electricity to run power-hungry systems while propelling the submarine through the water at a high speed. To propel the Shortfin Barracuda at, say, 20 knots for any length of time would draw very heavily on battery power. Perhaps this is why Defence say they don't want AIP on the boat, because this could add on an additional 400 tonnes of weight, of no value while on transits but with a significant impact on speed and submerged endurance. Yet in a combat scenario without AIP, a big submarine's limited power availability could mean it would have to come up to snorting depth to recharge its batteries, which could well be fatal.

The compromises that have to be made in the design of a large SSK give rise to very significant technical risks.

Why does the RAN want a very large SSK?

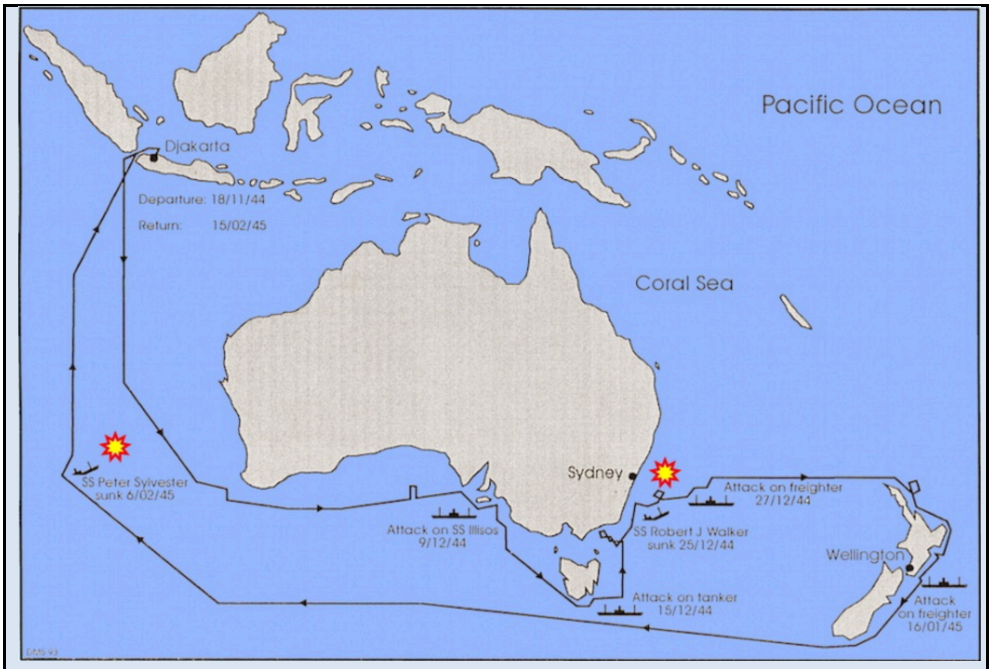
As suggested in Chapter 3, the general disposition in favour of a large submarine for the RAN seems to have coalesced before 2009, when ASC undertook an exercise ('Deep Blue') to develop a concept design of for the next generation submarine. There appear several reasons why the ADF decided that the *Collins* replacement should be a large submarine.

The first reason may well be the view that, because of the long transits that Australian submarines need to undertake to reach their AOs, a large submarine is required to provide greater range and endurance. According to retired Rear Admiral Peter Briggs, a former submariner, "a long-range submarine is therefore required because of our geography, and a long-range submarine means a large submarine".[105] Historically, however, there is very little correlation between the range of a SSK and its size. As is shown in Exhibit 6.3, the *Kriegsmarine's U-862* (1,800 tonnes and 57 crew), which undertook a 90-day patrol in Australian waters in 1944-45, had the extraordinary range of 23,700 nautical miles.

The range of "old" submarines, however, is sometimes discounted by modern submariners. *U-862* and even the *Oberons* were designed to travel mainly on the surface, as their hull shape attests. Because of great improvements in detection, subsequent generations of submarines were designed to travel mainly underwater. Yet these submarines are also capable of delivering a significant range and endurance capability. In the mid-1980s, the new Argentinian submarine *Santa Cruz*, 2,264 tonnes submerged displacement and built in Germany, travelled 6,900 nautical miles over 29 days from the Bay of Biscay to Mar del Plata, of which 6,300 nautical miles were transited submerged or snorkelling. At the end of the voyage, the captain said he still had a 50 per cent reserve of fuel and sufficient food to return to Emden in Germany. The *Santa Cruz* does not have AIP.

[105] Briggs, Peter (2015), *op. cit*.

EXHIBIT 6.3: SUBMARINE FAR FROM HOME: THE VOYAGE OF *U-862*, 1944-45



The *Kriegsmarine* only undertook limited operations in Asian waters during World War II, but a few U-boats were forward based at Penang and Jakarta. In November 1944, *U-862*, commanded by *Korvettenkapitän* Heinrich Timm, set off to disrupt shipping in Australian waters. Timm sank two freighters during his mission and attacked several others. He was hampered by a shortage of German torpedoes on the Asian station and for this patrol he was allocated only 14, some of which had deteriorated in the tropics.Timm's Type IX D2 U-boat was a long-range submarine and, at 1,800 tonnes displacement submerged, a relatively large boat for its time. Because of their size, Type IX U-boats were regarded as being at a disadvantage compared to smaller boats when under attack, with a relatively slow dive time and lack of manoeuvrability. Yet their displacement was not much more than half that of the *Collins* class. Timm's patrol lasted for 90 days, comparable to some of the longer missions undertaken by contemporary US nuclear submarines and more than any SSK would manage these days. *U-862,* the D2 variant of the Type IX, had an exceptional range of 23,700 nautical miles, more than double that of either the *Collins* or *Oberon* boats, and could carry a payload of 24 heavyweight torpedoes, two more than the *Collins* class. Its complement was 57 officers and ratings, similar to *Collins*.

Source: Royal Australian Navy, http://www.navy.gov.au/history/feature-histories/german-u-boat-operations-australian-waters; http://www.uboataces.com/uboat-type-ix.shtml

Understandably, the Navy places high importance on habitability, partly to reduce fatigue and partly to be better able to recruit and retain highly qualified crew members. The distance between Fremantle and Hainan Island in the South China Sea is around 3,200 nautical miles; at an average transit speed of eight knots this means 17 days submerged with perhaps 14 days on patrol and another 17 days on the return journey. A large submarine can provide better habitability for the crew. Hot bunking is now a relic of the past; every crew member has their own bunk and there is a bit more space for relaxation when off duty. In some respects, the much larger SSNs and SSBNs have set new standards as regards creature comforts that cannot be matched easily in a SSK. In addition, it remains a challenge in the twenty-first century to attract skilled people to spend weeks at sea in a submarine, lacking the company of friends and family and generally without the ability to use social media and other essentials of contemporary life.

Nevertheless, while trade-offs have to be made in the design of a submarine, it seems sensible to be biased in favour of operational effectiveness and the best possible level of security for the crew. While habitability is, of course, important, a reasonable compromise needs to be made, perhaps by providing even more attractive remuneration and other benefits such as extended leave in compensation for the rigours of life aboard a submarine.

Another reason for the RAN preferring a large submarine is so it can carry a substantial weapons payload and undertake a multitude of tasks. This is important because of the long transit distances between Fleet Base West in Fremantle and some of the AOs of Australian submarines. In any conflict it could take an unacceptably long time for a submarine to return to base to pick up more torpedoes or missiles, or to substitute one type of weapon for another.

On the other hand, rather than acquire a very large submarine, with all the attendant risks, because it has the capacity to carry more ordnance or special forces, other alternatives are available. In any conflict, the RAN could arrange to use forward bases at, say, Guam or Singapore to refuel and pick up more supplies. Another alternative, that we favour, is to acquire a submarine tender, a submarine mother ship that can be employed as a mobile forward base. The tender would carry supplies of diesel fuel, stores and munitions, as well as providing comfortable accommodation. Crews could operate on a fly-in, fly-out basis and benefit from much shorter operations..

Ultimately, there is no point in designing a super SSK and pretending it can mimic a SSN. A well designed and optimally sized SSK can undertake missions for which it is better suited than a SSN and these happen to be missions well suited to the maritime geography of Australia's northern approaches. As a former commanding officer of *Collins* class submarines puts it, "I do not believe an SSK significantly larger than *Collins* is possible, much less a good idea. There will always be some missions that can't be achieved; let's focus our solution on the ones which can."[106] The danger is that a large SSK will be able to replicate few or none of the strengths of a SSN (particularly if it does not incorporate AIP or new battery technologies) while amplifying the weaknesses of a SSK platform.

Developments in anti-submarine warfare (ASW)

In recent times, the rapid growth in computer processing power has enabled the use of technologies such as undersea laser detection of foreign objects and sound monitoring to enhance substantially the ability to detect submarines underwater. Add to this the improvements in low frequency sonar to detect submarines at very long range, the capacity to detect magnetic anomalies and the use of satellites to track the wake of submarines operating at great depths and the playbook has changed very considerably. Some believe that the oceans are becoming much more "transparent". Also, constant improvements to radar (such as the US equipment that Australia deploys in its fleet of P3 Orions and now also in the P-8 Poseidon) together with the increasing ability to deploy UUVs in choke points and the littoral,

[106] Harrap, James (2012), "Reflections of a *Collins* submarine captain", *Asia Pacific Defence Reporter*, 3 May, http://www.asiapacificdefencereporter.com/articles/226/Reflections-of-a-Collins-Submarine-Captain

and SSKs are in much greater danger of being detected both underwater and when they come to periscope depth in order to snort. Larger submarines, of the kind that Australia is seeking to acquire, are more vulnerable to detection because of their larger footprint, reduced manoeuvrability and greater acoustic and magnetic signatures.

It is of particular note that China, which used to lag behind the west in terms of ASW, has been increasing its capability in this area. For example, China has developed a small frigate, the Type 056, together with helicopters both optimised for ASW, as well as the deployment of fixed sonars on the sea bottom (Exhibit 6.4).

EXHIBIT 6.4: DEVELOPMENTS IN ANTI-SUBMARINE WARFARE IN CHINA

"Beijing has been experimenting with towed arrays since the 1980s. But most new surface vessels have deployed with long linear-type passive towed arrays. The new VDS will give the 056 additional active sonar capabilities (along with the bow array) that can "ping" more effectively from within or below thermal layers. According to the *Modern Ships* rendering, surface ships that [employ active sonar methods of operation will render submarines unable to hide]. Coupled with the possibility of new weapons, such as [homing depth bombs] or even [a new type of ASW missile], these forces promise a much more formidable challenge. Let's not forget, moreover, that even as the Chinese Navy has been upgrading the sonars and ASW weaponry in its surface fleet, it has also been pushing ahead with an ambitious program to set up fixed sonar arrays on the sea bed in its proximate waters as well.

Undoubtedly, a Chinese move toward more regularized "far seas operations"—quite visible in a variety of realms—will require a renewed emphasis on airborne ASW. Quite simply, fixed-wing and rotary-wing aircraft make for highly potent ASW platforms because of their speed, range, search rate and near invulnerability to submarine-launched weapons. Despite these advantages, aerial ASW has long been an Achilles heel of the Chinese Navy—a fact widely acknowledged in Chinese naval circles.

A decade ago, the PLA Navy may have had as few as a couple of dozen large Z-8 helicopters, progenitor of the new Z-18F. However, production was radically increased in the 2004-07 timeframe, according to the 2014 cover story in *Modern Ships*, indicative of a new priority for naval aviation. The same article highlights the much more prominent surface search radar on the new helicopter's chin. This radar is said to be capable of picking up submarine masts and periscopes at ranges of at least 40-70 kms."

***Source: Goldstein, Lyle J. (2015), "A frightening thought: China erodes America's submarine advantage",* The National Interest, 17 August, http://nationalinterest.org/feature/frightening-thought-china-erodes-americas-submarine-13592?page=1**

As Dr Andrew Davies of ASPI pointed out recently:

> "The risks of operating large submarines in contested spaces will likely be higher— possibly much higher—in the future than is the case today … It seems to me that the combination of high-power processing and robotic systems is likely to make submarine operations—at least in the form of sneaking large platforms into contested spaces—much more difficult."[107]

Davies concluded that:

> "The net summary is that future submarines will need to:
>
> - operate away from chokepoints and contested spaces but be able to project influence into them
> - have a low indiscretion rate
> - be a hub for a suite of long-range sensor and weapon systems

[107] Davies, Andrew (2014), "Trends in submarine and anti-submarine warfare", ASPI, https://www.aspistrategist.org.au/wp-content/uploads/2014/04/ASPI-submarine-conference-2014-Davies.pdf

- be networked with other units, including electronic warfare platforms and systems
- be able to manoeuvre quickly in response to a rapidly changing threat environment." [108]

Davies's conclusions are of critical importance for the FSM. He states that "the design of the future submarine has to be cognisant of these trends, which will make penetration of adversary space or operations in contested chokepoints by the submarine itself very much harder. Basing our investment around traditional ideas of submarine operations isn't likely to be a winning strategy a couple of decades from now." Australia needs "to decide whether our subs are going to play in the highest end operations. If we decide we need to, we're necessarily going up the risk reward curve for a conventional boat." The other option would be to "temper our ambitions and settle for a fleet that can still operate effectively in less than the most challenging situations." [109]

Davies's assessment was made in 2014. The PLAN's submarine detection capability, already having improved significantly, can be expected to improve further in the two decades before the FSM will be operating. This submarine, intended top be 'regionally superior', will explicitly be designed "to play in the highest end operations". But it will have a large physical footprint, is unlikely to have AIP and will have what will then be an uncomfortably high indiscretion ratio. This, as Davies points out, may not be a winning strategy.

6.5 New propulsion-related technologies

Perhaps the most significant development for conventional submarines since the snorkel (snort) was deployed in German U-boats at the end of World War II is air-independent propulsion (AIP). Another very important development is new battery technologies, particularly Lithium-Ion. At this stage it appears that the FSM will deploy neither of these technologies. It will, however, use pump jet propulsion, a system usually employed on nuclear submarines, rather than a conventional propeller.

