

STRATEGY

A S P I

The submarine choice

Perspectives on Australia's most complex defence project





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A Collins class submarine undergoing maintenance at the ASC facility in Adelaide. Photo courtesy the Department of Defence.

INTRODUCTION

In April this year ASPI staged a conference called *The Submarine Choice*. We brought together a group of distinguished speakers to discuss the reasoning behind, and the options for, what's almost bound to be Australia's most expensive and complex defence project—the replacement of the Collins class submarine fleet some time next decade.

Because of the scale of this enterprise, it's important that there's a broad consensus on all aspects of the Future Submarine project, from the strategic rationale that underpins it, through the industry arrangements that will deliver the boats, to the actual materiel solutions eventually chosen. That's why we invited a range of distinguished speakers, including military and academic strategists, policymakers, project managers and representatives of many of the firms that might have a role as the project takes shape.

My own view is that we must start with strategy. In Asia we see a worrying pattern of military strategic competition over disputed territories. The regional security architecture is underdeveloped and defence spending across much of the region is climbing. Our wider region is by no means all downside—indeed, opportunities for growth and cooperation remain strong. But this isn't a time for retrenching significant defence capabilities.

The government should look hard at what roles and missions it wants the submarines to perform and should think about broad capabilities, not just platforms. The Future Submarine will be part of a broader force, and a broader alliance structure. In an uncertain world, the ANZUS alliance is becoming more—not less—important to Australia. Moreover, there are regional and global partnership implications, as the Prime Minister's visit to Japan earlier this year made clear. There's an obvious potential for Australia to strengthen relations with Japan and with a number of European players. There's an industry core to this, but also a broader strategic point—Australia can use the submarine choice to strengthen key bilateral ties.

The scale of the submarine choice is so large that it has the potential to crowd out other necessary acquisitions. Australia can't afford to under-invest in critical land and air systems or, for that matter, in the surface fleet. Further new investment areas, for example in space and cyber, are emerging. A sustainable submarine choice is one that allows the rest of the ADF to develop as well.

As the government has made clear, the Future Submarine project can't be seen as a special case of job creation—to avoid the problems we had with the support of the Collins in its first decade of service, the industry outcomes should be sustainable, long term and believable. Australian industry needs to work within an increasingly globalised marketplace and the submarine project will almost invariably bring together technologies from a range of suppliers. But the success of the Future Submarine will also depend on some highly prized—and thus closely held—technologies from trusted partners. Bringing those elements together is no small challenge.

In these pages you'll find a summary of each of the talks that were given at the conference, and they contain a range of perspectives on each of the issues mentioned above. As well, we've included some analytic insights from ASPI. Mark Thomson and Andrew Davies write on the complex suite of industrial options. Benjamin Schreer shares his thoughts on the role the Future Submarine might play in alliance operations with the United States. And, to show that Australia's submarines will have to operate in an increasingly contested environment, Harry White presents a survey of regional submarine capabilities and plans.

Although the delivery of the first of class might still be more than a decade away, this is now a rapidly moving endeavour. The conference was only a few months ago, but several new possibilities and perspectives have come to light, either through public statements by officials or in the broader discussion of what has always been a topic of significant interest to the defence and general press. Perhaps the timing of our conference helped to shape emerging thinking on the submarine choice. Certainly few procurement projects have been held to such close public scrutiny before even reaching first-pass cabinet consideration.

Interested readers can stay apprised through ASPI's publications, including short pieces on our blog *The Strategist*, where we'll present our perspectives on developments as they occur. To that end, we've included some recent blog pieces in this volume to help bring the story of the Future Submarine project up to date.

Finally, I'd like to record my thanks to the participants in the conference, whose willingness to share their remarkably varied and often candid views made the event the success it was. And the ASPI team who organised and ran the conference did a superb job. It was a team effort, but special thanks are due to Benjamin Schreer, who coordinated the program and the speakers, and to our Events Manager Lynne Gozzard and Daniel Nichola for their efforts in making the event run smoothly. And I'd like to thank our conference sponsors, without whom we couldn't have staged such a successful event: Lockheed Martin, Northrop Grumman, Thales, ThyssenKrupp Marine Systems and Raytheon Australia.

Peter Jennings

Executive Director

THE SUBMARINE CHOICE

ASPI's 2014 International Conference

The Australian Strategic Policy Institute (ASPI) hosted its 2014 International Conference, *The Submarine Choice*, on 8–10 April at the Hyatt Hotel, Canberra.

With the government moving closer to deciding on Australia's Future Submarine, the conference aimed to bring together senior policymakers, high-level military officials, leading industry representatives and academics from Australia and around the world to discuss key aspects of what will arguably be the most expensive and technologically complex defence capability project in the history of the nation.

In eight sessions consisting of formal presentations and open forum discussions, the conference showcased different perspectives on the Future Submarine's strategic, economic and industry dimensions, with a view to informing government's decision-making. Topics included:

- The Strategic Context
- The Navy's Perspective
- The Role of Submarines in US Pacific Strategy
- Regional Perspectives
- Design Options
- Industry and Economics
- Project Management
- Lessons from Abroad.

The conference attracted the following high-quality speakers and summaries are provided:

- Senator the Hon David Johnston, Minister for Defence — page 10
- Admiral Harry B Harris Jr, Commander, US Pacific Fleet — page 21
- Vice Admiral Ray Griggs, Chief, Royal Australian Navy — page 11
- Rear Admiral Phillip G Sawyer, Commander Submarine Force, US Pacific Command — page 15
- David Gould, General Manager Submarines, Defence Materiel Organisation — page 26
- Rear Admiral Gregory Sammut, Royal Australian Navy, Head Future Submarine Program — page 14
- John Coles, Author, *Coles Review* — page 27
- Simon Todd, Lead, Future Submarine Integrated Project Team — page 18
- Chris Edmonds, Design Manager, Future Submarine Program — page 20
- Admiral Gary Roughead (ret.), 29th Chief of US Naval Operations — page 29

- Donald C Winter, former US Secretary of the Navy — page 25
- Janis Cocking, Chief of Maritime Division, Defence Science and Technology Organisation — page 28
- Hans Christoph Atzpodien, Chairman, ThyssenKrupp Marine Systems (TKMS) — page 31
- Stephen Ludlam, Chief Executive Officer, ASC Pty Ltd — page 22
- Thomas G Mahnken, US Naval War College — page 12
- John Birkler, Manager Maritime Programs, RAND Corporation — page 24
- Colonel Ngong Boon Kheng, Commanding Officer 171 Squadron, Republic of Singapore Navy — page 17
- Vice Admiral Charles-Henri du Ché, Admiral International Relations and Partnerships, French Navy — page 16
- Vice Admiral Michel Accary (ret.), Special Advisor Submarines, DCNS — page 30
- Andrew Davies, Senior Analyst, ASPI — page 13
- Mark Thomson, Senior Analyst, ASPI — page 23.

The conference also included a welcome reception sponsored by Thales and a private dinner sponsored by Lockheed Martin at the Hyatt before the first day of proceedings. Following the conference's first day, TKMS sponsored a pre-dinner networking event and Northrop Grumman sponsored a dinner in Anzac Hall at the Australian War Memorial. Attendees praised all the events highly. The conference as a whole was supported by Lockheed Martin and Thales as prime sponsors and Northrop Grumman, Raytheon Australia and TKMS as sponsors. All sponsors expressed their satisfaction with the conference.

Video of all conference proceedings and the PowerPoint slides used by conference speakers are available on ASPI's website (www.aspi.org.au/events/the-submarine-choice-aspi-international-conference,-canberra).

The conference was very well received. Over the two days of proceedings, the conference attracted more than 220 attendees. Completed evaluation forms recorded entirely positive feedback, particularly in relation to the quality of the speakers and the conference's organisation. Responses on all returned evaluation forms stated that the conference had achieved its aim and confirmed that all of the attendees would recommend the conference and its future iterations. The conference also generated significant media coverage: it was mentioned in more than 80 news reports before, during and after the conference.

ASPI asked attendees to submit feedback on the key messages that emerged from the conference's proceedings. The most recurrent themes mentioned included:

- the lack of agreement from Defence, the Navy and the Australian Government on design, capability requirements and numbers for the Future Submarine project
- the need to optimise the requirement to achieve a deliverable project at an acceptable level of risk
- the need to have one person in charge of the project
- the sovereign risk implications of the row between TKMS and the Swedish Government over Kockums
- the comment by the Minister for Defence that an evolved Collins or a new design are the options 'we are left with ... at this particular time'
- The statement by TKMS Chairman Dr Hans Christoph Atzpodien that TKMS could deliver the Future Submarine with an order of 12 boats for around \$20 billion (\$16 billion less than ASPI's estimated project cost of \$36 billion).

This paper provides a record of the conference as well as ASPI's reflections on its proceedings. The first section summarises the speeches delivered at the conference. These summaries were prepared by ASPI based on recordings of the presentations given. Any implied emphasis reflects ASPI's judgement. The full presentations may be viewed on ASPI's [YouTube channel](#). The second half of this paper then analyses key aspects of the strategic, economic and industry dimensions of Australia's Future Submarine choice, and offers some recommendations to inform the government's decision-making.

Mr Peter Jennings—Introduction

ASPI's 2014 international conference, *The Submarine Choice*, has assembled perhaps the most knowledgeable gathering ever held in Australia about matters to do with submarines. ASPI decided on this topic because of its relationship to ASPI's core business: systematic and careful analysis of strategy and force structure decision-making, supported by a close understanding of budget realities. While in past years ASPI has held conferences on broad themes about international and, in particular, Asia-Pacific security, our aim for 2014 is to inform government thinking and broader national understanding on one of the biggest and most consequential defence capability decisions ever faced by an Australian government: Australia's Future Submarine choice.

Eight rules of thumb highlight the approaches that government will need to apply in making the submarine choice:

- 1. Government's consideration of the submarine choice should lead with strategy.** A key policy challenge for the government will be grappling with the mix of risks and opportunities presented by Australia's wider region.
- 2. Government should look hard at what roles and missions it wants the future submarine to perform.** The only way to think sensibly about Australia's submarine requirements is to take a disciplined approach to thinking through what capabilities Australia really needs.
- 3. Government should think about broad capabilities, not just platforms.** Success in military operations stems from integrating capabilities into a fighting unit. The critical question is: how will the Future Submarine fit into a broader Australian warfighting concept, given that the submarine will be part of a broader force and a broader alliance structure?
- 4. Look at alternatives to deliver capability outcomes,** even if only to be assured that the original proposal is the right one.
- 5. Consider the alliance and regional implications.** The submarine choice—in a strategic if not an industry sense—has to be understood in terms of its impact on US alliance expectations, opportunities and risks, but also its implications for regional-global partnerships with Japan and with a number of European players.
- 6. Healthy scepticism is a virtue** in an incredibly challenging business like submarine acquisition.
- 7. Remember that there's a wider Defence Force.** The scale of the submarine choice is so large that it has the potential to crowd out other necessary acquisitions anticipated in the Defence Capability Plan. A sustainable submarine choice is one that allows the rest of the ADF to develop as well.
- 8. Industry outcomes should be sustainable, long term and believable.** The least useful situation is one in which there are rapid fluctuations in plans, major year-on-year changes to spending profiles and rapid redesigns of capability requirements.