AIP allows a submarine to remain submerged for up to about three weeks, with a maximum speed of around seven knots using the latest systems. Although AIP would not be used on transits, this provides a very considerable advantage while in the submarine's AO. Particularly in the littoral, where sonar is less efficient, it would be very difficult to detect a small SSK which could alternatively lie on the bottom or proceed on AIP, some systems of which provide for virtually silent running. The most important benefit of AIP is that it greatly reduces the need to snort while on operations. Snorting subjects the submarine to visual detection, but also, as sensor and processing capabilities continue to develop rapidly, increasingly to radar detection, particularly from aircraft. As shown in Exhibit 6.4, PLAN helicopters can now detect snort masts at a range of up to 70 kilometres. In a conflict situation, if the aircraft also deploys sonar buoys and homing torpedoes, detection may well have fatal consequences.

The benefits of AIP appear to be incontrovertible. Writing in 2012, one former Australian submariner stated that "AIP is an essential capability in modern conventional submarines. In the past ten years, the only countries

[108] *Ibid.*
[109] *Ibid.*

that have signed contracts for non-AIP submarines are new entrant navies or those that have or are developing a nuclear capability."[110]

The first AIP system was the Stirling engine, introduced in the 1990s and used in the Swedish *Gotland* class. The *Collins* class was built for but not with this system, with the intention of retrofitting it later. It was not fitted for a variety of reasons, including the impact on a limited budget with many other problems with the submarines demanding priority attention. Later systems, particularly fuel cells developed by ThyssenKrupp Marine Systems, have a higher energy density and are quieter. Naval Group is also now developing fuel cell technologies. On the other hand, AIP systems can be heavy and they take up valuable space.

It is perhaps these considerations or doctrinal reasons that have led the RAN to have little enthusiasm about AIP. In 2008, a US Navy Captain published an article noting that a RAN submariner Commodore had suggested to him that the RAN was unlikely to be interested in AIP from an operational point of view.[111] In the CEP process, Defence downplayed the importance of AIP and it seemed clear when the announcement was made that the Shortfin Barracuda would not incorporate it. Although since then the SEA 1000 team has denied that AIP has been ruled out, there remains little enthusiasm for the technology. A major consideration appears to be weight. Yet it is very difficult to see the logic behind ruling out AIP, which many experts regard as a transformational technology for conventional submarines. Particularly for a navy that seeks the capability of a SSN with conventional propulsion, AIP would appear to be a *sine qua non*.

One plausible argument against AIP, however, might be a preference to employ much more efficient batteries, the second major technological change noted above, and to use the space and weight saved by rejecting AIP to include more of them. Lithium-Ion batteries, are now being used on German submarines in particular, with Japan also replacing both lead acid batteries and its Stirling AIP system with Lithium-Ion batteries in its evolved *Sōryū* class design. In the recent competition for Norway's new submarine, tkMS (the eventual winner) and Naval Group proposed both fuel cell AIP and Li-Ion batteries. Lithium-Ion batteries have a much higher energy density than lead-acid cells and therefore can maintain a similar power output for a much longer period of time. Other advantages are that Li-Ion batteries charge much more quickly than lead acid, thereby reducing snorting time significantly, and also do not have a 'memory problem' that reduces battery storage capacity over time.

Hans Ohff has suggested that new battery technologies can obviate the need for AIP:

> On the energy front, lead-acid batteries will have been replaced almost entirely within 10 years. And by the time the first of the future RAN submarines is launched, lithium-ion battery technology may have been overtaken by lithium-sulphur (Li-S) Li-air, or Zinc-air battery technology. By providing much greater energy density at a fraction of the cost such an energy source would render submarine AIP

[110] Patrick, Rex (2012), "Conventional Air Independent Propulsion", *Asia Pacific Defence Reporter*, January, page 40.
[111] *Ibid.*

> technologies (PEM fuel-cell, MESMA, Stirling and closed cycle diesel engine) obsolete.[112]

However, Defence has also ruled out using Li-Ion batteries, at least in the first batch of four Shortfin Barracuda submarines. The reason is a concern about the increased danger of fire. While this concern may be justified at this point in time, given the long time line before the FSM enters the construction phase and the rapid rate of change in battery technology it would seem highly probable that the problem will be solved in the next few years. Other battery technologies are also emerging, such as Lithium-Sulphur, and with such a rapid rate of technological change it seems risky to rule out a state-of-the-art battery for the first batch of the FSM given its long lead time.

A rolling design acquisition and sustainment program, as proposed for the FSM, would provide the opportunity to insert technologies such as AIP and Li-Ion when proven and ready. Yet there has been no explanation from Defence as to why, in contrast to other submarine designers, at least AIP and Lithium-Ion are not achievable in the first boat's 15 year development, nor exactly how such a rolling program will work and at what cost.

The final technology discussed here is pump-jet propulsion. Pump jets have been used in nuclear submarines in preference to propellers since the 1980s. They are more efficient at higher speeds and are quieter both while travelling at a constant speed and under acceleration. According to the promotional materials for the Shortfin Barracuda, and although they have not moved to pump jets in their other submarine designs, including concept designs, Naval Group now considers propellers to be an obsolete technology for submarines.

In the 1980s the Soviet Union built one of its early Kilo class SSKs with pump jet propulsion. The boat had constant problems with its propulsion system and once suffered the ignominy of being towed into port. The experiment was not repeated; all subsequent submarines of the Kilo class, including the advanced 636.3 version, have been completed with propellers. Naval Group tested the pump jet on one *Agosta* class submarine, but the subsequent Scorpène class was built with traditional propellers. The UK moved to pump-jet propulsion on its nuclear submarines in the late 1970s, but when it came to designing its only SSKs built since the *Oberons*, the *Upholder* class in the 1990s, propellers were fitted. The 3,000-tonne concept submarine recently announced by Naval Group also appears to have a propeller, as does its latest version of the Scorpène.

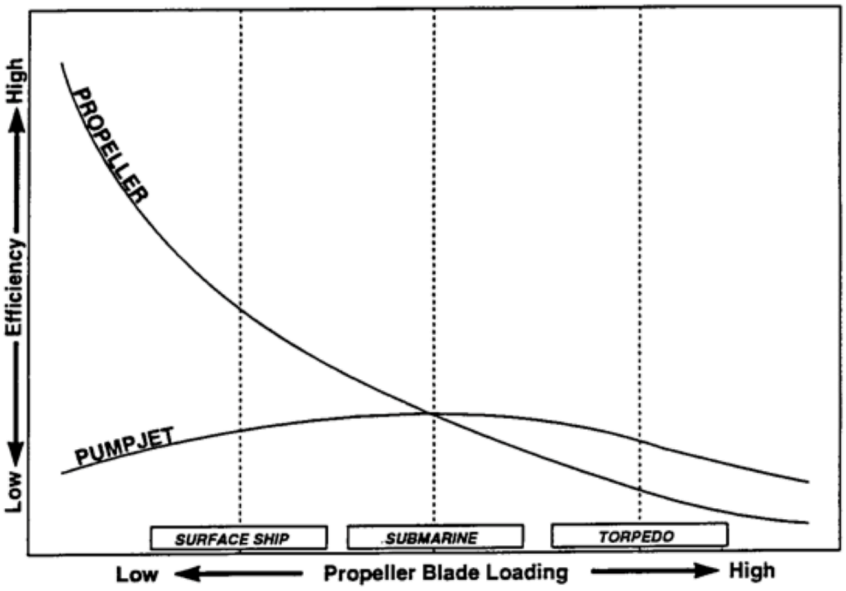
There is a view among many engineers, however, that unless Naval Group has solved the problem of reduced efficiency at the lower speeds at which SSKs travel, pump jet propulsion is not the best option for the FSM. In Exhibit 6.5, for most of the time a SSK would typically have a relatively low propeller loading, where a propeller would be more efficient, while a SSN, which travels at a much higher average speed, would have a high propeller loading so that the pump jet would be more efficient.

The choice of pump jet propulsion creates a technical risk for the future submarine. It is much heavier than a propeller system and, unless Naval Group has made a breakthrough, uses more energy at the speeds at which SSKs generally travel. With lead acid batteries, a large and heavy platform to propel through the water and a heavy and power-hungry combat and

[112] Ohff, Hans J. (2916), "A new submarine class is rarely designed from scratch", The Strategist, 18 January, https://www.aspistrategist.org.au/a-new-submarine-class-is-rarely-designed-from-scratch/

communications system, the last thing the FSM needs is an inefficient propulsion system. The submarine's indiscretion ratio is likely to be unacceptably high, particularly in twenty years' time when ASW sensors and weapons will have developed even further. Hopefully, preview T&E will be undertaken and will provide sufficient data for the first submarine not to be completed with an inappropriate propulsion system or the cost of re-design and retro fitting of a propeller could be extremely high.

EXHIBIT 6.5: RELATIVE EFFICIENCY OF PROPELLERS AND PUMP JETS



Source: Hauschildt, Peter, University of Hamburg

Overall, Dr Hans Ohff sees significant technical risks arising from the government's early decisions on propulsion systems in terms of:

> "the determination to procure a 5100-tonnes submarine that doesn't have air-independent-propulsion (AIP), and is based on lead-acid battery technology. It'll feature an innovative pump-jet system that requires prototype testing for flow, vibration, cavitation and magnetic signature, efficiency and reliability. Then the challenge will be to guarantee safe operational performance under all circumstances."[113]

6.6 Systems and weapons risks

Many of the Defence acquisition problems examined in the Mortimer report (Chapter 2) arise from the understandable desire of military professionals to integrate the best systems with the best available platform. Yet what Defence has done in the case of the FSM is to choose the combat and associated communications and control systems before choosing the platform. It has also mandated a specific torpedo to be integrated with the FSM. Defence clearly is highly committed to both the AN/BYG-1 combat system and the Mark 48 Mod 7 torpedo since it has invested around $1 billion in jointly developing these US systems.

[113] Ohff, Hans J (2017), "Australia's future submarine: a Class with no equals", *The Strategist*, 16 January, https://www.aspistrategist.org.au/australias-future-submarine-class-no-equals/

Combat system

When the original combat system selected for the *Collins* class failed to meet the required level of capability, Defence undertook a tender process to select a replacement. The project team recommended a German design as the best available combat system for the *Collins* class. Yet that was not the recommendation that went forward to the government. For alliance reasons, it was recommended that the US combat system for their nuclear submarines, AN/BYG-1, should be acquired. Since then, Australia has invested nearly $550 million in this system, and before the CEP process was underway Defence mandated that the AN/BYG-1 system should be employed in the FSM.

Because it is designed for a nuclear submarine, the AN/BYG-1 system can afford to be heavy, hot and power hungry with a big physical footprint. We understand that the *Collins* struggles to accommodate it. Its use of power and cooling requirements will result in the submarines' indiscretion ratio being higher than it would be if they employed a system designed for SSKs. While there may be some interoperability benefits to be derived from its use, it is not essential; no other SSK uses it and yet are able to undertake exercises with the US Navy with no obvious problems, while neither British nor French SSNs use AN/BYG-1 and they operate regularly with the US Navy, most recently in middle eastern waters. We understand that if a US communications suite is integrated effectively with other combat systems, the problems around interoperability can be resolved.

AN/BYG-1 is not the most modern combat system available, and it may not be the best. According to a former Australian submariner writing in 2011: "recently, the US Navy's Director of Operational Test and Evaluation indicated that the AN/BYG-1 struggled in high-contact density environments … These reports, coupled with stories of numerous submarine forces, including the RAN, doing well in exercises against US submarines, have cast enough doubt on the system's performance to make [questionable] the blanket suggestion that it is the correct answer for SEA 1000."[114]

The specification of AN/BYG-1 for the FSM inevitably had a major impact on the requirement for a large boat, with no MOTS or MMOTS boat, with the possible exception of the *Sōryū*, being able readily to accommodate its weight and appetite for electricity. There are risks to the FSM as well because, although weight should not be a problem, power demand may well be. We understand that as well as the AN/BYG-1 unit now installed on Collins, Navy wants to integrate a number of associated sub-systems as well. According to the former submariner quoted above, "it is not unreasonable to presume that the power load requirements of a total US combat system would be of the order of 100kW greater than the power requirements of a combat system optimised for conventional submarines and would thus substantially impact on the submarine's indiscretion ratio and radius of action".[115]

[114] Patrick, Rex (2011), "Combat Systems: Selection for SEA 1000", *Asia Pacific Defence Reporter*, October, page 42.
[115] Patrick, Rex (2012), "The Senate and SEA 1000", *Asia Pacific Defence Reporter*, October, pages 27-28.

Heavyweight torpedo

If the principal role of the submarine in wartime is sinking ships, the torpedo is its main offensive weapon. Torpedoes are much more effective than anti-ship missiles in this role and also in sinking other submarines. Although torpedoes have a long history, they have always incorporated contemporary advanced technologies that often lacked reliability. Both US and German submarines suffered badly from unreliable torpedoes in the early years of World War II.

All torpedoes exhibit technical risks. Apart from the incident when a North Korean submarine is believed to have torpedoed a South Korean corvette, the only time a submarine has torpedoed and sunk a warship since the Second World War was in May 1982, when the British nuclear attack submarine HMS *Conqueror* engaged the large, 1938 vintage cruiser, the ARA *General Belgrano*. Interestingly, the *Conqueror* carried the latest, high technology wire-guided British torpedoes, the Tigerfish, introduced in 1979, but *Conqueror*'s captain elected not to use them because of concerns about their reliability. Instead he chose the relatively primitive Mark VIII torpedo, introduced into Royal Navy service in 1927. He scored two hits at close range with catastrophic results for the old warship and its crew.

At the same time as the AN/BYG-1 combat system was specified for the FSM, the American Mk 48 Mod 7 CBASS torpedo was also mandated. The original Mark 48 was designed in the 1960s and the Mod7 CBASS is a variant jointly developed by the US and Australia. It is a powerful and reliable torpedo with the ability to destroy nuclear submarines at extreme depths. Yet it too is not without technical risks. For example, it uses a thermal engine, which is noisier than more recent European electrical torpedoes, meaning that the target may find it easier to detect and adopt counter measures against it. Its guidance system is linked to the submarine by a copper wire rather than the fibre optic cables used in more recent torpedoes, which allow for more extensive sonar processing aboard the submarine. It is not necessarily the ideal choice for a submarine entering service nearly two decades from now.