Mr Peter Jennings is the Executive Director of ASPI.

Senator the Hon David Johnston—The importance of the Future Submarine for Australia

Excerpted from Senator Johnston's full presentation as delivered, which is available on ASPI's website.

Those of you who know me appreciate the strong interest I have in submarines. They are a highly potent asymmetric capability of strategic importance to our island nation. Their importance is unlikely to abate; rather, they will grow in significance as we see their acquisition expanding right across North and Southeast Asia. They are a critical element in our maritime security planning.

The Australian Government is acutely aware of the importance of having a highly capable submarine force, especially given the rapidly changing strategic circumstances in our region. Our election commitment was to make a decision on our Future Submarines within 18 months of being elected.

In the lead-up to the last election I gave my support to Defence's charted course for the Future Submarine program—the suspension of investigations into Option 1 (an existing off-the-shelf design) and Option 2 (an existing off-the-shelf design modified to incorporate Australia's specific requirements with respect to combat systems and weapons) and more detailed investigation of Option 3 (an evolved design that enhances the capabilities of existing off-the-shelf designs, including Collins) and Option 4 (a bespoke new design). So we are left with options 3 and 4 at this particular time.

In truth, our requirements are probably far more complex than ever Collins was. Ideally, we are seeking a comparable capability to a nuclear submarine with diesel–electric motors inside. There are four primary objectives for the Future Submarine enterprise that I can identify, and these are:

- Firstly, to deliver an enduring regionally dominant superior conventional submarine capability.
- Ensure that our new submarine capability is affordable, and that is a very important part of the whole programme.
- To ensure Australia is able to sustain a superior conventional submarine capability into the foreseeable future in a cost-effective way.
- To avoid, of course, a submarine capability gap.

We have also committed to ensure that work in Australia on the replacement of the current submarine fleet will be centred around the South Australian shipyards. As a government, we want to give Australian industry every chance of success, as I have said, but let me be very, very clear: our primary and dominant purpose is to ensure that we provide Navy with a submarine which meets its requirements. A submarine is not industrial or regional policy by other means or another name.

The previous government did develop the Integrated Project Team with the intention that it be able to advise government as an 'informed customer' on the way forward for this vital program. I still do not know what the potential costs of a new design submarine or an evolved Collins submarine might be, and I'm very concerned about that.

There has been a lot of speculation about whether we need 12 boats. Let me be clear on this subject: my primary focus is not about numbers but on the capability and availability of boats required to meet the tasks set by government.

I propose to take to government this year, in support of the White Paper, a plan that balances up cost, capability and risk. The full details of this will be outlined in concert with the delivery of our new white paper.

Senator the Hon David Johnston is the Minister for Defence.

Vice Admiral Ray Griggs—Submarines in Australia's maritime strategy

It's important that, as we look at the upcoming White Paper process, there's a broad understanding of the role of submarines in Australia's defence strategy. Submarines are a critical element of our maritime strategy.

We're not looking at trying to deliver a science project that lives on the boundaries of the laws of physics. What we're looking at is probably best characterised as a contemporary version of the Collins class capability. Yes, as the Prime Minister says, this will be a significantly more capable submarine. And that improvement in capability can be achieved over time by evolving the design. This doesn't mean any decisions have been made with respect to any of the options that are before the government. As you've heard from the Defence Minister, government is understandably using the White Paper process to reconfirm in its mind what the right submarine options and numbers are.

For Australia, our submarines provide us with *strategic weight* in a way that no other ADF asset or combination of ADF assets does. By strategic weight, I mean that submarines are a capability that shapes or changes the behaviour of other nations and the calculus of their leaders. And what are submarines designed for? They're an offensive capability, intended to sink ships and other submarines. Yes, they do other tasks, but this offensive capability is the bread and butter of the trade. Because of their potency, our submarines can have a powerful conventional deterrent effect.

This deterrent effect operates in two distinct ways. The first is fairly well known—their offensive capacity means a potential adversary must consider whether the use of force against Australian interests is wise, achievable or without risk of an Australian response. This is an immediate, direct deterrent effect.

But there's also a much longer term deterrent impact. Because we have such capable submarines in the ADF order of battle, any potential adversary must be able to defeat our submarine capability. And, as many in navies and air forces around the world can testify, antisubmarine warfare is one of the more complex maritime warfare disciplines to be effective at. It takes a range of expensive high-end capabilities—surface, air and subsurface units—which must be developed and maintained over many years.

As we contemplate the direct cost of the new submarine program for Australia, I think we should always balance that against the considerable cost impact that the investment we make imposes on others to try to counter the effect of our submarine capability. This aspect of the submarine discussion is largely absent in the public domain; if we're truly thinking strategically, it needs to be there, front and centre.

Submarines provide the Australian Government with options to take action in our national interest. Importantly, the government can exercise those options to act at any time of Australia's choosing and under almost any conceivable threat scenario. And we can act as our interests dictate, either as part of an alliance, within a coalition or unilaterally.

So, as we discuss all the different characteristics of our submarines, we need to keep coming back to the strategic impact of different decisions. Decisions about capability, stealth, range and endurance all have an effect on the strategic weight we gain from our submarine capability. We can't say exactly where or when Australia will need its future submarines and all the strategic weight they bring. But their deterrent effect will continue to play a significant role in contributing to the security of our inherently maritime region—through their preparedness to fight and win at sea.

Vice Admiral Ray Griggs is Chief of the Royal Australian Navy.

Dr Thomas G Mahnken—Naval strategy under conditions of anti-access/area-denial

In peacetime, navies safeguard global and regional order through three means: safeguarding the free flow of trade, ensuring the maintenance of stability, and conducting military training and exercises that deter aggression and assure allies. In wartime, they use credible power to project influence where it's needed. This forms the backdrop for understanding trends and impacts upon navies.

Modern navies face interrelated challenges, which we can break down into three core areas. First, economic: the rising costs of platforms and personnel are creating smaller—yet more effective—navies. Second, the shifting balance of power and investment means that some states are trading off naval power while others, such as China, are expanding theirs. Third, the growth and spread of precision strike, along with the advent of cyber capabilities and the growing significance of the space domain, conspire to make precision targeting of vessels at sea more doable.

These challenges have created competition between power projection and anti-access capabilities. Until recently, there's been a clear advantage to the power projection and precision strike capabilities of Western powers—perhaps no more evident than in the 1991 Gulf War. Harnessing precision strike has been a key part of success in power projection for the US. But we're now entering a more challenging environment, triggered by the rise in anti-access/area-denial (A2/AD) strategies. The threshold issue of the next cycle of maritime capability development will be dealing with this challenge. The growth and spread of precision strike capabilities are creating a dynamic in which power projection has become more challenging.

While the spread of precision positional information and strike capabilities will be uneven, we can expect to face a broadly more challenging operating environment that will create both opportunities and challenges. The opportunity to provide precise locational data to people and platforms around the globe will enhance navigation and will also lead to better networked navies. However, the ubiquitous and cheap availability of precision strike will also create challenges, including making fixed points on the surface, such as bases, more vulnerable. Mobile forces will also be more vulnerable, and the stealth of submarines will be even more valuable.

A significant concern is that this trend could undermine the very purpose of navies. Accepting restrictions on free navigation, for example, would erode the norms that surface fleets have been upholding for decades. And a decreasing willingness to deploy navies would weaken assurance and deterrence in the international system. Ultimately, if power projection becomes more risky, more costly, or both, leaders may be less likely to safeguard global order.

In summary, the key attributes for Australia's Future Submarine in the light of these trends will be interoperability, stealth, endurance and precision strike capabilities. Stealth will be particularly important in an era when surface fleets are more constrained, and endurance will be significant given the vulnerability of fixed infrastructure. We're at a critical juncture in deciding the extent of the threat posed by A2/AD and how we'll deal with it.

Dr Thomas G Mahnken is the Jerome E Levy Chair of Economic Geography and National Security at the US Naval War College.

Dr Andrew Davies—Trends in submarine and antisubmarine warfare

The key questions that need to be grappled with in force structure decisions are:

1. What is Australia's strategic approach to security in the 21st century?
2. What military strategy (or strategies) support that approach?
3. How can those military strategies be operationalised (and what are the materiel solutions)?
4. What are the risks associated with the materiel solutions and how can they be mitigated?

The Future Submarine will be in service until well after 2050, so it's important to reflect on technology and trends in modern warfare. The likely continued exponential growth trend in computer power and bandwidth, known as Moore's Law, will affect every field of endeavour, and submarine operations will be no exception. In the past 40 years, the density of computing power on a chip and computer clock speeds have increased over 1 million times, and a similar increase can be expected in the next 40 years. While submarine stealth has improved steadily as well, keeping ahead of sensor and processing capability, we shouldn't take the relative advantage of the submarine for granted; history shows that major platforms can be overtaken by technological advances.

There's been a recent levelling out in improvements in submarine acoustic signature noise management (both radiated and flow noise), while processing power continues to increase. The result will be increased opportunities for submarine detection. Technological advance in underwater operations is more likely to lead to increased detectability of submarines than decreased. Moore's Law is likely to create four key advantages for antisubmarine warfare forces:

1. increased processing power, allowing even weak signals to be sorted from noise
2. networked processing power, so that signals from multiple sensors over a wide area can be integrated
3. increased bandwidth (and more efficient use of bandwidth), making moving volumes of data between sensors and processors faster
4. remotely operated or autonomous systems with enhanced processing power and ability to transmit collected data to a central processing point.

The result might well be a revolution in antisubmarine warfare. Enhanced processing combined with a 'swarm' of dispersed sensors across a wide area could detect subtle signals, making sneaking into monitored waters fraught with danger for a submarine.