The argument here is not that the AN/BYG-1 combat system and the Mk 48 Mod 7 torpedo are necessarily the wrong choices for the FSM. The concern is about the process that was followed. Generally, the capability requirement should first give rise to a choice of platform (or platform designer) with systems and weapons selections taking place later. As well as performance, these selections should take account of the risks in introducing new systems to an existing platform, the familiarity of the prime contractor with the preferred systems and a holistic view of all the systems to be employed on the platform, including their power use and footprint. Another concern is the apparent assumption that because Australia had made significant investments is both these systems in the past they should be adopted for future platforms. Defence needs to be aware of sunk costs in making decisions of this kind. If other systems and weapons would provide superior outcomes, there is little justification for choosing legacy equipment on the basis of previous investments.

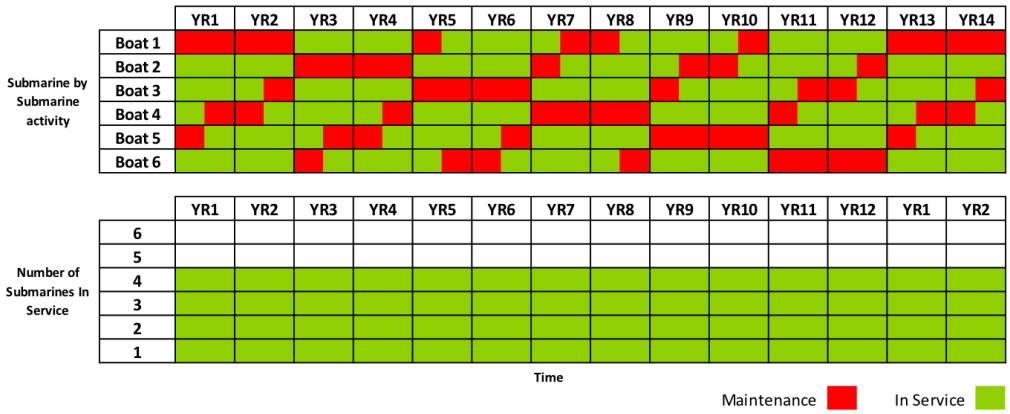
An important area of risk around these systems is the extent to which the US will allow French nationals access to the source codes and other data required to integrate American systems with French sonars and other systems. Despite the US seemingly having endorsed the Australian choice of a French

submarine, we cannot know how these issues will be resolved in the longer term.

6.7 *Collins* class life of type extension (LOTE)

The significant slippage in the schedule for delivering the FSM means that the life of the *Collins* class boats will need to be extended. The submarines were originally designed for a thirty-year life, suggesting that the oldest boat, HMAS *Collins*, would be retired in 2024. The intention is for the upgrades to occur in coordination with the relatively new 10 years plus two Usage and Upkeep Cycle (UUC) for the *Collins* class. The schematic for the UUC, which appears to be working well, is shown in Exhibit 6.6 below.

EXHIBIT 6.6: COLLINS CLASS – THE 10+2 USAGE AND UPKEEP CYCLE



Source: Coles, John (2016),* Collins *Class Beyond Benchmark Review op. cit., page 40

If the LOTE for each boat was planned to coincide with its major refit and upgrade, known as Full Cycle Docking (FCD), it is considered that the submarines may not need to be out of service for any longer than they otherwise would be. The FCD occurs every ten years for each boat, with lower level maintenance occurring every few years in between. The objective is to maintain four boats in service at any time with the other two in long-term maintenance and upgrade. Of the four boats in service, one is in short-term maintenance.

Although the LOTE programme will be required if a severe capability gap is to be avoided, there are some serious risks involved. First, there is a risk that, as with the F-111s, a life extension to the date required by Defence turns out not to be technically feasible. According to Coles, "there are a number of factors that could limit service life - e.g. fatigue, excessive hull or system corrosion for the pressure hull or systems and hull forgings, cable disintegration through heat and age, high pressure air bottle safety, or other safety critical items".[116]

The Coles review examined life extensions of submarines to 35 and even 40 years (Exhibit 6.7). In Australia's case, we need to consider how long a service life is feasible, given the number of advanced submarines that will be active in this region in the 2020s and 2030s. In terms of Exhibit 6.7, the fact that Chile plans to extend the life of its Type 209 submarines to over forty years has no relevance to Australia's situation. South American countries do

[116] *Ibid,* page 97.

not face a similar strategic threat to Australia and their navies typically retain ships in service long after they would be decommissioned elsewhere -- the ARA *General Belgrano* was 44 years old when she was sunk. Notably, the only country in our region that appears in Exhibit 6.7 is Singapore and that nation is acquiring more advanced submarines to complement the Swedish boats they are upgrading. In the case of the other countries except for Canada, they are all acquiring new submarines well within the timeframe for life extension of the other classes. The latter may well be used for minor operations or for training.

EXHIBIT 6.7: PLANNED LIFE EXTENSIONS OF SSKS

Country/Class	Surfaced Displacement	Planned Withdrawal Date	Forecast Life	Comments
Canada Victoria Class	2400 tonnes	PWD from 2030 onwards	40+ years with 6-18 year life extension	Note 7-10 year gap between UK and Canadian ownership Long range
Netherlands Walrus Class	2400 tonnes	PWD mid to late 2020s	35+ years	Long range
Chile Thomson Class Type 209	1800 tonnes	PWD mid-2020s	40+ years	Coastal
Sweden Gotland Class	1500 tonnes	PWD 2030s	35+ years	AIP, mid-life upgrade, modernisation Same family, age as Collins
Singapore Sodermanland Class - formerly Swedish Vastergotland	1200 tonnes	PWD early 2020s	32+ years	Same family as Collins New capability section inserted Tropicalised and modernised
Ula Class, Norway	1000 tonnes	PWD early 2020s	30-35 years	Coastal Tropicalised and modernised

Source: Coles, John (2016),* Collins *Class Beyond Benchmark Review op. cit., page 91.

These countries do not face the same strategic situation as Australia. By the 2030s half the world's submarines will be operating in the Asian region and these will mainly be modern boats with very advanced systems. In 2040, HMAS *Collins* will be 44 years old and the youngest of the class, HMAS *Rankin* will be pushing 40. We would challenge the comment in the Coles review that these will still be 'regionally superior' submarines by the 2030s; at the very least, without AIP their indiscretion ratio will be non-competitive and will leave them open to detection by what will be greatly improved sensors at that time. At worst, there is a material probability that, like the F-111, the platform will have aged to the extent as to not be capable of operations through the 2030s and beyond.

This is clearly the view of James Harrap, a former captain of *Collins* class submarines:

> Some components of the submarine are either not able to be changed or to do so would carry a prohibitive mix of risk and cost. The *Collins* class has many components that we are simply stuck with for the life of the platform. For example the diesel generators fit into this category because of their size; unfortunately they are quite possibly the least reliable diesel engines ever built. They have been problematic

> throughout the life of the class and, despite some design modifications and improvements, are only kept running by ingenuity and sheer determination of the crews at sea and supporting contractors alongside. Because of components and immutable design issues such as these, *Collins* has a finite service life.
>
> There is also a component of 'technology pull' that limits the effective life of any submarine platform. To extend the earlier analogy: it would be impossible to win next year's grand prix in a 20 year old car - no matter how good the driver and support team are. HMAS *Collins* when first launched was hailed as being ahead of its time; I don't entirely agree with that, but it was the vanguard of a new generation of submarine design. That was in the early 1990s. Since then numerous advances have occurred in batteries, electric motors, air-independent propulsion, sonars and electro-optics – all of which have revolutionised submarine design even further. These changes have been significant and whilst it may be possible (though very costly) to keep *Collins* operational for another decade or more, most advances can't be retrofitted and the boat will most likely be so technically obsolete by 2022 that the credibility of the capability it offers will be seriously eroded.[117]

In its submission to the 2009 Defence White Paper, the Submarine Institute of Australia (SIA) noted that "by 2025 HMAS *Collins* will be 30 years old and obsolete. If we are to avoid a critical capability gap, the future underwater warfare capability must be operational at this time." The SIA was strongly opposed to a Collins LOTE, however, as is shown in Exhibit 6.8 below.[118]

EXHIBIT 6.8: PROBLEMS WITH A COLLINS CLASS LOTE

"Similar to the *Oberon* experience at this time of life, it will not be cost- effective to sustain or replace ageing/obsolescent systems, nor is it an option to extend *Collins*, since:

- The capability gap between the 1987 specification and contemporary needs is increasing
- The *Collins* class currently lacks any design margins (space, ship stability, power, cooling etc) to sustain significant capability enhancements to meet the increasingly demanding environment and new requirements
- It is possible to achieve additional capacity by cutting the submarine and installing an additional length or 'plug', for example to provide air independent propulsion. Ship systems providing support such as power and cooling would also require upgrading. Such measures would still not achieve the full range of capabilities necessary to achieve the outcomes set out in the first part of this paper
- The ageing platform and its fundamental systems will become a demanding and expensive vehicle to continue to operate
- There is an increasing risk of major failures that would be costly and or time consuming to rectify; major defects will occur without warning, with compounding effects on availability, long term planning, bad press and recruitment and retention
- The application of new and up to date safety requirements will be difficult in an asset designed in the 1980s
- A life extension program is therefore likely to be a poor return on investment
- The attraction of this option to the bureaucrat, as a means of delaying a difficult decision should be resisted: it is a distraction and will result in a serious capability gap.

Source: Submarine Institute of Australia, Submission to Defence White Paper, op. cit, page 29

In March 2016, Defence announced that because of the delay in commissioning new submarines, all six of the *Collins* class boats would receive an upgrade of some kind. According to the ABC:

[117] Harrap, James (2012), *op. cit.*

[118] Submarine Institute of Australia (2008), Submission to 2009 White Paper,

> Head of Navy Capability Rear Admiral Jonathan Mead said while one or two of the current *Collins* Class submarines were expected to have substantial reworking, all six in the fleet would need to receive some form of upgrading. "[It is] to do with communications and sonars. [We are] aiming to get that submarine through — not just from a whole perspective, but a capabilities perspective — through into the 2030s," he said.[119]

Our understanding is that the *Collins* class will be upgraded in the near future with new sensors and an updated communications suite. This is clearly necessary and may cost around $3 billion. But such an upgrade alone will not allow *Collins* to operate safely into the 2030s. We understand that a much more comprehensive LOTE is also proposed, at a cost of up to $15 billion. We are advised that such a LOTE would not include AIP, Lithium-Ion batteries or even new diesels. There is also a significant possibility that the LOTE will not be effective. The experience with the FFG LOTE demonstrates the high risk of trying to upgrade platforms designed in the 1970s and 1980s. It is very difficult to integrate modern systems with old platforms and other systems that were installed long before open architecture became common.

In terms of filling a capability gap until the Shortfin Barracuda is commissioned in comparable numbers to the *Collins* class, therefore, there is a very high risk that this will not be technically possible. Although the first new submarine is due to enter service in 2032-33, Defence needs to allow for the probability that the programme is delivered at least five years late – typical of complex, developmental military projects around the world and particularly, noting Russia's problems with the Lada class and Spain's with the S-80, of new submarines. It is not reasonable to expect any *Collins* class submarine, refurbished or not, to be still able to be sent on operations by 2040 and probably not after 2030-2035. At the very least, the ADF's duty of care to its service personnel should not allow this to happen. The technical and operational risks will be just too high.

6.8 Implications

Most new submarines entering service with the world's navies are evolutionary designs, based on the preceding class. The technical risks of designing and building an *ab initio* submarine have always been high, but perhaps today, with the increased complexity of platforms and systems, they are higher than ever. For example, Russia has an excellent record in designing and building submarines. Yet Russia's attempt to produce a 'fourth generation' SSK, the Lada class, saw three submarines laid down between 1997 and 2006 of which none is yet in operational service due to extensive technical problems.

The technical risks inherent in the selection of a developmental design are magnified by what has been described as an 'engineering crisis' in the RAN. Although it would be unfair to describe today's navy as 'technically bankrupt', there is still a significant shortfall in engineering expertise. This has implications not only for the CEP that delivered the Shortfin Barracuda but also for the testing and evaluation of its design. Also, the establishment of a comprehensive T&E process for the FSM will take time and the slow progress to date in establishing land-based testing sites, including for cyber

[119] Greene, Andrew (2016), http://www.abc.net.au/news/2016-03-01/collins-class-submarine-life-to-be-extended/7212532

security, may well become a further element in pushing out the project's completion date.

The technical risks of a bespoke design are magnified by the government's choice of a very large platform. At over 5000 tonnes submerged, the Shortfin Barracuda will be a behemoth among the world's SSKs and twice the size of France's current SSN, the *Rubis* class. The implications of this include the greatly increased power required to drive it through the water at an acceptable speed, its manoeuvrability and, coupled with a power-hungry combat system, its ability to accommodate the weight of AIP. Most importantly, its sheer bulk means it will be easier to detect than a smaller submarine and, without the benefit of the Barracuda's nuclear reactor, will lack the ability to escape from danger at high speed.

The safety aspect is further clouded by the probability that the Shortfin Barracuda will deploy neither AIP nor modern battery technologies. It will have an indiscretion ratio that will be unacceptably high, particularly in the 2030s and 2040s when detection systems will have improved substantially. Even now, China is reported to be deploying helicopters that can detect a Snort mast at up to 70 kms. Whatever else the Shortfin Barracuda may be, it will not be a regionally superior submarine.

Past experience with new developmental platforms in Australia and overseas suggest that, apart from their costs blowing out, they are almost always delivered late. On the evidence of this and other similar programmes it is quite possible, even probable, that by 2040 Australia may have only one new submarine in commission. Under an only slightly more pessimistic scenario, we will have none. There is also a material risk that the capability delivered by the new boat will not exceed what could have been achieved, much more expeditiously and at significantly lesser cost, from an evolved *Collins* submarine or a MOTS acquisition.

Remembering that the original objective of the 2009 White Paper was to have 12 new submarines in commission by the early 2030s, this has substantial implications for the planned life extension of the *Collins* class. Because of limitations in the existing platform this will not be able to include desirable features such as AIP and perhaps even new diesels. As Australia discovered with the F-111, there are significant technical barriers to maintaining a sophisticated military platform in service long beyond its planned use-by date. The experience with the FFG upgrades also reinforces this point. It seems very difficult to contemplate sending even a life-extended *Collins* class submarine into harm's way in the 2030s, particularly in waters that will then be both teeming with advanced nuclear and conventional submarines and playing host to very sophisticated ASW sensors and weapons. From a technical perspective, the risk of a disastrous capability gap is unacceptably high.

CHAPTER 7
Industrial risks

"I wouldn't trust them [ASC] to build a canoe."
David Johnston, Australian Minister for Defence.

7.1 Background

The 2016 Defence White Paper made much of the government's new naval shipbuilding policy. It announced that nine future frigates and twelve offshore patrol vessels would be built in Australia. In order to maintain a work flow to the shipyards, there would also be a continuous build policy, which could result in naval platforms potentially being disposed of before the end of their economic lives.

Interestingly, the White Paper, published about a month before the results of the CEP were announced, was much less prescriptive about building the future submarine in Australia. It clearly stated that the extent of Australian industry involvement in the FSM project would be dependent on value for money: "the Government has already committed to maximising Australian industry involvement in the submarine program, without compromising cost, capability, schedule or risk". [120] In addition, it was made clear that the early retirement policy would not apply to the *Collins* class submarines, with the boats being expected to perform in the front line long after the end of their designed lives.

Yet, in April 2016, just after the government announced that Naval Group had been selected as the design partner for the FSM, there was an outburst of political to-ing and fro-ing about where the submarines would be built. It seemed evident that this critically important element in the acquisition process had played very little part in Defence's evaluation of the CEP process. While Defence had examined the three options (local build, overseas build or hybrid), we understand that it made no recommendation to Ministers on this critical matter. When the winner was announced, President Hollande announced that 4,000 jobs would be created in France while his Defence Minister, Jean-Yves le Drian, said on TV that the first two submarines would be built in Cherbourg. Yet almost immediately afterwards the Australian government stated that at least some of the submarines would be built in Australia, a statement that was immediately followed by an announcement by Christopher Pyne, the Minister for Defence Industry and a South Australian MP, that the boats would all be built in Australia, or, more precisely, in Adelaide.

All of a sudden, therefore, just one month after the White Paper was published, one of the key policy statements regarding the FSM acquisition was no longer in force. The decision to build all the new submarines in Australia was made with no assurance that this could be achieved "without compromising capability, cost or the project schedule" as the White paper required. The industry that a couple of years previously could not be trusted

[120] Australian Government (2016), *Defence White Paper*, op. cit, page 92.

to "build a canoe" was now placed at the cutting edge of the new drive for innovation, which in turn would fuel 'jobs and growth'.

Almost incredibly, the question of which of the three contenders was most likely to build the submarines cost-effectively in Australia appears to have played no part in the government's decision in favour of Naval Group in the CEP. The RAND Corporation had already estimated that naval shipbuilding costs in Australia were 30 to 40 per cent higher than the international benchmark. Yet the German contender, tkMS, had a plan for building the ships in Australia, on a fixed price contract, at the same price as in Kiel, and involving the transfer of digital build technology that should have helped avoid many of the difficulties experienced on the AWD programme. At the very least, before being selected as the FSM partner, Naval Group should have been required to propose a competitive plan for Australian construction.

Not for the first time in the CEP process, the value for money criterion was nowhere to be seen. Unfortunately for good administration, the government would soon be facing an election, the opposition was promising that any defence asset that moved would be built in Australia and several government seats in South Australia were at risk, including the seat of Sturt, represented by the Minister for Defence Industry himself. The decision to build the submarines in Australia was essentially a political one; the interests of the Navy and the taxpayer were subordinated to the political interests of Ministers. The risks to an already highly risky decision to design and build an *ab initio* submarine had now increased substantially.

7.2 Benefits of a local build: myths and reality

There are a great many myths about the economic and defence benefits to be derived from building military platforms in Australia. These stories are generally propagated by those with a vested interest, such as politicians and representatives of the military industrial complex. In terms of the community's economic welfare and its security in defence terms, the issue is rather more complicated.

Economic benefits

Any major investment gives rise to the creation of jobs, both directly in the company that benefits from the investment and indirectly in entities that supply goods and services to it. But some of these jobs will be drawn from other industries. Other things being equal, if this capital expenditure gives rise to a net increase in aggregate investment in the economy as a whole the economic welfare of the community is likely to increase.

When government assistance is added to the mix, the story is different. For much of the twentieth century, Australia's manufacturing industry was highly protected from international competition, mainly by means of import tariffs. This led to a misallocation of productive resources in the economy, with the protected industries able to bid up wages and returns to capital and thereby attract labour and capital away from more efficient activities that did not need protection in order to be profitable. High levels of industry assistance reduced the incentives for technological advancement in the protected industries, since they were not subject to a high level of competition from overseas.

In the 20 years from 1983, Australian governments of both political persuasions pursued a policy of reducing protection and opening up the Australian economy to global competition. It is no coincidence that Australia's economic performance improved significantly and, as a consequence of both greatly increased industry competitiveness and the resources boom the community's wealth climbed to previously unprecedented levels (Exhibit 7.1).

EXHIBIT 7.1: MOTOR CARS AND WARSHIPS – A CASE OF SCHIZOPHRENIA?

Since the Liberal – National Coalition came to power in 2013, it has been difficult to understand the direction of industry policy. At first it seemed that the government was going to be even more hairy-chested than the Hawke, Keating and Howard governments when it came to industry protection. The Treasurer declared an end to the 'age of entitlement', whatever that may have been, and then proceeded to dare the motor vehicle industry to exit manufacturing in Australia, a challenge that was swiftly taken up. This was a world first; most governments around the world would give their eye teeth to be able to attract companies like General Motors and Toyota to undertake high end manufacturing in their country, and once they had attracted the investment they would do whatever it takes to retain it. True the car industry was struggling at the time, but with an exchange rate driven up to above parity with the US dollar during the resources boom, this was to be expected. With the boom ending and the exchange rate likely to fall significantly, the industry could be expected to regain its competitiveness and contribute to the necessary adjustment away from the resources sector. The benefits of the industry were also clear; directly and indirectly it provided about 200,000 jobs and it brought a high level of engineering and technological competencies to Australian industry. Better still, after years of blood, sweat and tears, the level of protection to the industry had fallen to a very low level by international standards, with an effective rate of assistance (assistance to value added) of only eight per cent. Time, surely, to enjoy the 'broad, sunlit uplands'? But the Treasurer thought not.

Initially at least, the Abbott government was consistent in its treatment of manufacturing industry. In the wake of its performance building air warfare destroyers, which required an effective rate of assistance of over 300 per cent, the naval shipbuilding industry could not be "trusted to build a canoe". Confronting a need to acquire new submarines, Tony Abbott swiftly sealed an informal deal with Prime Minister Abe to acquire *Sōryū* class submarines off-the-shelf from Japan. But all of a sudden political considerations intervened. The age of entitlement was back on its feet, seemingly in ruder health than ever. Suddenly Adelaide was clearly a better place to build submarines than Kobe, but the government would not reveal at what cost. Bravely, the rationalists held out for a while. The White Paper stated in March 2016 that acquisition policy would "seek to achieve the best value for money" while giving consideration to "opportunities to maximise internationally competitive Australian industry involvement". The CEP report the following month reportedly was agnostic as to where the submarines should be built. Yet within two days of the CEP decision, much to the surprise of many, particularly Naval Group, it was decided: all twelve submarines would be built in Adelaide. There was no mention of cost or schedule or tedious considerations such as value for money. It was all about 'jobs and growth' and innovation. Yet compared with the vast number of jobs throughout the economy sustained by the automobile industry, the Defence Minister's estimate was something of a damp squib, with the FSM project giving rise to "1,100 jobs in the shipbuilding process, potentially 750 jobs in the supply chain". The cost per job just in terms of subsidy must be massive both in absolute terms and when compared to the automotive industry.

It is difficult to understand the government's philosophical justification (if indeed there is one) for the difference in treatment between motor cars and warships. Admittedly well before he became the Prime Minister who presided over the FSM decision, Malcolm Turnbull said in 2012: "After all today, the Liberal Party is thoroughly committed to free trade. And yet while high tariffs are a thing of the past, we still spend billions supporting Australian industries with little analysis or understanding of its costs – politicians "save jobs" without any debate about how many other jobs are lost because of the public resources diverted."[121]

Source: Insight Economics

[121] Turnbull, Malcolm (2012), Media Release, https://www.malcolmturnbull.com.au/media/book-launch-the-modest-member-the-life-times-of-bert-kelly

At that time, the Hawke government created a naval shipbuilding industry that was internationally competitive. The ten *Anzac* frigates were built on time and on budget, at approximately the same cost as it would have cost to build them in Germany. The problems with the *Collins* class submarines had little to do with the construction process and more with significant design faults due to, *inter alia*, lack of timely T&E before production. The level of protection provided to these two projects was very low and literally thousands of Australian companies in the supply chain benefited from them, not merely by supplying goods and services but in developing new competencies. The *Anzacs* achieved local content of over 80 per cent and the *Collins* class over 70 per cent, on an internationally competitive basis. Consequently, economic benefits did flow from these two projects to the Australian community as a whole.

By contrast, the air warfare destroyer (AWD) project has not provided net benefits to the Australian community. Not only, as the Finance Minister has said, have the destroyers cost three times as much as a MOTS overseas acquisition, but they have had a very low level of Australian industry content, probably less than 30 per cent. Their effective rate of assistance (that is, assistance to Australian value added) would be in the region of 300 per cent, an immense subsidy and far higher than that provided to the motor car and textiles, clothing and footwear industries at the height of Australia's protectionist indulgence. The community would have been better off in economic terms if the AWDs had been built overseas and if the skilled labour resources and the capital used to build them had been employed in more efficient Australian industries.

The government has announced, however, that the naval shipbuilding industry will play an increasing role in Australia's industrial development and the Minister for Defence Industry has painted an optimistic picture of Australia becoming an exporter of warships.

It is also important to note that whatever the naval shipbuilding industry will be in terms of technology transfer and innovation, it can never be the major generator of jobs that some would have us believe. The government's Naval Shipbuilding Plan suggests that by the late 2020s, a total of around 15,000 people will be employed in the industry, including jobs created in the supply chain.[122] However, many of these jobs will be in sustainment, which would have occurred anyway even if the ships had been acquired overseas. If we consider only the acquisition side, with a budget of nearly $90 billion for the three major naval shipbuilding projects, only around 9,000 jobs will be created (and this includes a generous assumption that all the jobs created in the supply chain are allocated to acquisition rather than sustainment). The impact of naval shipbuilding on employment, therefore, pales into insignificance besides the employment generator that was the motor car industry.

The implication of this discussion is that there are minimal net economic benefits from building naval vessels in Australia unless it can be done in a cost-effective way. The RAND studies, commissioned by Defence, suggest a cost disadvantage of between 30 and 40 per cent (it seems to have been much higher for the AWDs). This is quite unacceptable and unless the cost penalty can be reduced to an acceptable level the government should rethink

[122] Australian government (2017), *Naval Shipbuilding Plan*, op. cit., page 68.

its commitment to the local industry. Any subsidy to the industry, delivered in the form of a higher acquisition cost, should be no more than about five per cent, which is the prevailing tariff on manufactured goods imported to Australia, or, at the most, 10 per cent.

Defence benefits

The supposed defence benefits arising from the local production of military platforms are frequently cited as a reason for paying an excessive price for them. This argument is predominantly a hollow one.

Australia has a doctrine of self-reliance in terms of its defence platforms and systems. It is important not to confuse self-reliance with self-sufficiency. Self-reliance means that Australia has the sovereign capability to sustain defence assets in-country, to undertake upgrades when required and to repair damage and return them to operational availability as quickly and efficiently as possible. As an example of this, the *Oberon* class were the first submarines operated by the RAN for fifty years and were built in Scotland. Yet Australian industry was able to undertake a highly efficient mid-life upgrade, arguably elevating their capability beyond that of their sisters in the Royal Navy.

Similar arguments apply to RAAF and Army assets. Australia no longer builds any of the fixed wing aircraft employed by the RAAF, nor do we construct Abrams tanks. But we sustain them in-country efficiently, particularly now that we have outsourced much of the work from the ADF to industry. We do build armoured personnel carriers in Australia, but this appears to be an efficient operation and generates some exports.

The arguments for building naval platforms in Australia are superficially attractive, but this is because of the confusion between self-reliance and self-sufficiency. For example, while we have built the AWDs in country, they have a very low Australian content. Many of the critical components are imported including:

- Engines
- Propellers and rudders
- Aegis command, combat and communications system
- All radar systems
- All sonar systems
- Electrical systems
- 5-inch gun
- SM-2 missile system
- ESSM missile system
- Harpoon missile system
- Tomahawk missile system (if fitted)
- Vertical launch systems

The AWDs would be useless without these systems and assemblies and so, in Defence terms, what is the benefit of assembling the platforms in Australia if it cannot be done efficiently?

The other critically important point, from the national security perspective, is that it is all very well spending 2 per cent of GDP on defence, but it makes

no sense to do this if you could get the same 'bang for the buck' by importing the platforms for a much lesser cost. This could mean spending say, only 1.7 per cent of GDP on defence and spending the extra 0.3 per cent of GDP on health and education. On the other hand, if Australia continued to spend 2 per cent of GDP on defence but acquired platforms at internationally competitive costs, the ADF would enjoy a substantially greater capability.