Technological advances tend to cut both ways, and all is not lost when it comes to the future of submarines. However, the design of the Future Submarine needs to take account of these trends, which have the net result of making penetration of adversary space in chokepoints more difficult. The Future Submarine will need to be able to stand off further from adversary-controlled waters and exert influence through long-range remotely operated or autonomous sensor and weapon systems in the form of unmanned underwater vehicles (UUVs). Endurance and payload—especially important for the deployment of multiple UUVs—will be paramount.

Nuclear attack submarines have these characteristics, but that isn't an option for Australia. The two broad options are:

- invest heavily into designing a large, fast, long-range boat that can operate at high levels in a future characterised by advanced anti-access technologies
- temper our ambitions and settle for a fleet that can operate in less than the most challenging situations.

Dr Andrew Davies is a senior analyst at ASPI.

Rear Admiral Gregory Sammut—Where do Australia's submarines need to operate?

A number of key considerations should guide the development of Australia's Future Submarine (FSM):

1. Submarines are an offensive capability that work best 'up-threat'. In this context, the importance of stealth can't be overlooked, considering that around 50% of the world's submarines will be operating in the Asia-Pacific region in the near future.
2. The offensive advantage of submarines could be undermined during reactive operations in shallow waters. German U-boats sent to attack the D-Day force in the English Channel during World War II demonstrated that submarines don't work well as 'crocodiles in the moat'.
3. The twin issues of range and endurance are critically important for the FSM. Considering the large distances between some of Australia's own ports alone—such as the 2,259 nautical miles between Fremantle and Darwin—the ranges to cover by the FSM will be vast. Submarine operations also depend on the ability to remain on station for sufficient periods, which needs to take into account fuel requirements as well as crew size.
4. Payload and sensor capability are also essential. Payload's needed not only for the storage of weapon systems but also for the potential requirement to employ Special Forces, electronic warfare equipment, and in some cases the specialist personnel needed to operate such equipment. When it comes to sensors, the hydrophone count matters when you're trying to find very quiet threats while maintaining tactical advantage.

The FSM will need to operate offensively, calling for sufficient stealth, as well as range, endurance, payload and sensor capabilities. Moreover, the FSM needs to be interoperable with the US. While that doesn't mean Australia needs the largest conventional submarine with all the 'bells and whistles', we need to be mindful of what's important and remain fully aware of what we trade off as we contemplate the FSM.

Rear Admiral Gregory Sammut is Head of the Future Submarine Program.

Rear Admiral Phillip G Sawyer—The role of submarines in US Pacific strategy

The US and Australia share a long history of cooperation in the submarine space. For instance, Brisbane was critical as a resupply and rest port for US submariners during World War II. Today, a team of US submariners is stationed in Perth in support of the Australian submarine force, while an Australian team based at Pearl Harbor supports the US submarine force.

The US submarine force in the region remains very strong. About 60% of the US submarine force is located in the Pacific: 30 SSNs, 8 SSBNs and 2 SSGNs, as well as 11,000 submariners. Forward-deployed nuclear submarines are an integral part of US military strategy to deter major conflict in the Asia-Pacific region and to safeguard the freedom of the seas, which is critical for the security and prosperity of the US.

US submarine forces operate forward through a combination of rotational deployments from the US and the forward stationing of submarine tenders and submarines in places like Guam. Next year, USS *Topeka* will bring the total of permanently based nuclear attack submarines in Guam to four. Guam also serves as the forward operating base for SSGNs, which provide 365 days of coverage in the Western Pacific. The Guam-based submarines provide the ability to conduct longer routine patrols in the region while also reducing response time for contingency operations in the Western Pacific. To that end, the US has devoted considerable resources to Guam, including building new facilities and a submarine training centre. Guam is an apt location to conduct bilateral and multilateral submarine exercises. A second SSGN based in Diego Garcia provides all-year presence around the Arabian Peninsula and the Indian Ocean.

The US carefully monitors submarine acquisition trends in the Asia-Pacific theatre. Vietnam has just acquired advanced diesel-electric submarines. Bangladesh has signed a submarine deal with China. India is acquiring SSNs and SSBNs. And Thailand has built some infrastructure for future submarine operations. These developments will increase the risk of submarine collisions, which makes investments in submarine rescue capability a priority for every nation operating submarines. Improved water-space management and agreements in the Asia-Pacific will become much more important as the undersea domain becomes more crowded. The US looks forward to playing a role with its submarine nation partners in working through water-space management agreements and submarine rescue procedures.

Rear Admiral Phillip G Sawyer is the Commander Submarine Force of the US Pacific Fleet.

Vice Admiral Charles-Henri du Ché—French strategy for submarines

The submarine—with levels of mobility, versatility and stealth that are getting better and better—is not only a very potent weapon, but also a deeply political tool. This is why—taking into account the manpower and industrial and financial investment that they imply—they must be suited to specific strategic requirements. For the French Navy, France's very large exclusive economic zone and its interests overseas require long-range submarines. This requirement is shared with Australia: Australia's navy—and especially its submarine force—is linked to Australia's geography and world interests.

From the French point of view, the driving force behind our submarine force was the creation of France's nuclear deterrent force at sea. Maintaining a credible continuous at-sea deterrent of three SSBNs during the Cold War demanded enormous feats of secrecy, reliability, security, education and training. The French Navy now possesses four SSBNs and six SSNs.

The size and shape of France's submarine force haven't changed since 1996. The longevity of this submarine force can be explained by a combination of two factors. First, proof of the requirement through operational success recognised at the political level—the delivery of unbroken continuous at-sea deterrence requires four SSBNs, and the operational need to have three SSNs deployed justifies a squadron of six. Second, control of acquisition and running costs, without which—irrespective of operational utility—confidence in the submarine force would be lost at the joint headquarters level and the political level.

Achieving success in developing the Barracuda class of SSNs required first listening to the feedback from the operational side and from industrial experience to determine the minimum finances required, and then making choices about what was essential. Learning from innovations of previous classes of submarine was also key. Permanent linkages between industry and the users, but also the presence of an active broader technological and defence industry base, allowed France to successfully run the Barracuda project without the price exploding.

For sure and credible submarine forces, six necessary conditions must be met:

- Determine and justify real operational needs to make the right decisions for the right target.
- Build and maintain a submarine that is operationally effective to ensure a good return on investment and an operational advantage, which will then be attractive to personnel.
- Control costs over the long term for both acquisition and upkeep.
- Have a robust national organisation able to make the right capability-based decisions balanced with value for money.
- Have a sustainable defence industry able to collaborate seamlessly and openly for the long term, with active research and development supported at the highest levels, with the ability to absorb lessons from previous classes of submarine and also from current operational feedback, and with frank and honest dialogue over technological and financial limits on the desired capabilities.
- Train and operate across the full spectrum of operations—including with the other services—to build credibility with political and military authorities and also to motivate crews, without which there is no submarine capability.

Success is about the virtuous circle of dialogue and cooperation between the operators and the contractors, which demands experience, honesty and, above all, continuity.

Vice Admiral Charles-Henri du Ché is the Admiral for International Relations and Partnerships in the French Navy.

Colonel Ngong Boon Kheng—A Singaporean perspective on submarine rescue

As navies develop submarine capabilities, it's necessary to build up a submarine rescue capability—be it individually or collectively—as a parallel development. The Republic of Singapore Navy (RSN) submarine force has gained much operational experience in submarine escape and rescue (SMER) capability over the past decade through participation in various internal, bilateral and multilateral exercises. The knowledge gained has reinforced the RSN's belief in the need to build a viable organic submarine rescue capability to respond swiftly to emergencies. SMER capability is vital to the management of worst-case scenarios involving distressed submarines.

There are two main options for SMER capability development: raising organic submarine rescue assets or leveraging partner navies with existing rescue capabilities. On the one hand, establishing an agreement with a partner navy can promote mutual understanding and deepen navy-to-navy relations, while at the same time saving the costs of raising and maintaining an indigenous SMER capability. On the other hand, having organic assets allows for faster response and coordination and avoids reliance on external counterparts. An organic rescue capability can either be raised within the navy, which requires significant investment of naval resources and manpower, or leveraged from available commercial expertise and resources, with suitable mechanisms to allow the navy to exercise command and control over the capability.

The RSN has opted for a commercially owned, commercially operated approach rather than raising a new naval capability. This approach has proven to be more cost-effective and less resource intensive, from both manpower and training perspectives. This public-private collaboration provides three chief benefits. First, it allows the RSN access to the highly specialised field of submarine rescue while leveraging the ship construction capability of Industry. Second, it delivers a means of achieving a reliable rescue service without taxing the already lean manpower of the RSN. And third, it has enabled the rapid build-up of an organic submarine rescue capability for the RSN, taking only four years from conceptualisation to operationalisation.

Building and maintaining strong networks for multilateral submarine rescue is key as more countries in the region acquire or enhance their submarine capabilities. The RSN's efforts to promote regional SMER cooperation have included hosting and participating in exercises and professional forums. To date, the RSN has established bilateral submarine rescue arrangements with the Indonesian Navy, the Royal Australian Navy and the Vietnam People's Navy. The safety of lives at sea is paramount, and the urgency of a distressed submarine incident means that the importance of submarine rescue cannot be overemphasised. The RSN is ready to join the larger SMER fraternity in a concerted and purposeful commitment to the growth of submarine rescue in the region in conjunction with submarine acquisition decision-making.

Colonel Ngong Boon Kheng is the Commanding Officer Submarine Squadron of the Republic of Singapore Navy.

Mr Simon Todd—Submarine capability: requirements definition for Australia

The Future Submarine Integrated Project Team (IPT) comprises a mixture of industry (mostly Australian) and government (Defence Materiel Organisation, Defence Science and Technology Organisation, Capability Development Group and Navy) personnel. Most of the team of approximately 60 come from industry. Six team members come from the UK and two from the US, and there's considerable US engagement through the NAVSEA Peer Review Team.

The IPT's remit includes generating an organisation with all the necessary information, infrastructure and know-how to operate as an 'intelligent customer', so that the Commonwealth is equipped to direct and manage the Future Submarine design and build program, whatever option is selected by government. While the IPT's technical focus is principally on a new submarine design, most of its products are likely to be used whatever design option the government selects for the program.

The following key assumptions and derived requirements underpin the IPT's work:

- Australia will maintain a regionally superior conventional submarine capability, principally enabled through continued access to sensitive American and British technologies.
- The Australian Government places considerable value on its strategic alliance with the US, and on submarine interoperability.
- Australia's submarine requirement is unique and won't be met by an off-the-shelf solution, so the government should be prepared to commission and manage a new design and shouldn't expect any export sales for the Future Submarine.
- The IPT is directed to 'grow sovereign submarine enterprise capabilities' in order to be able to generate and manage an independent submarine capability.
- Australia's Future Submarines will be assembled in South Australia, so any design created overseas must be imported and matched to Australian shipyard practices.