In this context, it makes no sense to spend $10 billion or so on building three small AWDs when for the same cost the Navy could have acquired five much larger and far more capable *Arleigh Burke* class ships from the US and commissioned them several years earlier. The saving, in fact, would have been more than this for two reasons. First, the size of the *Arleigh Burke* platform means it is readily upgradable in many ways that the Spanish F-100 design is not and thereby providing a greater capability in the future. Secondly, if the *Arleigh Burke* route had been followed it may not have been necessary to attempt the highly risky and largely unsuccessful upgrade of the FFG-7 frigates. This alone would have saved $1.6 billion.

There is another important point here relating to the welfare of RAN personnel. The fact that the AWDs will be delivered at least three years late means that Australian sailors will continue to serve in obsolete ships rated as being fit for operations only at low to medium level threat levels.

Overall, therefore, if defence platforms cannot be built in Australia in an efficient and effective way, there is no significant Defence argument in favour of local construction. This particularly so when Australia's strategic circumstances are more threatening than in the past. The President of the Washington-based International Strategic Studies Association said in May 2017 that Australians should feel "outraged to the point of revolution" that it cost three times more to build a submarine in Adelaide than in Japan or Europe.[123]

There is one caveat to this analysis. Where Australia sees fit to acquire a unique platform for which it has parent navy responsibilities there may be some benefit in local construction from a sustainment and cyber security perspective. The *Collins* class, for example, contains a number of bespoke components. If these had been acquired from overseas in the first place, with a low production requirement it is likely that they would become unobtainable long before the platform reached the end of its life. If such components can be produced in Australia this at least provides some safeguards for future sustainment and cyber security, although, of course, companies can exit manufacturing industries just as readily in Australia as overseas.

A better way is probably to extend production runs of bespoke components so as to stockpile a sufficient inventory for through life sustainment, although this is unlikely to work for any software-intensive componentry or architecture. It is also less critical if a rolling design acquisition and sustainment approach gives a comparatively short submarine life of say 18 years.

[123] Walker, James (2017), "The world is sleepwalking to war, Admiral Chris Barrie warns", *The Australian*, 22 May, http://www.theaustralian.com.au/national-affairs/defence/australia-is-sleepwalking-to-war-admiral-chris-barrie-warns/news-story/96c762fca72da26a34a909d12239a1c6

7.3 Naval shipbuilding – lessons learned or not

Australia has a history of naval shipbuilding that extends for over 100 years, with HMAS *Warrego* being delivered to the newly formed RAN in 1912. At least in terms of larger ships, however, the story is mainly one of significant underperformance, with high costs and lengthy delivery periods.

For example, just after World War II the government ordered four (later three) *Daring* class destroyers from Australian shipyards. This was a MOTS design from the UK, where the ships took around three to four years to build at a unit cost (converted to Australian pounds) of £2.6 million.[124] The three Australian ships, then the largest and most powerful destroyers ever operated by the RAN, were delivered years late, taking between seven and nine years to build, with a significant blow-out in the cost per ship to £7 million, or well over twice the cost of a MOTS acquisition from the UK.[125]

Probably nobody currently working in Defence was there sixty years ago or they would have a strong sense of *déjà vu*. The three AWDs currently being completed in Adelaide, to be the largest and most powerful destroyers ever operated by the RAN, will be delivered years late and way over their already excessive budget, with a cost well over twice that of a MOTS acquisition from Spain.

This is ironic, if not tragic, because less than two decades ago the Australian government, at last, had created an efficient and internationally competitive naval shipbuilding industry. In a period of about fifteen years from the late 1980s, with three large vessel projects (two FFG-7 frigates, ten *Anzac* frigates and six *Collins* class submarines), the industry performed at a very high standard in global terms. While delivering ships and submarines at prices comparable to an overseas build, they also achieved high levels of Australian industry content in at least two of the projects, with around 80 per cent for the *Anzacs* and 70 per cent for the *Collins* class (excluding the combat system).

Although the construction task was undertaken to a high standard, particularly in a country that had never built a submarine before, overall the *Collins* class project was less successful than the *Anzac* frigates. Some reasons for this are:

- The design of the submarines was essentially *ab initio*, while the frigates were based on a MOTS design
- The submarine was a considerably more complex platform than the frigate and there was a comparatively poor test and evaluation regime[126]
- There were substantial design problems with the original combat system, which was over-ambitious and never worked, and ASC was tasked with oversighting its integration with the platform without being privy to its more sensitive technical specifications

[124] Blackman, Raymond (1962), *Jane's Fighting Ships,* 1961-62, page 256.

[125] Wikipedia, https://en.wikipedia.org/wiki/Daring-class_destroyer_(1949)

[126] ANAO (Australian National Audit Office). 2002. Audit Report No. 30: 2001–02 Test and Evaluation of Major Defence Equipment Acquisitions. Canberra: ANAO; RAND Corporation. 2011. Learning from Experience, Volume IV – Lessons from Australia's Collins Class Submarine Program. Santa Monica, CA: RAND Corporation on Behalf of Australian Department of Defence. www.dtic.mil/dtic/tr/fulltext/u2/a552686.pdf.

- The ownership of IP increasingly became a major issue with the *Collins* class and this was not the case with the *Anzacs*
- There was poor quality control by some of the sub-contractors, for example with welding undertaken in Sweden and the component that later caused dangerous flooding on HMAS *Dechaineux*.[127]

Lessons from Anzac *and* Collins *projects*

The lessons from the *Anzac* and *Collins* projects seem fairly clear to an outside observer. Unfortunately, governments have failed to draw similar conclusions.

The first lesson was that these programmes were undertaken by privately-owned contractors rather than the government-owned shipyards that had built earlier warships so inefficiently. Although the government had a stake in ASC, the Prime for the frigates, Amecon, later Transfield and then Tenix, was wholly privately owned. As industrial organisation theory would suggest, the companies, being profit maximisers, recruited highly qualified managers with a strong engineering background and built up a very well trained workforce. There was also a strong focus on industrial relations, which had bedevilled previous performance in the industry. There was also never any doubt as that accountability for performance lay with the contractor.

Secondly, the Australian economy in general and the budget in particularly were not in great shape at this time; consequently the government placed great emphasis on value for money in both these acquisitions.

Thirdly, both projects were based on fixed-price contracts. This meant that the risks lay with the contractor rather than with Defence. On Defence's part, it also meant that any changes to the design during the course of the project were extremely difficult to make. This caused some resentment. The only substantial change to the *Anzac* design, for example, was to substitute a 5-inch gun for the original 3-inch at additional cost.

Fourthly, in both projects the Prime was committed to involving Australian industry to the maximum extent that was consistent with a cost-effective outcome. They developed mutually beneficial close and productive relationships with a large number of sub-contractors in both Australia and, in the Anzac project at least, New Zealand.

Fifthly, each project involved the construction of a significant number of vessels to be integrated in one shipyard per project. Particularly in the case of the *Anzac* frigates, with ten ships, this allowed unit costs to fall significantly through the course of the project as economies of scale and learning curve benefits were exploited.

Finally, in both cases there was a good cultural fit between the Prime and the overseas designers, Blohm & Voss and Kockums, with clear and detailed blueprints available for both the frigate and the submarine.

Lessons ignored: the AWD project

It still seems extraordinary that in commissioning the local acquisition of three AWDs in 2006, which followed on almost immediately from the Anzac project, the Howard government ignored all these lessons and returned to

[127] Ohff, Hans J (2015), "Caveat Emptor", Address to SIA Conference, November.

the flawed public ownership model and what was effectively a cost plus contract. In terms of the five success factors identified above:

- Rather than awarding the AWD contract to Tenix, which could have retained its management, highly experienced workforce and supply chain at the end of the *Anzac* project, the contract was awarded to a recently nationalised ASC, which had never built a surface ship and had to recruit a new workforce and supply chain.
- There was no obvious emphasis on value for money in the acquisition, with the original budget for the project being far higher than the cost of acquiring the capability on a MOTS basis from overseas.
- Instead of a fixed-price contract for the acquisition, the government opted for an 'alliance' based approach between ASC, the DMO and Raytheon, with no obvious accountability for cost and schedule overruns.
- Extraordinarily, the ship designer, Navantia, was excluded from the Alliance
- The strong focus on developing a substantial network of trusted suppliers on the Anzac project was discarded and Australian content on the AWDs fell from over 80 per cent to around 30 per cent.
- With only three ships to be constructed, the availability of economies of scale and learning curve benefits was extremely low; it would have made more sense to acquire the capability on a MOTS basis from Spain or the US.
- There was a poor cultural fit between the designer, Navantia and the shipbuilder, with no 3D CAD blueprints but rather a series of 2D drawings in Spanish that turned out not always to be accurate.

Hugh White has compared the AWD approach to that of the Anzac frigates:

> The ANZAC project involved stringent competition, with an exhaustive, competitive Project Definition phase between teams of designers and builders leading to fully-detailed tenders for a fixed price contract to a prime contractor solely responsible for delivering the agreed product at the contract price. Compare this with the AWDs, where the builder was selected before the design, the design was selected before it was fully developed, and responsibility for delivery was entrusted to a committee with no one clearly in charge, and almost all the risks falling on the Commonwealth. That's why it's gone pear-shaped.[128]

Why did a conservative government adopt such a *dirigiste* approach and put at risk a nascent efficient naval shipbuilding industry? There are a number of reasons. Politics played a large part, as it did in the Hawke government's puzzling decision to establish a submarine capability in Adelaide, which had no tradition of shipbuilding and no significant potential supply chain. In 2006, a large number of Ministers on the National Security Committee of Cabinet who made the decision on the AWDs were South Australians. Another reason was that Defence considered there was only room for one shipbuilder in Australia and that the activity should be consolidated in South Australia. There was also a belief that the problems around IP that were

[128] White, Hugh (2015), "Naval shipbuilding in Australia: a strategic necessity?", *The Strategist*, ASPI, 31 August, https://www.aspistrategist.org.au/naval-shipbuilding-in-australia-a-strategic-necessity/

becoming apparent with the *Collins* class could best be resolved by government ownership.

Furthermore, the Navy did not have a high regard for the *Anzac* frigates as delivered. They were frustrated at their inability to intervene so as to upgrade the frigates during the course of the project. Long regarded as the only truly successful naval shipbuilding project for significant warships in Australia's history, the story is now being re-written so that the project is regarded as unsuccessful because the RAN believed the capability of the ships to be lacking. This ignores the budgetary stringency at the time. The Navy was able to procure eight ships only on the basis they would be built 'for but not with' advanced capabilities, with the understanding these would be retrofitted later. This has occurred, and now, with multiple channels of fire and the ability to shoot down supersonic sea-skimming missiles, the ships are among the most potent frigates of their size in the world.

Finally, the early days of Defence policy in the Howard government were shaped by the difficulties in the *Collins* programme, borrowing of US ships for aspects of the East Timor operations, and politically by an Opposition led by the ex-Defence Minister who was forced into defending *Collins*. As a consequence, there was a focus on getting bigger ships (i.e., LHD & AWD) cheaply by leveraging what was believed to be MOTS platforms.

7.4 Building the Shortfin Barracuda

In May 2017, the Prime Minister and Minister for Defence released a Naval Shipbuilding Plan for constructing the future submarines, future frigates and offshore patrol vessels (OPVs) worth in excess of $90 billion. *Inter alia*, the Plan will involve an investment by the government of around $1.3 billion in new construction facilities, mainly at Osborne (Adelaide) for the FSM and future frigate projects. The government had previously commissioned, in December 2016, a Centre for Defence Industry Capability in Adelaide that is tasked with developing industry supply chains for the industry. The Plan suggests that this will be funded to the tune of around $250 million in the first instance. In terms of innovation, the government has established the Next Generation Technologies Fund, with a budget allocation of $730 million to 2026.

The Prime contractor

As stated above, the Naval Shipbuilding Plan does not provide any detail on the Prime contractor for SEA 1000. In 2016, the government split ASC into three groups: Infrastructure, Surface Ships (building and sustaining) and Submarines (building and sustaining). It makes sense for the government to retain ownership of common user infrastructure at Techport and then to lease it out to shipbuilders on a commercial basis. The key question relates to ownership of the construction and sustainment groups. Will the government continue with an alliance model, where ASC remains in public ownership, or will it privatise these groups?

Naval Group has now moved to establish a company in Australia. Recently we have heard that Naval Group has no intention of working with ASC and instead expects to 'consume' the government-owned company. Since ASC alone in Australia has any corporate memory of how to build a submarine, this decision may add to the riksks.

The contract

It is tiresome to keep returning to the *Anzac* frigates and, to a slightly lesser extent, the *Collins* class projects, but in the whole history of naval shipbuilding in Australia, they were the only major vessel construction projects that could be considered a success in terms of delivery on time and on budget.

Both these projects were based on fixed price contracts. Most of the risks were borne by the Prime contractor rather than the customer (Defence). On the other hand, if the Prime had negotiated a good contract that shared the benefits from a successful project, then the Prime would also earn a respectable rate of return. To the benefit of both the Prime and the customer, therefore, there was an overwhelming incentive for the shipbuilder to perform well.

If the government wants to discard this approach, it needs to have a very good reason to do so. The AWD project provides a clear example of the perils of alliance contracts. Defence departed from the fixed price contract model and voluntarily took on most of the risk itself, while having very little control over the shipbuilding task. It is difficult to see why any commercially savvy customer operating in the private sector would ever contemplate such a high risk approach.

The way that the government has approached SEA 1000 creates some difficulties for employing a fixed price contract. With a much greater incidence of both known unknowns and unknown unknowns, it is always difficult with an *ab initio* design to estimate the construction costs. With Naval Group establishing a wholly or partly owned Australian subsidiary, it may well refuse to sign a fixed price contract. If that is the case and some cost plus arrangement is established, the outcome could be very bad for Australia. There would be very little discipline that could be imposed on the Prime by the customer.

The supply chain

Accepting the government's decision to build the future submarines in Adelaide, it makes sense to maximise local industry content where Australian companies can deliver components at a competitive price. Particularly where Australia acquires a unique platform using bespoke components, these should be produced locally where the company concerned is internationally competitive. Where components are supplied by overseas companies on small production runs, there is no guarantee that they will be readily available in the future. In addition, any positive economic impact of the FSM project will be significantly greater if there are spin-off benefits to other Australian companies, particularly if they can expand their production into global supply chains.