Central to the IPT's program is the generation of a design brief—an encapsulation of Australia's requirements. The government is likely to commit considerable engineering and technical resources both to ensure compliance with the brief and to acquire sufficient technology transfer and knowledge to enable Australia to discharge its responsibilities as an owner and a user. Submarine safety is a chief driver: there are no international standards, and Australian safety legislation places specific responsibilities on designers and operators.

The IPT is also charged with generating cost and schedule forecasts for a new design; delivering a procurement strategy; growing Australia's sovereign submarine enterprise capabilities and capacity for the future; engaging with industry and government organisations to facilitate the formation of the total national enterprise that will deliver Australia's Future Submarine capability; and advising on organisational and commercial arrangements for the SEA 1000 program.

Australia has no track record of designing submarines, rendering it inconceivable that Australia could undertake the Future Submarine design without significant overseas help. So the IPT intends to engage a proven submarine design house to assist with the design of the submarine. The IPT is working so that the government will be ready to select a preliminary design in late 2016 or early 2017 (consistent with the in-service dates mentioned by the Defence Minister). The IPT's task of deciding how the design house engagement will work to produce an acceptable balance of risk to the Commonwealth is especially vexing. Although we've been offered many opinions on this matter, there's no obvious winner. The IPT isn't seeking to select the design house at this stage—that's at least a year away.

Much needs to be done in the short term to maintain momentum in the program, including determining how the engagement of an overseas design house might affect access to key US and UK technologies necessary to deliver a capability edge in the region; access to the intellectual property required to operate and sustain the boats safely and

effectively; and finding a business model that's attractive to the Australian Government and its principal industrial partners, the design house and its parent government.

Then there's the question of how much the Future Submarines will cost to design, build and sustain. Despite many unknowns remaining, the IPT's efforts to address affordability include challenging the ambitious 2009 White Paper requirement, keeping requirements in check (focusing on a requirement best characterised as 'Contemporary Collins'), and having a robust design and requirements management process. At this stage in the acquisition process, there's no need for a commitment to final numbers, other than what's necessary to avoid a capability gap—and that's really only an issue after the early 2030s.

Mr Simon Todd is the Lead of the Future Submarine Integrated Project Team.

Dr Chris Edmonds—The new design option

Australia should pursue the new design option for its Future Submarine for a number of reasons. First, by definition the world market can't provide a regionally superior submarine. Second, Australia's regulatory standards and the issue of reliability—the distance between Australia and its strategic partners—dictate a high level of self-sustainment. Third, the capability requirements—interoperability with the US Navy and other partners, and the range and endurance necessitated by geography (submarines are offensive weapons, and the best place to use them is up-threat) are specific to Australia.

Determining the best value for money for the Future Submarine requires undertaking cost–capability trade-offs in a highly complex and unique environment, and understanding the costs of designing, building and sustaining any of the potential alternatives. In turn, that requires an understanding of the cost base and the drivers of those costs. Understanding the connection between design options and costs is the focus of the IPT.

The task, ultimately, is to provide a submarine that can fight and win, and the IPT is working to derive the appropriate measures of effectiveness for the future boats. For offensive weapons, measures of effectiveness include kill probability and vulnerability to detection. Other tasks, such as intelligence, surveillance and reconnaissance, have other measures of effectiveness. Amalgamating these measures to determine their combined benefit requires an understanding of the operational environment and strategic goals relating to the FSM, including the current and future threat environment. Operational requirements need to be set in a solid way without being too optimistic—the right level of ambition is needed. And once the required performance is clearly defined, we should avoid pushing the technology too far and resist the temptation to alter performance requirements once they are set.

The IPT is right at the start of this process, looking at Australia's submarine solution space and working hand-in-glove with the Capability Development Group. The aim is to start initial/preliminary design, but everything that the IPT is doing at the moment is in essence exploring that solution space. It's not about making finalised decisions—it's too early for that—but about informing the government about what that affordable capability should be.

Understanding the design well enough to make intelligent decisions in the trade space of capabilities and project risks is important, as is understanding the design to allow for an upgrade path to maintain a capability edge. The IPT is working closely with the seaworthiness team to understand the government's legislative responsibilities. Maintaining and evolving the capability into the future requires maintaining the customer capability and the industrial base, as well as the ability to generate all of the fundamental inputs to capability, including research and development, tactics and training. If Australia is to pursue this goal, then a way needs to be found to manage and contain the risk and the associated costs, and it has to be an enduring capability, rather than a one-time procurement. That way we'll be able to evolve the design between batches of submarines, rather than moving to completely new designs at intervals.

The IPT is working towards a sovereign capability of a world-class and reliable SSK, excelling in its required role, and designed by Australians (with international support) for Australia. The FSM will constitute a battle-winning combat edge with offshore support where required and with best-of-breed military-off-the-shelf equipment. We'll get there through a clear, stable, underwritten capability requirement, with batch procurement to stabilise the design process—which reduces integration risk through certainty of design data.

Dr Chris Edmonds is the Design Manager of the Future Submarine Program.

Admiral Harry B Harris Jr—Dinner speech: The evolution of US Pacific strategy

The main reason why the US Pacific Fleet maintains a strong presence throughout the Indo-Pacific in support of the US strategic 'rebalance' is to support vital US national interests tied to a region that's emerged as the driver for the global economy. In this context, China's recent assertive maritime behaviour is of concern. Beijing's declaration of an air defence identification zone was done unilaterally without prior consultation with other parties, and over disputed waters. Its maritime sovereignty claims have no basis in, or relationship to, international law, such as the area within the so-called 'nine-dash line'. China's neighbours are concerned, and attempts to unilaterally change the status quo would negatively affect regional stability. There are both growing uncertainty in the region and increasing tensions, which could lead to dangerous miscalculations.

These challenges underscore the importance of the US remaining active and strong in the Indo-Asia-Pacific. The US has key interests in this region, and Washington takes its treaty commitments seriously. The US strongly opposes coercion as a means to resolve territorial disputes and believes that a peaceful resolution to territorial disputes is in the interests of all nations of the region. For this reason, the US applauds the recent decision by the Republic of the Philippines to take its ongoing territorial disputes with China to the International Tribunal on the Law of the Sea.

The US is focused on working with regional allies and partners to maintain security, stability, prosperity and peace. RIMPAC 2014 is a case in point, with 23 participating nations, including for the first time ever Brunei and China. China's acceptance of the RIMPAC invitation has been an important milestone. Despite the aforementioned concerns, the US welcomes the emergence of a peaceful, responsible and prosperous China as a positive contributor to Asian stability and as a member of the community of nations. It's in the best interests of all that frictions are managed and misunderstandings at sea are prevented through sustained navy-to-navy dialogue and practical cooperation on maritime challenges.

When it comes to its future submarine capability, Australia has a choice to make: to be a relevant maritime power or not. There's scope for deeper cooperation between the US and the Royal Australian Navy. US Marines are now rotating through Darwin. After more than a decade of fighting ashore, the US Marine Corps is returning to its roots and deploying from Navy ships. The emerging Australian amphibious force and new naval ships, such as the new Hobart class air warfare destroyers, increase the potential for enhanced cooperation and interoperability.

Admiral Harry B Harris Jr is the Commander of the US Pacific Fleet.

Mr Stephen Ludlam—The view from Industry

One key question about Australia's FSM is whether its design should be based on a military-off-the-shelf (MOTS) or modified MOTS solution. Those in favour argue that these options will reduce risk and will be cheaper. However, Australia has unique geographical requirements, demanding a submarine that's bigger and can travel further than many existing designs allow. Moreover, the initial acquisition cost of a submarine is only a third of its total lifetime cost—the other two-thirds are for maintenance and sustainment. Because submarines are very complex to build and difficult to maintain, the only in-depth way to understand the design is to build them in-country.

Australia must also be able to maintain and service the FSM onshore; we can't rely on other countries to do so, particularly in times of crisis. Accordingly, even if Australia were to buy offshore, the government would still need to be across the intricate details of the design to maintain the submarine effectively and efficiently. And if two-thirds of the FSM's costs are in maintenance and only one-third in build, there's a strong case for Australia to become expert at designing submarines.

It makes sense for Australia to both design and build the Future Submarine in-country. This also becomes apparent when considering the option of selecting a MOTS design and modifying it to suit Australia's operational requirements. A modified MOTS option is pretty much akin to a new design, and a time-consuming and expensive process, which in the end might not produce the best possible platform. The complexity of a modified MOTS approach shouldn't be underestimated and would have to be thought through very carefully to make sure Australia doesn't end up in a de facto new development and design program.

In contrast, either the evolved Collins or the new design option would constitute an excellent outcome for national security, the ADF and Australia's naval shipbuilding industry. It would provide the base for a continuous build program that would benefit over time from increased productivity and lower costs. In this context, the counterargument about high labour costs disregards the fact that a premium in workforce-related expenses is only required at the start or restart of the program. It's also important to note that pay rates in Australia are broadly comparable to those in shipbuilding industries around the world. There's no reason why Australian shipbuilding can't be efficient and effective, like the top-end shipyards around the world, provided there's perseverance, lean manufacturing, increased productivity, motivation and good leadership.

A key lesson from the Collins program is that the design needs to be right from the very beginning. That's why it should be proven through either prototype or a land-based test facility before the building starts. The sooner the preferred builder can be brought into this process, the better. There needs to be an interactive discussion between the designer and the builder to make sure the design is something that can not only be built, but subsequently maintained.

Australia's one of only a handful of nations with the ability to produce its own submarines and the opportunity to be innovators, not improvisers. The FSM program provides a great opportunity to develop an affordable and highly productive industrial base, which will create jobs and provide for Australia's national and economic security and prosperity for generations to come.

Mr Stephen Ludlam is the Chief Executive Officer of ASC Pty Ltd.

Dr Mark Thomson—An economic perspective on defence and industry

Apart from the unqualified success of the Anzac program and, I hope, the local completion of the two massive landing helicopter dock vessels, there have been serious problems in every major naval shipbuilding program undertaken in Australia. In many instances, the problems reflect the intrinsic technical difficulty of what industry has been asked to do, and often the cause is the pursuit of Australia-unique requirements.

The most common explanation proffered for the trials and tribulations experienced by local naval projects is the stop-start, boom-bust demand schedule from Defence. Many in industry and some in government believe that we need to move to a 'continuous build' program, in which vessels are delivered in a never-ending stream. One problem with this approach is that it would constrain the ability of future governments to make decisions, as a continuous build program would lock the government into maintaining the size of the submarine and surface fleets, thus fixing the minimum size of a large and expensive part of the force structure. From a public policy perspective, it would lock in a substantial chunk of what was previously discretionary spending. And a permanent shipbuilder and its workforce would also have every incentive to lobby to preserve their privileged position and expand it to the extent feasible.

The seeming certainty of a 12-boat Future Submarine build has evaporated—quite properly, as the new government will determine the number of boats to be built on the basis of strategic and operational analysis yet to be undertaken. Nonetheless, the potential benefits of a continuous build option remain relevant to decision-making, especially if an enduring indigenous submarine design and build capability remains a policy goal. But the government appears to be backing away from a commitment to 12 submarines. I'm not sure that these positions can be reconciled. I'm not convinced that there's a business case for a continuous build with 12 boats, and I'm certain that there isn't for a smaller fleet.

Similarly, the scale of Australian demand for warships—11 surface combatants— makes the business case for a continuous build program tenuous. Either it would have to work at a glacial pace, or the Navy would have to reduce the life-of-type of its vessels. The question becomes: is the added cost of replacing vessels more frequently (offset to some extent by fewer mid-life upgrades) justified by the savings and benefits of continuous build?

I'm not sure it is. While such a program would allow the shipyards to progressively deliver higher productivity, thereby reducing costs and lowering the risk of schedule delay, the cost of more frequent replacement would be hard to overcome. Even assuming a favourable learning-curve benefit from continuous build, against this would be several countervailing costs, including the added cost of more frequent replacement, and added costs from maintaining administrative and managerial overheads continuously rather than for a limited time, both in industry and in the Department of Defence.

The question of the acquisition strategy for the Future Submarine is critical. While it may be too early to answer some of the obvious questions, the sooner they're thought about and debated in public, the better the chance of making the project a success. (See Pages 32–44 for more details on the acquisition strategy.)

Dr Mark Thomson is a senior analyst at ASPI.

Mr John Birkler—Building the right industry skills

Designing submarines and managing their production are extraordinarily complex endeavours, made even more complex in Australia's FSM program because key program decisions have yet to be made, including desired performance (displacement, speed, range and so on), whether the design will be derivative or new, the level of acceptable risk, government–industry roles and responsibilities, and when the first-of-class is required.

For Australia to design a new, conventionally powered submarine to replace the Collins, RAND studies show that it'll need a domestic workforce of roughly 1,000 skilled draftsmen and engineers in industry and government to create and oversee the design. Such a workforce doesn't exist in Australia today, but one could be cultivated over the next 15 to 20 years under the right circumstances. By collaborating with foreign design partners rather than relying exclusively on a domestic design workforce, Australia could shorten the duration and lessen the costs of designing a new submarine.

The RAND study into Australia's domestic submarine design capabilities estimated that designing a conventional submarine today would require an effort of 8 million to 12 million man-hours over 15 years from a workforce of fully proficient, experienced submarine design personnel. This translates into a labour pool that, at its peak, would involve 600–900 submarine-proficient draftsmen and engineers in industry plus 80–175 oversight personnel in government. While government employs enough oversight personnel to meet its peak demand in most skill areas (although the availability of some may be in question insofar as they're involved with other naval and commercial programs), that's not the case for Australian industry, where acute shortfalls exist in multiple skill areas.

There are a few options for Australia to close these gaps and be in a position to develop and acquire the FSM using domestic design capacities. RAND's analysis identified two industry options and one preferred option that makes the most sense for government:

- Industry Option 1: hire and train personnel from within Australia. This would require recruiting and training draftsmen and engineers with no submarine experience. Not only would this workforce need more man-hours and a longer schedule to design the new submarine, it would need to shrink as the design program nears completion. But the result would be a capability to design submarines solely within Australia.
- Industry Option 2: infuse submarine-experienced personnel from abroad—by recruiting internationally, by having Australia-based companies draw from their international offices, or by partnering with another country's design organisation. This would shorten the schedule and lessen the cost. The advantage of this approach would be that international personnel could return to their home countries as the new design program winds down. The disadvantage is that new submarine design programs in the US and UK may preclude the availability of experienced submarine design personnel from those countries, and Australia might not be left with the total capability needed to design a new submarine.
- Preferred Government Option: draw core personnel from the Collins class to start the Future Submarine program, then grow new personnel. This option would draw from the Collins-class experience, reduce the risk of under-resourcing the Collins class and other programs, and be likely to incur reasonable costs in training.

Mr John Birkler is the Maritime Programs Manager at the RAND Corporation.

Dr Donald C Winter—Systems integration

Systems engineering and integration (SE&I) skills are critical to the successful development of complex systems such as submarines. Multiple approaches have been employed in the US to obtain and apply such skills, with varying degrees of success. The optimal approach for any program depends on multiple factors, including the diversity of stakeholder priorities and agendas; the maturity of the design concept; the complexity of design, physical and functional integration challenges; and the available sources of SE&I skills and experience.

After the end of the Cold War, a push to adopt commercial practices took hold in the US military. The P-8/Boeing 737 program provides a good example of the successful adaptation of a commercial product, leveraging an ongoing production activity to derive a valuable military capability by utilising an invested base of technology, tooling, personnel and production capabilities to order quantities of an effective platform on an annual basis. In most cases, however, the effort required to adapt commercial products has been grossly underestimated. The difficulties faced in transforming commercial coastal ferries into the littoral combat ship capability are a case in point; significant changes were required to accommodate the multi-mission modules that were being separately procured and to deal with the unique requirements of naval operation rather than commercial operation.

The 'prime integration contract' approach has in general proven to be less than satisfactory and difficult to execute successfully. Challenges arise from contractors attempting to optimise system solutions and from dealing with multiple stakeholders with potentially conflicting priorities and agendas. This approach fundamentally diminishes the ability of the government—and the military in particular—to influence the design and production approach. The result is that the course often becomes one of optimising a specific acquisition as opposed to optimising the enhancement to the fleet. The improvement to the fleet's capability is always more important than how much ship you can buy with a given dollar, and the two are not necessarily the same when one considers issues such as crew size, sustainment costs and sparing.

The SE&I efforts needed for success are very diverse, and some SE&I products, such as concepts of operations, system specifications reflecting trades of stakeholder priorities, and verification and validation requirements, must be developed by the military with support from trusted agents. Design and physical integration are often best contracted out to industrial organisations with appropriate skills because generic systems-engineering skills are inadequate; what's needed is knowledge of technologies and the application domain. Moreover, oversight by an SE&I trusted agent is invaluable. New systems create major SE&I challenges, with multiple stakeholders with differing priorities and multi-level trades without historical baselines. For these projects, an SE&I team must be established in a timely manner to provide conflict-free advice and counsel.

Every program is unique, requiring an honest assessment of SE&I capabilities and weaknesses as well as necessary SE&I functions and potential sources. There never seems to be enough time to do it right, but it will take more time to do it wrong.

Dr Donald C Winter is a former US Secretary of the Navy.

Mr David Gould—The view from the top

The FSM is a strategic program designed to produce a platform that isn't just tactical but is one that'll produce a fundamental shift in an adversary's ability to act. Strategic programs are lengthy and expensive and involve technological challenges. They can be difficult due to the advance of technology and the requirement to keep them at the edge of research and development, and strategic effect comes from very closely guarded technologies. But these projects are also driven by time, and schedule should be at the heart of the project. While the extension of the Collins class life is inevitable, it shouldn't delay the FSM project.

To reconcile these demands and overcome challenges and difficulties, the program needs to be both credible and solidly supported within government. Successful projects usually include two key elements. First, they contain sophisticated technological challenges, but those will be constrained by project risk management of what really matters. Second, they exploit the national technology base and beyond—with technology coming from and being shared with partners.

Australia's FSM will have to operate independently of a ballistic missile force, and its strategic effect will depend on its operation forward and up-threat. Given our geography, this imposes serious capability demands. Stealth and the combat system will confer survivability and superiority in combat. These are the 'crown jewels' of submarine design and aren't (and shouldn't be) readily shared. We have to earn the trust of partners, so Australia needs to have a credible science and technology base to establish credentials. We have such a base in Adelaide, which is showing increasing credibility to our allies.

Capability really matters, but the program shouldn't be just about designing an elaborate SSK but also about managing the interplay of capability and cost. The control of the design process and the transition to design and construction needs to be strong, since that's where risks will manifest. Earlier boats in the FSM project might need to trade off capability, while later models will be able to incorporate new technologies. Rigid discipline is essential for a successful project: design margins are there for design, not new capabilities.

The builder and maintainer should be involved in the design, and Australia should embark on a formal design process with industry. Since we lack contemporary experience in turning a design into an executable program, care will need to be taken when conducting consultations.

Australia needs an approving authority for the design and certification for the submarine throughout its life. This may challenge assumptions about how people are recruited and contracted in Australia. Such a body can't be entirely home-grown, but we hope a substantial part can be. Finding the right partners won't be easy, and we'd be fortunate indeed to find all the capabilities in one place. But we need to have partners we're comfortable sharing sensitive capabilities with.

We also need to develop a commercial model for execution. While the design process is critical to determine cost, the commercial arrangement will provide the incentive for execution. However, allocating commercial risk is tricky. Fixed price agreements usually make for trouble, and government ends up paying the price. Australia should look to create an enduring enterprise and make a long-term commitment to the program, rather than a one-off purchase.

Mr David Gould is the General Manager Submarines at the Defence Materiel Organisation.

Mr John Coles—Lessons from the past

The value of defence project reviews by government audit offices in assessing lessons learned can be limited. They're undertaken with 20/20 hindsight and are restricted in their ability to report on classified information and by the nature of parliamentary committees, which can be more like a blood sport than an opportunity to comprehend challenges. But audit reports can nonetheless provide useful lessons by drawing on both the errors and successes in programs and by observing how others achieve excellence.

There are two critical and interdependent elements of submarine programs: what to buy and how to buy. As other speakers at this conference have said, the 'what to buy' element could be summarised as a 'contemporary Collins' with improvements in stealth. Left to the aims of the 2009 White Paper, this design could end up on the higher end of technical difficulty due to the push for a conventional submarine with desired capabilities closer to those of a nuclear model. But design is always about resolving conflicting demands and, if the 'what' isn't controlled, a project can be in serious trouble from the outset. Key stakeholders will need an iron grip to prevent capability creep.