Unlike the AWDs, both the *Anzac* and *Collins* projects had a high local content, with a larger proportion of the work being undertaken by suppliers than the Prime (for *Collins*, see Appendix 3). This approach provided very significant benefits for literally thousands of SMEs throughout Australia. For example, at the end of the *Anzac* project, the head of Tenix at the Williamstown shipyard advised a Senate committee that:

> The current contract value of our largest program, the Anzac ship project, is about $A7.2 billion. Of that amount, over 80 per cent was subcontracted to about 3,000 suppliers in Australia and New Zealand.

> Stated differently, almost $5.6 billion flowed into small to medium enterprises in Australia and New Zealand as a result of the government's decision to construct those ships in Williamstown. It should further be noted that many of those businesses are now exporters themselves.[129]

In terms of the value of Australian production on the *Anzac* ships, this suggests that the percentage of work undertaken by the Prime ran at around 25 per cent, with 75 per cent occurring in SMEs in the supply chain. By comparison, the very limited data that are provided in the government's recent Naval Shipbuilding Plan suggest these proportions are likely to be reversed in future projects (Exhibit 7.2).

EXHIBIT 7.2: NAVAL SHIPBUILDING – EMPLOYMENT IN MID TO LATE 2020'S

Source: Department of Defence (2017), "Naval Shipbuilding Plan", May, page 68.

Remembering that this workforce refers to the whole future naval shipbuilding programme and not just the submarine, our interpretation of Exhibit 7.2 is that only around 3,000 jobs will be created in the supply chain. We also assume that this covers both the acquisition stage and the sustainment stage thereafter. It may be, therefore, that only around 2,000 jobs will be created in the acquisition supply chain. This seems to be a very poor return in employment terms for a projected capital expenditure of nearly $90 billion on these acquisitions, and is clearly at odds with the Prime Minister's and Defence Minister's aspiration to spend 90 per cent of any Defence acquisition budget in Australia.

While disturbing, this is consistent with our discussions with industry representatives where there is a concern that there is no great commitment to maximise Australian industry content on the FSM. There is a view that, more generally, Defence is prejudiced in favour of US suppliers of equipment and is often unwilling to give local industry what they regard as a 'fair go'. Paradoxically, the plan to 'cut steel' on the future frigate and OPV projects by 2020, designed to address the 'valley of death' problem when the AWDs are completed, will have a negative effect on the ability to recruit SMEs to the supply chain for these projects. With no design yet having been selected for either project, there will be only very limited time available to understand

[129] Miller, David (2007), Senate Standing Committee on Foreign Affairs, Defence and Trade, http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Foreign%20Affairs%20Defence%20and%20Trade/Completed%20inquiries/2004-07/shipping/report/c05

the precise requirements of these projects for many thousands of components and to evaluate which Australian companies could supply these on a cost-effective basis. For software-intensive systems the chances of cyber-secure supply chains with appropriate sovereign protections being achieved in such short timeframes are very low, especially given the low levels of such expertise and testing in Australia.[130]

Meetings with Naval Group have so far left some local industry representatives underwhelmed and with concerns about the level of commitment to a high Australian content. The first CEO of Naval Group Australia suggested that the level of Australian content would be around 90 per cent, a figure that appears unlikely when compared to the 70 per cent achieved on *Collins*. At a media conference in June 2017, where the acting CEO of Naval Group Australia proposed that ASC would be "consumed by Naval Group", he also refused to commit to any particular local content level for the FSM while stating that the aim would be for a figure higher than 60 per cent.[131]

One significant issue is that it is understood that potential suppliers will need to install Dassault's proprietary digital CAD/CAM system, at a reported annual cost of around $100,000. There is no certainty that this system will be used for projects other than the FSM. The most common system in naval shipbuilding globally is the Siemens PLA Integrated Product Development and Support Environment (IPDSE), which is used in the US and UK as well as Germany and a number of other countries. In view of the contenders for the future frigate project, which will enter the construction phase much sooner than the FSM, it seems much more likely that project will be based on Siemens PLA rather than Dassault.

With the strong support of both the government and Defence, the successful *Anzac* and *Collins* shipbuilding projects were both led by Prime contractors that were committed to achieving a high level of local content. While the government is talking of achieving a higher level of local content on the current naval shipbuilding projects than was ever achieved on *Collins* and even *Anzac*, the employment numbers put forward by Defence belie this

Cultural challenges: building foreign naval platforms

Naval Group has had a patchy experience in delivering its submarines by means of constructing them in customers' shipyards overseas.

In 2005, India ordered six Scorpène class submarines, to be built in Mumbai for delivery from 2012 through to 2016 at a total cost of US$3 billion. The programme is running at least four years late, with the first submarine being commissioned into the Indian Navy in 2017. This is the first French submarine to have been delivered at an overseas facility. In 2009, Brazil ordered four Scorpène submarines, with the first laid down in Cherbourg in 2010 but to be completed in Brazil. This submarine has yet to be delivered.

[130] Alberts, C., Haller, J., Wallen, C., and Wood, C. (2017), Assessing DoD System Acquisition Supply Chain Risk Management, *Crosstalk* May/June 2017;
Joiner, K. F., (2017), How Australia can catch up to U.S. cyber resilience by understanding that cyber survivability test and evaluation drives defense investment, *Information Security Journal*: A Global Perspective, pp. 1-11, DOI: 10.1080/19393555.2017.1293198

[131] Akerman, Piers (2017), "PM Malcolm Turnbull's submarine deal will cheese us all off", *Sunday Telegraph*, 15 July

The other three boats, currently at various stages of construction in Brazil, may be completed in France.

Australian industry has assembled a number of platforms of French origin in the past. These have been mainly in the aerospace sector, where the local construction of over one hundred of the RAAF's principal fighter aircraft before the 'Classic' Hornet, the Dassault Mirage III, is the most substantial example. While this programme appears to have been successful, Joiner and Atkinson (2016) addressed the cultural challenge of the Defence acquisitions from France. In reviewing concerns on five such programmes across four decades (Mirage, two helicopters and lightweight torpedo), they stated that "points found common to all programmes were:

- Difficulties certifying the equipment in Australia due to either difficulties with release of test reports, the different standards between the countries, translation and in some instances, end-to-end explosive testing use of sub-system testing only.
- Generally low levels of environmental qualification of sub-systems, systems and platforms against vibration, shock, temperature, humidity, solar radiation, erosion, fatigue and electromagnetic environments, as well as packing, handling storage and transport of components to do in field repairs.
- A high through-life sustainment cost, in part due to the innovative designs and materials as well as limited environmental qualification."

EXHIBIT 7.3: ACQUISITION OF HMAS *SUCCESS* – CULTURAL DISHARMONIES

The 1976 Defence White Paper identified the need to develop Australia's self-reliance through investing in key industrial capacities. The local construction of the Fleet Underway Replenishment Ship, HMAS *Success,* reflected this policy.

At that time, HMAS *Success* was to be the largest ship built in Australia for the RAN. In 1977, the Government of France was awarded the design contract for $2.7 million based on the DTCN-PR *Durance* Class Ship. In October 1979, Vickers Cockatoo Dockyard Pty Ltd was awarded the construction contract for $68.4 million (in November 1978 prices) with ship delivery by 31 July 1983. In June 1983, however, the contract was renegotiated, extending the acceptance date by three years and increasing the project cost to $187.3 million (in January 1983 prices). When the vessel was finally commissioned in 1986, the total project cost was estimated at $197.41 million.

The main reason for the cost and time overrun on HMAS *Success* was a protracted dispute between the Commonwealth and the Vickers Cockatoo Dockyard Pty Ltd over the drawings and specifications contained in the 'Production Package' (PP) from the French company *Directions Techniques des Constructions Naval*. There is evidence that the Department of Defence significantly underestimated the extent of the differences between the original building specifications and the French PP. A 1983 Auditor-General's report criticised the department for failing to ensure that the French company had the PP needed for an Australian build.

On the other hand, Defence argued that the builder had deliberately underestimated the value of its original contract price in order to recover the costs from a significantly more expensive design package.

Source: Senate Foreign Affairs, Defence and Trade Committee (2006), "Blue water ships: consolidating past achievements", Final Report, December, page 45

Defence has experienced one naval shipbuilding programme with a French company, DTCN – a forerunner of Naval Group. This was the construction of a single fleet replenishment ship, HMAS *Success*, at Cockatoo Island in Sydney. As described in Exhibit 7.3, this was not successful. The delivery of the ship was delayed by three years and the cost blew out from $68.4 million to $197.4 million (in current prices). This appeared to be largely as a result

of a dispute over the drawings and specifications provided by DTCN and differences between these and the original building specifications.

Defence has encountered some well-publicised difficulties in working with Navantia, the designer of both the AWDs and the LHD ships. Some of these problems have been around the quality of the blueprints, which, we understand have not been produced to a contemporary, digital standard. On the first AWD, the manufacture of a module to dimensions that turned out to be incorrect contributed to a significant delay in the whole programme. But some of the problems can equally be sheeted home to Defence, for example that Navantia was excluded from the alliance responsible for oversighting the AWDs.

The main implication of this discussion is that there needs to be a good cultural fit between the overseas designer of the platform being constructed in Australia and both local industry and the customer, namely Defence. Clearly a common language helps here, although the technical approach to shipbuilding and industrial practices are also important. The Australian naval shipbuilding industry has generally worked well with American, British, German and Swedish companies in the past. The experience with Spanish and French companies has been less satisfactory.

7.5 Sustaining the Shortfin Barracuda

Another very important element in the cost of the Shortfin Barracuda and the risks around the acquisition relates to sustainment.

Parent navy responsibilities

The Collins class submarine was (and is) the only substantial platform for which the RAN has had to assume parent navy responsibilities. The implications of parent navy responsibilities are that Defence cannot draw on an overseas shipbuilder's deep knowledge of the platform, which can be invaluable in terms of routine maintenance, refits and significant upgrades. Instead, the Navy has to call on its own engineering expertise or buy in skills from local industry or overseas.

It is not clear that the Navy understood the full implications of parent navy responsibilities for the *Collins* class, which were taken on at the end of last century just as the Naval Technical Services engineering group was being wound up. The initial budget for *Collins* class sustainment was patently inadequate and there were significant problems with the reliability of the submarines, including breakdowns at sea. This contributed to a chronic lack of availability as well as the "dud subs" label, which in turn contributed to difficulties in recruiting and retaining personnel to the submarine force. Writing in 2012, at a time when the problems with Collins were at their height, an-ex submarine captain, James Harrap, wrote:

> Submarines are highly complicated machines and being a submariner has always required a skilled blend of operator/technician unique within naval service; but the Collins Class has taken the technical arguments to a whole new level. The planned maintenance requirements are onerous enough but the constant stream of defects and operation control limitations makes getting to sea difficult, staying at sea harder and fighting the enemy a luxury only available once the first two have been overcome. The submarines have maintained an operational capability for most of the past 15 years, but that is often despite many aspects of the

> submarine's design rather than because of it.
>
> Sustainment and reliability problems have plagued the Collins Class since first launch. This is not news to anybody who has followed the history of the boats. As commissioning crew onboard HMAS RANKIN, I recall fitted equipment being 'cannibalized' to support the other boats even before the submarine was commissioned. The expected reply to stores demand signals is usually 'Nil Stock Global' reflecting no suitable inventory holdings – though this is often attributable to accounting inadequacies as much as it is a true reflection on the state of inventory. Over the last two years though I believe these problems have become worse; throughout my command of both COLLINS and WALLER full capability was never available and frequently over 50% of the identified defects were awaiting stores.
>
> Sustainment budgets and schedules must continue to factor the requirement to improve the capability. Much of the existing equipment is bespoke (and often obsolete), the need for upgrades is increasing but cost of acquiring and retrofitting equipment is high. Rising numbers of defects swell work scope during maintenance periods and merely getting the scheduled maintenance done in the allocated time is a challenge before capability replacement and upgrade is even considered. Whilst continuous improvement is essential, there comes a time when the incremental changes possible in this process are not enough.[132]

While the maintenance issues have now largely been overcome, it took twenty years from the commissioning of HMAS *Collins* for this to be achieved and for availability of the boats to reach international benchmarks. Even now, while great improvements in efficiency have been achieved, the cost of maintaining the *Collins* class submarines is reportedly at least twice as high as for other SSKs around the world. For example, in 2012 it was reported that "the French recently signed an AUD 635 million sustainment contract with Naval Group for their six SSNs for five years… The sustainment costs for a French SSN are AUD 22 million per boat per annum [while] Australia will pay AUD 81 million per boat on sustainment this year."[133] Part of this high cost is likely to relate to the cost of replacing or maintaining bespoke components. Another issue is fundamental design faults with major components that cannot be replaced, most notably the notoriously unreliable diesel engines.

Lessons for the future

An important lesson from the Navy's experience with sustaining the *Collins* class is that in assessing the relative cost of different designs for the FSM it is of critical importance to take account of the whole of life costs of the platform rather than just the acquisition cost. The likely cost of sustaining the Shortfin Barracuda is not clear. The rule of thumb is that through life maintenance costs are around three times the acquisition cost, which is why numbers of up to $150 billion have been bandied around for the Shortfin Barracuda. These costs seem to be unacceptably high. Of course, on this formula if the acquisition cost is excessive, the sustainment costs will multiply this prodigality by a factor of three.

[132] Harrap, James (2012), *op. cit.*

[133] Patrick, Rex (2012), "Collins class – life extend or euthenase?, *Asia Pacific Defence Reporter*, May, page 36.

Drawing on the experience with *Collins*, some obvious lessons for the Shortfin Barracuda are:

- As is now common practice in many manufacturing industries, it is important for the designers of the FSM to place a high priority on minimising through life maintenance costs
- Wherever possible utilise components, especially critically important ones such as diesels and electric motors, that are widely used in submarines around the world
- Where bespoke components are necessary, extend the production run well beyond the acquisition requirement, perhaps to the extent of providing replacements as required for the whole life of the submarines.