Then there's 'how to buy'. The next class of submarines should be managed strategically. As archetypes, programs such as the UK's Polaris and Trident were examples of strategic projects that were successful in time, cost and performance. But the unsuccessful example of the UK's Astute class should warn us of the 'conspiracy of optimism' and remind us that all such programs are high risk.

When building a small fleet in-country, it must be accepted that the submarine will be procured from a single source, and that large elements of the program will therefore be non-competitive. For a program to succeed, the government must hold most of the risk and accept the cost of ownership from the outset.

And the job doesn't stop at delivery. The readiness demanded and maintenance required for the fleet are key drivers of sustainment cost and were poorly managed in the Collins class. If the Future Submarines are to engage in long and distant patrols, reliability must be ensured. A competent team within the government as well as a capable industry will be needed to handle the immense tasks associated with this.

Australia needs clarity about both what and how to buy. It has to be a partnership between a capable buyer and a capable supplier, and both need to avoid reaching too far in capability ambition—if it works, don't break it.

Mr John Coles is the author of the Coles Review into Submarine Sustainment.

Ms Janis Cocking—Systems integration

One of the important roles that scientists play in the FSM project is identifying and mitigating risk. This is particularly critical for submarines, given the nature of their operating environment—submariners bear the most risk when it comes to submarine projects, not the government. Scientists must work hard to decrease that risk as much as possible.

Of course, there are other benefits from scientific input. Take the Anzac class frigate anti-ship missile defence upgrade, for example. In that case, identifying technical risks early and bringing modelling and simulation to the enterprise both paid off for the capability eventually delivered. It also showed the benefits of keeping operators in the loop. Those lessons will be critical to the FSM project.

The Collins class experience also has lessons for us. At the time the fleet was being designed and built, Australia had no coordinated program for submarines and lacked experience in many key areas. But those problems were solved, and that resulted in a class of submarines with many successful design elements. One such is the capacity of Australian submarine plates to withstand explosions. This example demonstrated the value of collaboration between the Defence Science and Technology Organisation, the US and industry. The Collins class's indigenous anechoic tiles are another significant example of success; they were developed independently for the Collins class and now represent Australia's own 'crown jewels'. I'm also particularly proud of the adhesion of the tiles to the boats; the Royal Australian Navy is the only navy to have never lost a tile at sea.

There were problems, many of which are widely (and often inaccurately) reported upon. And there were technical missteps as well, but they also allow us to learn. As John Coles said, 'You learn more from failure than successes.' One of the major criticisms of the Collins class was to do with radiated noise—one journalist wrote that the boats are as 'noisy as an underwater rock band'. While it's acknowledged that the Collins class had problems with noise, this became an issue of balancing risk and cost during the development of the submarines. The program also suffered from capability creep and flaws in the contractual agreement, which made it hard to tackle the problems effectively. We're in a much better place now: the Defence Science and Technology Organisation's hydro-acoustics program is now very sophisticated, and Australia is a smarter buyer when it comes to major acquisitions. We'll have to be good, though, because Moore's Law (see the summary of Andrew Davies' talk on page 13) will have implications for noise management in the FSM.

We'll also need to improve Collins class availability. We've had extensive problems with power and energy system issues, and the diesel engines caused many problems. This is a problem best solved by good systems engineering, and the Defence Science and Technology Organisation is now much better placed to help. It's important to get this right, as it affects the overall design of the boat and can be very expensive. Risks can be managed if specifications are clear, and processes need to be in place before the design is locked down.

Finally, there are human interfaces. The human element will provide the value and capability edge in the FSM. Issues such as anthropometrics are often overlooked when considering the human element of submarines. An unexpected problem was that the average height of personnel had increased over the lifespan of the Collins class; the FSM design will need to take such factors into account. Creating optimal conditions for submariners improves capability. The operators need to be involved in the design, and their experience needs to be embraced in Australia's FSM program.

Ms Janis Cocking is the Chief of Maritime Division at the Defence Science and Technology Organisation.

Admiral Gary Roughead (ret.)—The US experience

The nuclear submarine force is a key capability for any US operational commander. It's based on the requirement to operate across two great oceans, including in polar transit and operations. Size clearly matters; it enables additional missions, such as the employment of unmanned systems, special operations forces and additional strike payloads. The Virginia class submarines are testament to the formidable US submarine force.

A great submarine force is based on a healthy submarine ecosystem, consisting of three key elements: mission, industrial base and budget. First, it's critical to determine what the submarines are supposed to do. Otherwise they could turn into an unnecessary and expensive capability. Maintaining top-quality submariners is also essential to be able to perform missions. Second, when it comes to the submarine industrial base, the workforce needs to be regarded as a national strategic asset to guarantee high technical standards. Once an industrial base has ceased to exist, it's very difficult and expensive to restart it. Third, the budget must support the submarine ecosystem, including submarine safety and maintenance. The ecosystem must also prepare for and acknowledge that defence budgets rise and fall.

Two of the most successful programs in the US, the nuclear submarine program and the Aegis combat system, share several attributes. They both effectively dealt with—and didn't ignore—criticism. The projects also created and sustained the aforementioned 'ecosystem', and they demonstrated an insistence on excellence that became a standard for capability development. Finally, accountability was key to success. In both projects, unquestioned single points of accountability existed at the highest levels. The projects also had exemplary leaders in Admiral Hyman G Rickover and Rear Admiral Wayne Meyer, the latter known as the 'father of the Aegis'. Who, then, will be the father of the Australian submarine? And how can Australia put the right submarine ecosystem in place?

Admiral Gary Roughead (ret.) is the 29th Chief of US Naval Operations.

Vice Admiral Michel Accary (ret.)—The French experience

Industry skills and know-how are paramount to successful submarine building, as is a symbiotic relationship between industry and procurement. The successful design and build of submarines requires four elements:

1. the outstanding importance of safety
2. the need for a specific industrial environment
3. a dedicated research and development program
4. a harmonious and confident relationship between stakeholders.

Establishing an effective relationship between many stakeholders is a challenge that's growing rapidly with the size and complexity of ships. It's essential that stakeholders are trained to work together and conscious of the decisions and trade-offs they need to make.

DCNS was recently able to achieve the 'Holy Grail' for procurement agencies by successfully designing and building a series of Barracuda class SSNs within a fixed price contract. DCNS achieved this primarily through good management in the preliminary design phase. Fitting the design to cost, and making smart choices about trade-offs, were also important to this project's success. A good program is not an addition of requirements but a product of trade-offs.

Successful submarine design and build programs in India and Pakistan demonstrate the French experience of the transfer of technology in submarine programs. DCNS is currently involved in its most ambitious transfer of technology submarine program in Brazil, which is on track to design and build six SSNs in-country. These experiences highlight three challenges for building submarines in a new shipyard:

1. Building a series of sea-proven submarines requires specific industrial equipment and training.
2. Building a series of specifically designed submarines requires designs to be made in the same location as the builders, and with strong assistance from the designer.
3. Designing and building a submarine in-country requires commitment to human resources to create a local design office, but provides nations with all-important sovereignty over the design.

Submarine forces are of strategic importance to a number of nations, and DCNS respects the legitimate requirement for national sovereignty and autonomy in this area. DCNS can provide SEA 1000 with the benefit of its vast experience.

Vice Admiral Michel Accary (ret.) is the Special Advisor for Submarines at DCNS.

Dr Hans Christoph Atzpodien—The German experience

The German experience in submarine building has been a very international one, involving lots of different clients around the world. Naval business has dramatically changed since the global financial crisis. The 'drive for survival' in 2009—brought on by a build-up of shipbuilding in Asia—led European companies to dispose of underutilised and unproductive assets and focus on high-end specialised technologies, like submarines. The ability to draw on a long history of shipbuilding means companies like ThyssenKrupp Marine Systems (TKMS) have invaluable and irreplaceable experience in this sector. TKMS has become a leading designer and system supplier of conventional submarines and has accumulated experience in working with 22 different countries. The company has the capacity to build submarines in Germany and also to export the technology to customer shipyards—a critical and unequalled element of its successful business model.

Successful businesses in this sector strike a balance between capability, cost and risk. The ultimate goal of low-risk, highly reliable submarines with a long service life and minimal problems rests in design evolution—an area TKMS has developed over five decades. The company has a similar track record with surface vessels. Its experience guards against trapping customers with low initial prices that end up much higher due to unforeseen problems.

Export contracts have become increasingly vital for the company. TKMS customers' increasing experience and fleet size has led to a greater ambition among them to build—and in some cases design—in-country. In this regard, the protection of third-party intellectual property is fundamental to TKMS's customer relationships. Customers typically alter submarine designs to suit their individual operational needs, and this would probably be the case for Australia. Yet, size isn't a requirement but an outcome of all the specified requirements. The approach to a larger design, rather than the size of the design itself, can increase or reduce risk. Obviously, the need for long transits as a routine part of business for Australia's submarines will drive crew size, range and endurance requirements.

In contractual relationships, clear responsibilities and a simple contract model help to minimise risk. The aspiration for a unique design for the FSM should take into account that the submarine can be unique to the individual customer and incorporate sensitive allied technologies. This would help to ensure overall reliability, availability and long-term sustainment. Using TKMS's design experience—and thereby lowering risk—could decrease the projected cost of the FSM project with an order of 12 boats to around \$20 billion (\$16 billion less than ASPI's estimated project cost of \$36 billion).

Dr Hans Christoph Atzpodien is the Chairman of ThyssenKrupp Marine Systems (TKMS).

INDUSTRY ISSUES

How to buy a submarine: Part 2

Andrew Davies and Mark Thomson

Executive summary

The building of a replacement for Australia's Collins class submarines will be the country's most expensive defence project to date. It's also likely to be the most complex, with a myriad of capability, commercial and industrial issues to be managed: the expertise for the design and construction of conventional submarines resides in Europe and Asia while Navy's preference is for American combat and weapon systems. Pulling those elements together while managing the technical risks is no easy task.

Local construction of the future submarine has been a bipartisan position for several years, and it has the support of industry and the bureaucracy. But there's no simple or fast way to produce a unique Australian submarine. If the government decides to go down that path, it will have to do so in the knowledge that it's a high stakes venture. This paper describes some of the approaches that could be taken and outlines their pros and cons.

Despite claims to the contrary, there's little doubt that the merger of a European design and American combat system is possible—after all, that's what the Collins is. But a sensible early step in the process would be to have government-to-government discussions with the potential players—especially in Washington—to determine what the actual constraints are, and what's merely unsubstantiated folklore.

Surveying the world market, conventional submarine design capability with the experience and maturity required for our purposes can be found in France, Germany, Japan and Sweden. The UK hasn't designed or built a conventional submarine in over two decades, but the trusted nature of the 'five eyes' intelligence relationship and its ongoing nuclear submarine programs means that it's also a potential partner.

Of the possible European partners, France and Germany have established export markets, including the export of designs for construction elsewhere. The Swedish submarine industrial base is currently undergoing significant changes, but the close relationship between the Swedish and US Navy submarine arms makes them a credible contender. Japan is an established builder of large conventional submarines and there's high-level political support on both sides for a collaborative effort—and this is rapidly developing into one of the more likely options.

Then there's the Australian end of the arrangement. The most recent public statements from officials involved in the Australian program suggest that their preferred approach is similar to the Collins project—the standing up of a commercial entity specifically to execute the design and build. The advantage would be that a purposely created Australian-based entity could manage the interplay of participating European and American firms and their intellectual property. However, having created such an entity, the government would carry the majority of risk associated with the project from the start.

Other approaches are possible. Most simply, the government could go to the market and contract an existing international submarine designer/builder to undertake the project. Not only would this result in a cleaner commercial relationship, it would also give the Commonwealth a commercial counterparty with sufficient financial depth to shoulder a share of the risk in the project.

Finally, there's always the possibility that the government will weigh up the issues we describe in this paper and decide that it's all too difficult. In that case it'd need to decide whether offshore procurement options are able to deliver the required capability—or find an acceptable compromise between capability and risk.

Background

In April 2014, ASPI held a two-day conference on Australia's future submarine program entitled *The Submarine Choice*. At the conclusion of the conference, we were left with three disquieting impressions.

First, the submarine project has the potential to be very risky and expensive—especially if we decide to pursue an entirely new design. Conference presenters drove home the message that Australia currently lacks two key prerequisites for success: ongoing collective experience and a highly trained design, engineering and submarine-specific building workforce.

Second, there's a worrying disconnect between Defence's plans and the government's thinking.

Third, it was clear that Defence's thinking on the submarine acquisition strategy was simultaneously prescriptive and vague—prescriptive about the sort of commercial entity it wanted to undertake the submarine project but vague about how to create such an entity.

With these three impressions in mind, we decided that it was time to revisit what Defence calls the 'Future Submarine' project, with a focus on the practical problem of building the boats. This paper is our attempt to do so. It thus represents an update of ASPI's 2009 paper *How to buy a submarine*, written when the enterprise was newly instigated.

To inform our thinking, a preliminary draft of this paper was offered to stakeholders for comment. Our thanks go to the many who took the time to respond. Apologies are also due, because it has proven impossible to include, let alone reconcile, all of the widely disparate views we received on many issues. Such are the differences of opinion surrounding this complex undertaking. Of course, the views expressed in this paper are solely the responsibility of the authors.

Where we are today

Work is underway to initiate a submarine construction program to replace the RAN's Collins class boats. Estimated to cost anywhere between \$20 billion and \$40 billion, the project aims to avoid a capability gap when the Collins class leaves service.

But long before HMAS *Collins* is lifted out of the water for the last time, there's another gap to be filled: the gap between where we are today and the awarding of a commercial contract to build the new vessels. Given that a truly off-the-shelf contract—the only option in which things could move relatively quickly—seems unlikely, getting from requirements definition to concept design to detailed design and contract is likely to be a protracted affair.

Here's how things stand at the moment. On the basis of decisions taken by the previous government, Defence is progressing two options for the next-generation subs: an evolution of an existing design (in practice, the Collins) and a new design. For the moment—at least as far as is known from public announcements—the less ambitious military-off-the-shelf (MOTS) and modified MOTS options have been put on hold. This could change once the new government is fully briefed on the potential costs and risks of various options, but so far there's been no indication

of a redirection of effort. And, based on the consensus among speakers at the ASPI submarine conference, it doesn't seem likely that the government will get advice from Defence to reopen those options.

An integrated project team (IPT) made up of Defence and industry personnel is working in South Australia to develop a design brief. The submarine IPT will assist Defence and the government to make an informed decision on the future submarine program. In the jargon being used, the IPT will help the Commonwealth be an 'informed customer'. Views from within the IPT were made public at the ASPI submarine conference in presentations by Simon Todd and Chris Edmonds.

At the time of the conference, it seemed likely that the next step in the process would see Defence formally invite selected firms to consult regarding the project. While the details of that consultation weren't set out, the apparent aim was the formation of a commercial entity to deliver the submarines. Uncertainty about how we get from where we are today to the formation of the commercial entity is understandable, and it would make sense to talk to industry so that subsequent steps can be fine-tuned. Nonetheless, as things stand there seems to be a critical gap in the acquisition strategy for what's likely to be the largest single defence project in Australian history. The work to bridge that gap has started, but seems to us to be somewhat fragmented.

We'll discuss the 'new commercial entity' strategy in this paper, as it's based on the most recent public comments from within the project. But we'd caution that it's not necessarily the best approach, and it's always possible that the government will take the project in other directions as it becomes more attuned to the issues it has to navigate. We discuss several other possibilities, including the more 'traditional' approach of running a competition to identify a prime contractor for the design and/or build phases.

At the same time the details of the future submarine project are being decided, the Collins fleet requires attention in order to keep it operating effectively until the follow-on boat enters service. Given the scarcity of resources available to Defence and industry (at least locally), it'd be advantageous if some synergies could be found. That's possible if—and probably only if—an evolved Collins forms the basis for the future submarine. Otherwise, some careful resource management will be required, and a 'minimalist' approach to Collins life-of-type extension work might be necessary. As the 2011 RAND study of Australia's submarine design capabilities and capacities told us, we can't assume that there's an inexhaustible supply of suitably qualified people available to do everything that we might want within the timeframes available—even without the parallel requirements of the Collins life-of-type extension.¹

A new Australian Submarine Corporation

As best we can determine, the commercial entity that Defence envisages is likely to be a firm created for the sole purpose of designing, building and (perhaps) sustaining the new submarines. Much like the original Australian Submarine Corporation created for the Collins project (now known as ASC Pty Ltd), the new entity will include key industry participants in the project as equity shareholders. This doesn't exclude the possibility of the 'old' ASC playing a substantial role in the 'new' Australian submarine company.

There's a balancing act here. Although this sort of arrangement means that participants will have some skin in the game, the scale of the project and the cash flow to participants will comfortably exceed the capital base of the entity. At some point, therefore, risk will revert to the Commonwealth. Indeed, a purpose-created entity will shield the parent companies by putting their more substantive corporate assets beyond reach. One way to help manage the attendant risks is for the Commonwealth to have a 'golden share' or some other means of intervention to allow it to take control should the enterprise unravel—but, we should hope, not to intervene in the day-to-day running of the project.

It's too early to tell what sorts of firms will be in the commercial entity and what sorts of activities will be relegated to subcontractors. But it's probably a fair bet that the commercial entity will at least bring together the three core components of the project—design, integration and construction. Other possibilities would be a non-defence

professional project execution firm (such as Bechtel), key subsystem suppliers, and specialist technical consultancy services from the US (such as Electric Boat).

And thought needs to be given to through-life support of the new boats. Setting up an entity to produce the boats and then letting a contract for support separately might give a higher overall cost of ownership than approaching with a ‘design for support’ remit. That might entail a contract to build and support the fleet, at least for the first part of its service life, in which there are incentives in place to produce a supportable platform. If so, a firm with submarine sustainment expertise—such as Babcock in the UK—might usefully form part of the team.

It can’t be taken as given that through-life support will be provided for as part of an integrated build and support project. Neither the air warfare destroyer (AWD) project nor the landing helicopter dock (LHD) project currently underway has availed itself of this opportunity. Indeed, the through-life support arrangements for these soon-to-arrive vessels are yet to be set—as was the case when the Collins began its unhappy in-service phase.

Commercial combinatorics

On paper, at least, there’s a range of potential firms in the three disciplines of design, integration and construction. Perhaps the broadest range of options exists for systems integration. Major US companies such as Boeing, General Dynamics, Lockheed Martin, Northrop Grumman and Raytheon are all plausible contenders, as is BAE Systems. Swedish firm Saab also has a strong local presence, has performed well in the Anzac frigate anti-shipping missile defence upgrade, and has provided the combat system for the LHDs in construction and ship management systems in the Collins.

Accurate or not, there’s a widely held perception that a European firm would have difficulty obtaining the permissions required to integrate sensitive US subsystems and submarine technologies onto the vessels. Of course, that’s an easy assumption for officials and industry players to make. And for a number of players circling the submarine program, it’s a convenient one, too. In sorting through the many comments we received on a draft of this paper, we found black and white views expressed in both directions. The only way the Australian Government can get a definitive answer to the question of which international entities will be able to participate in the project is to start a government-to-government discussion with the British, French, German, Japanese and Swedish governments and, of course, with Washington. We need to ask the hard questions that allow us to identify any truly inviolable issues.

When it comes to construction, the possibilities are complex, to say the least. Through its ownership of ASC Pty Ltd, the Commonwealth already owns a yard that built submarines from 1990 to 2003 and has sustained them since. But it’s far from a foregone conclusion that ASC will be the builder of the future submarine. Despite having set up an internal cell (‘Deep Blue Tech’) to work on the Collins replacement, ASC wasn’t engaged by Defence on design work on the future submarine. Although ASC is involved in the submarine IPT, it’s just one of many firms contributing. Given the perceptions arising in decision-making circles from ongoing problems with the AWD project, the prospects for ASC’s involvement are now probably even lower.

Without going into detailed permutations, ASC could be kept as is or be broken up into as many as three pieces—submarine maintenance, submarine construction and shipbuilding—although how submarine building and sustainment are most efficiently organised will depend on which design is chosen for the future boats. All or any of the resulting pieces could be sold to the private sector or retained in public hands (including by retaining ASC infrastructure as a public asset). And if the government wants to divest itself of all or part of ASC (as suggested in the Commission of Audit Report)², the best time to do so is probably going to be when the arrangements for the future submarine are established.

What’s likely is that some of ASC’s infrastructure (and adjacent assets owned by the South Australian Government) will be used for the new submarine project—by ASC Pty Ltd as submarine constructor, by a private-sector firm operating physically adjacent to the existing ASC yard, or by a private-sector firm that acquires ownership of all or part of ASC. There are any number of local and foreign firms that could play the third role, including BAE Systems, which already operates a shipyard at Williamstown in Victoria.