7.6 Implications

The decision to build the Shortfin Barracudas in Australia was taken on the run with no obvious in-depth consideration by Cabinet. It seems clear that the decision to select Naval Group as the design partner for the FSM was made on the basis of the capability it was seen as offering. We understand that the report to Cabinet on the CEP process made no recommendation as to where the submarines should be built. Only a month before, the White Paper had stated the policy position that Australian industry involvement in the FSM project, *inter alia*, would be contingent on not compromising the project's cost, schedule or risk.

This is of critical importance because Australia's naval shipbuilding industry is not in good shape. ASC is still building three AWDs, to be delivered over three years late and at a highly excessive cost – for the same budget, Australia could have acquired five larger and more capable *Arleigh Burke* class ships that would all be in the water by now. The RAND corporation estimates that naval shipbuilding costs in Australia are 30 to 40 per cent higher than the internationally competitive level, and judging by the AWD example, this seems optimistic. Yet any thought that the extravagant budget for building submarines was an outlier is far from the truth. For example, the SEA 5000 future frigates programme has a budget of over $35 billion for nine ships, an absurd outlay by international standards.

Following the successful *Anzac* and *Collins* class shipbuilding projects, the Howard government returned to the discredited public ownership, cost plus model. The recent Naval Shipbuilding Plan gives no signal that this is to be changed or that Defence has developed a strategy to reduce or eliminate the present cost disability in the naval shipbuilding industry. Taken together with the perception that Naval Group had strong commitment to building the submarines in Australia, there is a high risk that a local build could lead to a significant blow out in both the cost of the FSM and the delivery schedule.

Australian industry has not built a submarine for fifteen years. The corporate memory as well as the remnants of the management and workforce with submarine building experience all reside in ASC, yet Naval Group is setting up a new facility to build the submarines in Adelaide. The main industrial risks to the project emanate from this. When British industry started to build the *Astute* submarine in a yard with a long history of building submarines, it also had not built a submarine for fifteen years most of the experienced

workforce had been lost. The result was severe underperformance, with shipbuilder requiring very significant assistance from US industry. The submarine was delivered five years late and greatly over budget.

The creation of a credible Naval Shipbuilding Authority should be given urgent consideration by government. Such an authority would need to have a board composed mainly of senior industrialists with a strong understanding of success factors in naval shipbuilding. The Authority should have a strong remit to oversight industry performance in terms of costs and schedules and also play an important role in developing the local supply chain. It should have the ability to hold contractors to account. The Authority should report to three departments, namely Defence, Finance, and Industry, Innovation and Science.

CHAPTER 8

A better way forward

"Unthinking respect for authority is the greatest enemy of truth."
Albert Einstein.

8.1 Background

The future submarine project is Australia's largest-ever defence investment, in real terms on a par with the Snowy Mountains Scheme. It is both too big and too important for Australia's national security to contemplate failure. Yet failure is a distinct possibility.

It is clear from this report that we consider the acquisition process for the future submarine to be deeply flawed. The submarines will be excessively costly and subject to a considerable number of very high risks. In summary, there are two major concerns.

First, it is entirely possible, if not probable, that the schedule of the Shortfin Barracuda will blow out to an unacceptable degree. The industrial and technical risks to the project are very high. On the industrial side, no submarines have been built in Australia for fifteen years and what corporate memory remains is located in ASC, which will be 'consumed' by Naval Group. The technical issues around building a very big submarine that will deploy neither AIP nor modern batteries are also daunting. Taken together with the experience of similar projects overseas such as the British *Astute*, it may well be that there will only be one platform in the water by 2040. With the *Collins* class becoming obsolete in 2026 to 2033, the risk of either a complete capability gap or a lack of any credible submarine capability is very high.

The second issue is the significant risk that the design of the Shortfin Barracuda will be unsuccessful. It might be too expensive, so that not enough platforms could be provided within the budget and it would not offer value for money. It may not be able to provide an appropriate balance between size and capability. It may fall so far short of being a 'regionally superior' submarine, perhaps because of an uncompetitive indiscretion ratio, that it is not worth acquiring. If the Shortfin Barracuda were to fail, without any alternative solutions that would be a disaster for Australia's defence capability.

In our view, therefore, it is important to:

- Take action to guard against the capability gap
- Provide insurance against the possible failure of the Shortfin Barracuda

We also understand that our proposed remedies to these significant problems would be unlikely to be accepted were they to recommend significant changes to existing policies or a reversal of previous Cabinet decisions. We do not, therefore, advocate any changes to the protocols with the French government that establish Naval Group as Defence's design partner for submarines. We also understand that the government wants all the submarines to be built in Adelaide, although we do not believe that any responsible government would apply this policy regardless of cost.

8.2 Avoiding the capability gap

The most immediate and possibly the biggest risk flowing from the decision to acquire the Shortfin Barracuda – a submarine that is yet to be designed, let alone built – is the inevitable long schedule for its delivery. Even on the best possible scenario where everything goes according to present plans, the first Shortfin Barracuda becomes operational only in 2033, while the *Collins* Class submarines are scheduled to be progressively withdrawn at the age of 30, between 2026 and 2033. Even then, under these very benign circumstances where everything goes according to plan, the Navy will have only one submarine in 2034 and perhaps four by 2040. This capability is clearly inadequate.

An alternative and more likely scenario, however, is that, in line with other developmental submarine projects around the world, the cost and schedule of the FSM blows out significantly. In that case the number of new submarines to be acquired could be reduced perhaps to eight, with the first entering service in 2040. Apart from the increased threat to national security from this substantial capability gap, the Submarine Force would then suffer increasingly from a lack of well-trained and effective personnel, and its capabilities would need to be re-built out into the 2050s. At the same time, the number of platforms would be clearly inadequate.

By comparison, the 2009 Defence White Paper proposed a doubling of Australia's fleet of submarines, with most of these new submarines to be in the water by the early 2030s. Since 2009, the security environment in the Asia Pacific has become more threatening. It is unlikely to improve over the next two decades and a prudent government would prepare for the situation to get considerably worse. One possibility, flagged as remote in 2009, is that Australia could become involved in a conflict with a major adversary without the support of the United States. Submarines are some of the best assets available for a middle power to prosecute asymmetric warfare. Thus Australia now needs a greater submarine capability than was envisaged in 2009.

The most urgent imperative for the government, therefore, is to address the high probability of a future capability gap in Australia's Submarine Force. There are essentially two options:

1. A life of type extension (LOTE) of the *Collins* Class submarine, or
2. Acquire a fleet of new MMOTS submarines

These options are explored below.

Option 1: Collins *class life extension*

The *Collins* class was designed for a thirty-year life. On that basis, the six submarines will reach the end of their effective lives between 2026 and 2033, when the first FSM is scheduled to enter service. In fact, if there were any slippage at all in the delivery of the FSM, the *Collins* class would need to operate into the 2040s. If the *Collins* submarines were to be used to fill the expected future capability gap they would need a comprehensive life extension. This raises major technical and financial issues.

First, from a technical perspective it is not feasible to upgrade the capability of a 1980s platform design like *Collins* to contemporary standards, particularly to the minimum level that will be required in the Asia Pacific in

the 2030s, let alone the 2040s. As described in Chapter 2, Australia's unilateral project to extend the life of its US-designed FFG-7 frigates provides a salutary warning of the problems involved in putting new wine into old bottles. As reported in *Defense Industry Daily*, "FFG-7 updates were problematic, thanks to very little reserved space for growth, and the inflexible, proprietary electronics of the time. Indeed, they were so problematic that the US Navy gave up on the idea of upgrades to face new communications realities and advanced missile threats." Nevertheless, Australia went ahead with the LOTE. The project blew out by up to seven years and only four of the six ships could be upgraded within the budget, with the end result being that the upgraded FFGs could only "perform the full range of naval duties to varying levels in low to medium threat environments".

A LOTE for a submarine would be much more complex and risky than for a surface warship. One aspect is that the hull would need to be strengthened and re-certified for deep diving. This alone can cost $1 billion per boat, or by itself more than the acquisition cost of a new, advanced MOTS submarine with a thirty-year life. As reported in Chapter 6 of this report, even in 2008, the Submarine Institute of Australia (SIA) stated that it is not "an option to extend *Collins* since … the capability gap between the 1987 specification and contemporary needs is increasing. … The *Collins* class currently lacks any design margins (space, ship stability, power, cooling etc.) to sustain significant capability enhancements to meet the increasingly demanding environment and new requirements." (Exhibit 6.8 above.) A decade later, with rapid advances in the capability of regional submarine fleets, these arguments are even more compelling.

Secondly, we understand the cost of extending the life of *Collins* for ten years is around $15 billion, nearly ten times the cost of the FFG-7 LOTE and equivalent to acquiring around 18 new MOTS submarines. In terms of the moderately enhanced capability that at best could be provided, which would not include AIP, and the very high technical risks, this cannot represent value for money for an additional ten years' life, particularly if the upgraded boats cannot safely be sent into harm's way. To quote the SIA again from 2008, "a life extension programme is therefore likely to be a poor return on investment. It is a distraction and will result in a serious capability gap."

The other argument against the *Collins* LOTE is that, because the extension would be for only ten years duration, not only would it would make a very poor investment in light of the cost, but it would not also be able to fill the whole of the potential capability gap. If the first Shortfin Barracuda were delayed until 2040 and *Collins* had a ten-year life extension, the thought of it operating up threat in the South China Sea in the 2040s is little more than a theoretical abstraction. A *Collins* LOTE does not provide cover for the late delivery of the Shortfin Barracuda.

Accordingly, we propose that while continuing the design phase for the Shortfin Barracuda with Naval Group as contracted, the government should not proceed with the planned LOTE of the *Collins* class. While *Collins* should be equipped with updated sonars and communications systems as is currently being undertaken, the comprehensive LOTE is too costly and risky and could make the capacity problem worse. There are more efficient and cost-effective ways available to address a capability gap than by undertaking a *Collins* LOTE.

Option 2: Acquisition of new MMOTS submarines and tender

We consider that a better alternative to the Collins LOTE would be to take action now to acquire a new fleet of MMOTS submarines. To address Defence's concern with the capacity of smaller MOTS submarines to undertake the lengthy patrols required by the RAN, we also propose the acquisition of a submarine tender that could be forward based.

Given Australia's present circumstances and the strategic outlook, there is a recent precedent for this. By 2007, it had become clear that a life extension of the RAAF's fleet of F-111 fighter-bombers as planned would not be technically feasible. It was also evident that the F-35 joint strike fighter, designed to succeed both the F-111 and Australia's F/A-18 'Classic' Hornets, would be delayed. With the probability of a capability gap in Australia's air defence, then Defence Minister Brendan Nelson took prompt action, with no competitive process, to order 24 Super Hornet MOTS aircraft to fill the gap. This was followed by further orders when the Rudd government came to power. These actions were heavily criticised by some at the time. They are not criticised now. Unlike military aircraft, however, it is not possible to procure new submarines within a short timeframe. Modifying a submarine's design and then building it necessarily takes time. It is therefore necessary to take action now.

If action had been taken a few years ago, perhaps the best way forward would have been to build an evolved version of the *Collins* class. Most nations with a national submarine capability adopt an evolutionary approach to procuring new submarines. But this opportunity effectively passed in 2014 when the government shut down ASC's design house, Deep Blue Tech. The risks around resuscitating Collins Mark II now are, in our view, too great to be confident of avoiding a capability gap in the timeframe available to us.

The inescapable conclusion is that the only way to be confident of bridging the looming capability gap is to acquire a submarine based on a MOTS platform.

In reality, there is no such thing as a purely MOTS submarine. They are always modified in some way, if only to meet the standards of the nation acquiring them. But most modern MOTS submarines, especially those designed for global markets, have the flexibility in their design to allow for modifications desired by different customers. Ideally, apart from the need to meet Australian standards, required modifications to the proposed MOTS boat should be kept to a minimum. They would include additional fuel tanks to allow for an extended range of up to 10,000 nautical miles with an additional three weeks' endurance on AIP. In order to sustain the required high levels of interoperability with the US Navy, an advanced US communications suite would need to be integrated with the boats' combat systems. There should be no need to require the AN/BYG-1 combat system to the new submarines. It would be too heavy and power hungry for a platform any smaller than *Collins*.

The new boats should offer advanced capabilities so as to meet the RAN's essential operational requirements. They would not necessarily be 'regionally superior', whatever that may mean in a region where an increasing number of SSNs are deployed, but with highly trained crews they would be capable of outstanding performance in the operations for which they were designed, the main ones being sea denial and ISR. They should provide superior service to an extended *Collins* boat, at a much lower cost.

In practical terms, the only two competitors for an Australian MMOTS platform would be the Naval Group Scorpène and the German Type 212 (tkMS), the two submarines that recently competed for a Norwegian acquisition. The Navy has already rejected the Japanese *Sōryū* and the Swedish A26 is not yet operational and so cannot be classified as being off-the-shelf.

This report has emphasised the benefits of competition. While in principle, the best approach for acquiring a modified MMOTS submarine would be to invite these two contractors to prepare a PDS and fixed price tender, in Australia's present situation there are some practical problems in this approach. The main issue is that the government has entered into a strategic partnership with the French government and Naval Group to develop its future submarines. In addition, if the Government has a strong preference for building the MMOTS submarines in Adelaide, and a non-French submarine were selected, there could be problems with introducing a third design and construction approach for submarines. With Naval Group establishing a facility to build submarines in Adelaide and supplying companies qualifying on the French Dassault CAD system, these problems would be avoided if the French Scorpène were chosen for the new MMOTS submarines. In addition, the Shortfin Barracuda will be derived in part from the Scorpène and will have many common components, leading to scale advantages and benefits for the supply chain. Apart from these industrial benefits, with Australia's submarines coming from the same family, training will be greatly simplified.

Yet while these issues would clearly place Naval Group in a highly advantageous position, the government-to-government agreement does not require Australia to build to a French design if that design turns out to be unsatisfactory or too expensive. In the case of the Scorpène, there is also the issue that comprehensive classified data on its performance were leaked to the media in 2016. Naval Group would need to show that effective action had been taken to nullify the effects of this security breach. But most importantly, it would also be highly desirable to impose some competitive pressure on Naval Group to ensure that Australia gets the best capability that can be provided in a MMOTS package, at the right price in a fixed price contract and within an acceptable delivery timeframe. As we have stated in our report, Naval Group has had a patchy record in delivering the Scorpène outside France.

Therefore, while we are aware of the difficulties, our proposal is for the government to invite both Naval Group and tkMS to prepare a funded PDS and fixed price tender for building their MMOTS submarines for the RAN. The contenders should prepare fixed price tenders for building the submarines in both Australia and overseas. They would need to be delivered between 2026 and 2034.

Even though the PDS would be funded by Defence, it may be that tkMS will decline this invitation to compete with Naval Group, which is the government's submarine design partner and has the advantage of having established a shipbuilding position in Adelaide. German participation should be encouraged, however, and perhaps Ministers from both countries could discuss the issue in the context of the recently signed bilateral agreement between Australia and Germany. Nevertheless, should tkMS choose not to compete, the fall back position with Naval Group would be a negotiation on price, delivery and a satisfactory resolution of the security issues relating to

the performance of the Scorpène. The approximate cost of the Scorpène in various markets is in the public domain and presumably Naval Group would recognise the benefits of providing a mutually satisfactory outcome at this early stage in what could be a long partnership.

This solution is not ideal but it does have some advantages. Importantly, it requires no change to existing policy since it only replaces the proposed *Collins* LOTE, on which we understand no decision has yet been taken, with a cheaper, far less risky and more effective option. If the new submarines were built in Adelaide it would also relieve pressure on the Valley of Death, which currently is giving rise to unfortunate decisions such as constructing the first two OPVs in Adelaide and the rest in Perth, and developing new facilities for building the future frigates before the designer and contractor have been chosen. Instead, if the process began this year, construction of the new submarines could commence in 2020 and more sensible arrangements could be put in place for the surface ship acquisitions, particularly allowing time for ASC/Austal participation.

There is an important second element to our proposed way forward. The RAN has generally been opposed to acquiring MOTS submarines for reasons that are understandable. With submarine missions of up to ten weeks, including total transit times of four weeks, the Submarine Force's operations tend to be much longer than those undertaken by the European navies that use the submarines that would be available as a MMOTS acquisition for Australia. RAN crews are subject to a greater workload over a longer period, thereby requiring higher standards of habitability than can be accommodated in a small MMOTS platform. Also the payloads of MMOTS boats are smaller, thereby reducing effectiveness on a long patrol. These are legitimate concerns about MMOTS submarines for the RAN and they need to be addressed.

In an operational scenario involving, say, a naval conflict in the South China Sea, a major issue would be how to maintain as many submarines as possible on station. This would require expeditious action to allow them to refuel and take on fresh provisions. They would also need to replace torpedoes and other essential munitions as well, perhaps, as taking on UUVs and Special Forces.

We also propose, therefore, that the government should acquire a submarine tender. Such a vessel, possibly of around 6,000 to 8,000 tonnes displacement, would act as a 'mother ship' for the submarine fleet and, during peacetime at least, could be forward-based offshore at an Australian territory such as Christmas Island or Cocos Keeling, right on the doorstep of the Submarine Force's AOs. This would greatly reduce transit times as well as compensating for the reduced payload of smaller platforms by providing the opportunity to re-fuel, re-arm and re-provision the submarines. It would also address the fatigue problem by allowing for replacement crews after a patrol, on a fly-in, fly-out basis. By having more submarines on station at any time, together with an enhanced ability to operate in either the Pacific or the Indian Ocean, a mobile forward base could also effectively act as a force multiplier. In a situation of extreme threat, the tender could be withdrawn to the mainland.

Supported by a tender, the MMOTS submarines would have several advantages over an upgraded *Collins* class. They would have AIP and therefore be able to remain submerged for up to three weeks on patrol where they would be far less liable to detection. They would have smaller crews

who would respond positively to much shorter missions and the better lifestyle provided by access to a 'mother ship' in a tropical location and fly in, fly out operations. In terms of value for money, compared with a cost of $15 billion for a *Collins* ten-year life extension with a poor outcome in terms of capability, the MMOTS submarines plus tender should cost less than $10 billion for an advanced submarine capability with a 30-year life. They should also have lower sustainment costs. The investment case is strong.

The submarine tender would also provide significant benefits beyond sustaining the new submarines. It could be designed in Australia, probably with an overseas design partner. As a single unit, a local build would be unlikely to be economic, but as with the LHDs, the hulls could be built overseas and the ship could be fitted out in Australia. It would also provide valuable service in different roles, such as a command ship and in humanitarian operations.

8.3 Insurance policy for the Shortfin Barracuda

Apart from the probability of a capability gap, the other contingency to be addressed is the possibility that the design of the Shortfin Barracuda, when complete, is not accepted. It might be too expensive, leading to an insufficient number of platforms being able to be acquired. Its performance might be unsatisfactory in some way; for example, its indiscretion ratio may be found to be too high for the future operational environment. Perhaps Australia's strategic circumstances will change for the worse and the government moves to consider the need for nuclear submarines rather than a large SSK.

Another benefit of our approach, therefore, is that the six MMOTS submarines under construction would provide a valuable insurance policy against this eventuality. These issues could be considered in the context of the review proposed in the 2016 Defence White Paper:

> During the long life of the new submarines, the rapid rate of technological change and ongoing evolution of Australia's strategic circumstances will continue. As part of the rolling acquisition program, a review based on strategic circumstances at the time, and developments in submarine technology, will be conducted in the late 2020s to consider whether the configuration of the submarines remains suitable or whether consideration of other specifications should commence.

This review could be brought forward to the early 2020s, when the design of the Shortfin Barracuda was much further advanced than now. The review should include:

- An assessment of the strategic environment, including potential threats, together with analysis of developments in the order of battle in other navies in the region.
- A decision on whether, if further SSKs are to be procured, they should be of the successful MMOTS design, which would then be under construction, or the Shortfin Barracuda.
- A re-assessment of the required roles for RAN submarines, including whether more operations 'up threat', where survivability would be greater in a SSN, will be required and whether the deterrent value of the Submarine Force needed to be increased.

- A decision on whether to seek to acquire SSNs, probably by taking up France's offer to provide Barracuda (*Suffren*) class submarines, in which case, given the lead time, an additional six MMOTS boats could be acquired.

In any future conflict in which Australia was involved in a coalition with the United States, it is difficult to see what complementary role that an Australian force of SSNs would play. Presently, the RAN's submarines operate in the littoral and perform other roles that are more effectively carried out by a SSK. In our view, the acquisition of SSNs by the RAN should only be considered in the event of a major change in Australia's strategic circumstances where Australia could no longer be covered by the US extended deterrent and could conceivably be involved in a conflict with a great power without recourse to ANZUS.

At least fifteen years would be required to build the hard and soft infrastructure required for the operation of nuclear submarines. Much work would be necessary to establish a regulatory framework, via ARPANSA, as well as intensive training within the submarine force which would need to be significantly expanded.

It is vitally important that the costs and benefits of such an approach should be rigorously evaluated. A bipartisan approach would also be essential if such a policy were to be pursued.

APPENDIX 1

Designing your own submarine: That shouldn't be too difficult – should it?*

Introduction

Since World War II Australia has had its ups and downs in the successful design and manufacture of major military equipment.

In the naval sector the nation achieved a number of genuine successes, but mostly in the modification of other established naval designs. Examples are the three *Daring* class destroyers; six River class frigates (two designs – the last two with significant changes from the British *Leander* class); HMAS *Stalwart*; patrol boats; minehunters; hydrographic/survey/oceanographic ships, culminating in the construction and subsequent modification of 10 *Anzac* frigates (eight for Australia and two for New Zealand).

The extent of weapons, sensor and habitability changes made in conjunction with the privatisation of HMA Dockyard Williamstown by Australian industry and the overseas designer Blohm & Voss (now thyssenkrupp Marine Systems) made the Meko 200 class much more suited to the RAN's operational needs.

Until the end of the 1990s, the technical direction for these projects came from the Naval Technical Services (NTS) department within Defence. Until the formation of Defence Central in the 1970s, the Chief of Naval Technical Services (CNTS) had an effective seat on the Naval Board with direct access to the Minister of Navy and (subsequently the Minister of Defence) on all new naval construction projects and other acquisitions.

For over 50 years, NTS was populated with experienced naval architects, engineers and technical personnel (in both military and public service positions) to operate effective naval design, production and maintenance divisions of the NTS, that could fully support all required naval work in Australia and acquisitions abroad.

Experienced engineers and technical personnel came up through the ranks of the two naval dockyards in Sydney and Melbourne, supplemented by new graduates from universities and technical colleges.

With the appointment of the Chief of Naval Matériel (CNM) in the 1960s, the combination of a dedicated technical services authority under CNTS and a financially accountable and dedicated project authority under CNM, the skills, capacity and confidence existed to embark on most state-of-the-art naval construction projects for the future.

However, with the sudden demise of CNTS and the many management changes before and since the establishment of the Defence Matériel Organisation (DMO) in the 2000s, the 'core' of dedicated and well trained engineers and architects that previously made up the NTS and indeed Naval Materiel was first fragmented and then effectively lost, presumably forever.

* This Appendix was written by Keith Snell, of Scientific Management Associates Pty Ltd. Mr Snell worked for a quarter of a century in Naval Technical Services within the Department of the Navy and then Defence.

Proven naval design/development process

Treasury and Finance regulations have always placed great importance on the pursuit of value for money in all government acquisitions. This has relied heavily on the concept of sound competitive tendering to control pricing and achieve genuine value for money.

Over time, however, Commonwealth departments (notably Defence) have departed from the practice of precisely defining outcomes and operational requirements and then developing full engineering specifications to allow competitive tenders to be released to a short list of qualified companies or consortia. This has finally given way to using the design process to develop final requirements and hence the desire to run the contractor's design process in conjunction with the relevant Defence project team.

SEA 1000 – Future submarine project

This is evident in the FSM acquisition. Now without a 'core' of engineering/design expertise such as the NTS there is a move to recruit a disparate group of individuals from international sources, with vastly dissimilar backgrounds and standards to those used in France and little or no understanding of Australian industry or its established supply chain of Australianised products. Without strong and capable engineering/shipbuilding design leadership, this concept is doomed to failure from day one.

Many naval officers who have virtually grown up in submarines, culminating in their own command, believe they are well placed to specify customer design requirements. Indeed, this is true when talking about 'operational requirements'. But this is not the 'design process' which ultimately is expressed in detailed engineering specifications and manufacturing drawings for others to interpret in remote locations, i.e. at system/equipment supplier works, fabrication shops and final assembly within a productive shipyard. This process has been enhanced over the past five years in Europe and the USA to gain production efficiencies of 15 per cent or more by the development of new digital design tools.

It will also be appreciated that the design of many systems and equipment involve major subcontractors that have to work hand in hand with the submarine design team, to achieve the desired system outcome through integration within the total design process.

Naval shipbuilding design, especially with advanced submarines, involves tens of thousands of unique parts, materials and entire items of equipment. An experienced and integrated design team is essential for the organisation and coordination of this work. This is unlikely to be consistent with the integration of outside, 'customer selected' designers that have little or no understanding of the standards, products or processes used by the overseas Design Authority.

Furthermore, the naval designer will have a strict regime to implement the total design, starting with an approved set of operational parameters. This is then evolved into a set of specifications and drawings that can be matched to available or like products from industry, so that the various systems and equipment can be sized and further specified, first to fit into the evolving hull design and then developed in accordance with the approved acquisition

specifications. The initial selection of a specific hull size and format by Naval Group makes this an even more difficult task.

The normal design process finalises the numerous systems capabilities first and then optimises the hull size to have these evolved systems and other required hull features (endurance, weapons and accommodation to name a few) incorporated to achieve the best hydro dynamic performance.

Included in the design process is a detailed test and evaluation requirement, including prototype manufacture and test to ensure that all new critical systems can achieve the required performance and reliability required for submarine type approval for service use including safety aspects.

The selection of the nuclear powered Barracuda as the reference point for the RAN SEA 1000 requirement – designated by Naval Group as the Shortfin Barracuda –raises a host of major concerns. Most of the existing heavy machinery, (excluding the nuclear propulsion plant and turbines) such as main motors, pump jet, steering, diving and a host of auxiliaries are based on a nuclear plant electrical capacity of at least 5 times (50 MW versus 8-10 MW generated power) greater than a scaled down conventional boat with four diesel generators, a single Permasyn drive motor and a large bank of batteries either, lead acid or Lithium Ion, with totally new electrical switchgear for main propulsion control and electrical services.

Together this adds up to a major design change of all the critical equipment required to drive and submerge the new submarine. Little or no commonality will exist with either the Barracuda or aging Scorpène designs.

Accordingly, each new critical system or equipment will require extensive prototype testing under controlled lifecycle extension programs to be approved for service use before being installed into a new designed submarine.

The more Australian project personnel that are engaged in the design process, the more the Commonwealth will be committed to the ownership of the design and, indeed, may have to accept legal responsibility for the design outcome if serious problems arise.

When the design moves to the more detailed areas of fitout:

> *such as location and layout of cable runs, ventilation trunks, piping, electrical fitout (switches, light fittings, controllers, transformers and cable glands), fresh and seawater systems with numerous fittings and valves and a host of other systems, distributed throughout the submarine, all competing for available space on the deck heads, bulkheads and sides of the submarine,*

the need for a fully integrated team of Defence and DCNS personnel will be inevitable.

Indeed, the management structure for such an arrangement could become unworkable given the need to have some, 'arms length' arrangement between the Defence project team and the contractor. This would presumably control the total design team effort, including assigned project team personnel with some form of input and/or delegation for detailed decision-making. Without very experienced and capable engineering management within the Defence project team and those imbedded into the Naval Group design team, the effectiveness of the arrangement may be seriously compromised.