The situation looks even more interesting when it comes to choosing a design partner. Only two submarine builders spoke at the ASPI conference: DCNS from France and ThyssenKrupp Marine Systems (TKMS) from Germany. As well as building submarines for their national navies, both firms have extensive experience in helping other countries build and maintain conventional submarines (see Table 1). As is discussed below, the AWD project suggests, and foreign experience confirms, that having the designer also be the builder (or at least giving them significant direct oversight of the build) offers many advantages.

Table 1: Recent European submarine exports

Supplier	Customer	Submarine type	Contract signature (first delivery)	Comments
DCNS (France)	Brazil	4 × SSK (Scorpene derivative) 1 × SSN	2009 (2017)	The forepart of the first of class SSK will be manufactured in France before being transported to Brazil for completion, along with the build of the other three boats.
	Pakistan	3 × SSK Agosta 90B	1994 (1999)	First boat built in France, remaining two in Pakistan.
	India	6 × SSK Scorpene	2006 (2016)	All boats to be built in India.
	Chile	2 × SSK Scorpene	1997 (2005)	
	Malaysia	2 × SSK Scorpene	2002 (2009)	Built cooperatively by DCNS in France and Navantia in Spain.
Kockums (Sweden)	Australia	6 × SSK Collins	1987 (1996)	Design elements and intellectual property.
	Singapore	6 × SSK Challenger / Archer	2005 (2009) Archer	Refurbished ex-Swedish Navy Sjöormen and Västergötland classes.
	Brazil	5 × SSK Type 209		The first four delivered from 1989–1999 and the 5th is a substantial redesign as the Tikuna class.
TKMS* (Germany)	Greece	Up to 6 × SSK Type 214	2000	First of class constructed in Germany, next three in Greece.
	South Korea	9 × SSK Type 214	2000	Assembled in South Korea. Follows nine Chang Bogo class Type 209 boats between 1993 and 2001.
	Portugal	2 × SSK Type 214	2005 (2010)	German-built.
	Turkey	6 × SSK Type 214	2009 (?)	Will be built in Turkey, with German technology packages provided. Turkey is a long-term TKMS customer, taking 14 Type 209 variants 1976–2007.
	Israel	3 × SSK Dolphin 2	2006 (2012)	German built, follows previous purchase of three Dolphin class.
	Singapore	2 × SSK Type 218SG	2013 (2020?)	Evolved design with AIP, will be built in Germany.
	South Africa	3 × SSK Type 209	2000 (2005)	

*TKMS has also refurbished and exported a significant number of Type 209 submarines for a variety of customers – omitted here for brevity.

Until recently, it looked as though the German-owned but Swedish-resident submarine builder TKMS-AB—previously known as Kockums—was also a possibility. But here hangs a tale. The Swedish firm Kockums (designer of the Collins class) was sold to German firm HDW in 1999. In 2005, HDW became a subsidiary of TKMS. Since that time, what was Kockums has been operating under the name TKMS-AB in Sweden.

Earlier this year, the Swedish Government decided to bypass TKMS-AB and award work for the upgrade and replacement of its submarines to Swedish firm Saab. To secure the expertise necessary to execute the program of work, Saab has been actively recruiting TKMS-AB employees. Negotiations are now underway for Saab to purchase TKMS-AB and its facilities, thereby allowing Kockums' assets to be reunited with its workforce. If negotiations fail, Saab will build a new facility to undertake Sweden's future submarine work. Critically, the Swedish Government has retained the intellectual property associated with Kockums throughout the changes of ownership.

Notwithstanding this recent turmoil, Saab stands ready to play a role in Australia's ongoing submarine programs (including the Collins life-of-type extension) and has the backing of the Swedish Government to do so. Indeed, a strategic partnership between the two countries has been suggested. Meanwhile, TKMS-AB has been working on the evolved Collins option, and the first stage report is due by mid-2014. If the Saab acquisition of TKMS-AB proceeds, we presume that work on the evolved Collins will transition to Saab.

There's a question about the amount of effort that would be needed on a 30-year-old design to 'evolve' it into a 21st century warship, and many observers are of the view that it would practically amount to a new design—but one unreasonably constrained by Collins features such as the hull diameter. Less ambitiously, a technologically refreshed Collins design with a new propulsion system and updated combat system and sensors might be a useful benchmark against which other options can be tested for cost-effectiveness.

In any case, be it an evolved Collins or a new design leveraging Sweden's submarine replacement program, Saab has now emerged as a credible contender to design Australia's future submarine. In doing so, it offers continuity of design philosophy and synergies between the Collins life-of-type extension and its eventual replacement.

To be successful, however, Saab will need to overcome the legacy of disputes between the Commonwealth and Sweden/HDW over Collins intellectual property in the early 2000s. More importantly, the compatibility of Australia's and Sweden's submarine programs would need to be examined closely. We're both small nations, so effective collaboration would depend on the compatibility of resource demands, in terms of human capital and production schedules, and aspirations, in terms of submarine size and performance. As with all the potential partners, the ability of Sweden/Saab to manage third-party intellectual property will be critical, though the healthy relationship between the Swedish and US Navy submarine arms would help.

In terms of export experience, it's clear that the German and French firms are well ahead. The Swedish firm Kockums provided much of the design for the Collins class, and has refurbished six ex-Swedish Navy boats for Singapore in two tranches, but hasn't otherwise won export contracts for either submarines or designs.

Media reports have made a lot of the possibility of Japanese submarine technology feeding into Australia's submarine project. It's not clear how much is known in Australian circles about Japanese submarine systems and capabilities, but any knowledge gaps would need to be filled in before informed decisions could be made. That might be hard to do; Japan is only slowly working its way through the question of defence exports and may be reluctant to share its naval 'crown jewels'. Left solely to the bureaucrats in Canberra and Tokyo, the prospects for effective cooperation are low. But interest in collaboration seems to be growing at the highest levels of government on both sides, so more discussion of this option is in order.

The obvious strategy of simply placing an order with Japan's established submarine builders might seem unlikely, but it can't be ruled out given the shared enthusiasm of both Prime Ministers for a deeper collaborative relationship. Local Australian industry would fight to prevent overseas competition, and the political cost would be high in South Australia. The export of a complete design also seemed unlikely until recently, given Japan's glacial pace of

normalising its defence posture. But it would guarantee lucrative exports of key propulsion subsystems, such as diesel engines, along with many other vessel subsystems.

Another possibility is a collaboration that stops short of a complete transfer of a Japanese design, but involves the transfer of some subsystems and perhaps even some sensitive technologies or techniques. For example, Japan seems to have successfully integrated propulsion components from a range of suppliers (Swedish AIP in some Japanese boats, for example), and the know-how to do that could be valuable.

Finally, the Spanish seemed to have a shot at one stage, with Navantia's AIP-equipped S-80A design—a larger derivative of the French Scorpene—catching a few eyes. But although Navantia has exported a warship design to Australia—with the results described below—it hasn't exported a submarine. News last year that the Spanish AIP was underperforming and, worse, that the submarine design lacked adequate buoyancy, effectively counts Spain out as a design source for the future submarine.

So it looks to be a three-horse race for the role of design partner for the future submarine—at least as far as European design houses are concerned—between DCNS, TKMS and, as a late entry, Saab. But because of the possible complications with US-sourced systems mentioned above, the door's open for a 'three-eyes' Australia–UK–US arrangement, with a UK–Australia led design effort with only limited assistance from the European designer. How plausible would this be?

British submarines have been exported in the past. For example, Australia, Canada, Brazil and Chile were customers for the Oberon class. Canada subsequently traded in its Oberons for second-hand British-built Upholder class boats in the late 1990s. Since that time, the UK hasn't exported a submarine of any kind after transitioning its own submarine fleet to all-nuclear in the mid-1990s. As is discussed below, exporting a design is a complex undertaking.

Despite that, and although the UK hasn't designed a conventional submarine since the late 1970s (the Victoria/Upholder class), there's a noticeably British feel to the leadership of our submarine enterprise. Key appointments include the Defence Materiel Organisation's General Manager Submarines (David Gould), the head of the submarine IPT (Simon Todd), Submarine Design Manager (Chris Edmonds), ASC Pty Ltd CEO (Steve Ludlam) and head of the Collins Sustainment Review (John Coles), all of whom gained the bulk of their professional experience in Britain.

Either the experience gained from UK nuclear submarine programs is highly relevant or we've made a mistake. Nuclear submarines share some common design principles with conventionals, but their maximum speed and operational cycle are different, and they aren't energy-constrained in the same way as conventional boats, so we can't assume that we'd be getting the full suite of expertise required. In particular, we wouldn't have access to suitable expertise in propulsion systems—diesel engines, electric motors and generators, and batteries—which have proven so problematic in the Collins. Assuming that there's enough commonality to make the exercise workable, a UK–Australia partnership exploiting BAE Systems' reach back to the UK nuclear submarine programs can't be discounted. Other British firms, such as Thales (UK) and Babcock (which maintains the UK nuclear boats), may also have expertise to offer, although capacity might be an issue as design work on Britain's future nuclear deterrent submarine ramps up.

The extent to which a UK-based approach would be viable independent of European design expertise is important to determine. If it's necessary to draw extensively on European conventional submarine design expertise, there's a risk of repeating the error of the AWD project and leaving the designer outside of the core commercial entity.

Assuming the British option is feasible, we're left with a five-horse race between France, Germany, Sweden and, perhaps on the outside, the UK and Japan. And although the UK has no recent experience with conventional submarines, it's probably the best placed when it comes to managing American intellectual property, although American concurrence will be required regardless. We should also note that a shared language is a significant advantage when it comes to collaboration on complex projects.

Learning from the air warfare destroyer

To see what we're looking for in a design house to partner with, we can draw some useful lessons from the AWD project. In that endeavour, the Commonwealth partnered in a formal alliance with ASC as the builder and Raytheon as the systems integrator, but—significantly—not with Navantia, the designer of the chosen solution. The result, as reported by the Australian National Audit Office (ANAO), has been poor performance, cost increases and schedule delays. Because of the ANAO's focus, this section deals largely with production issues, but many similar issues will apply to planning, engineering and supply chain management.

The ANAO's recent report on the AWD program allows us to drill down to the root causes of the problem.³ Some of them are to do with low productivity in the Australian shipyards, but many have had to do with the translation of the design to the build stage. An analysis of the project's 'problem and issue reports' database shows that nearly half the records relate to design issues. Frequently, drawings had to be redone—up to four times in some cases—when they were found to be unfit for purpose. Given that Navantia had successfully constructed similar vessels in its shipyards at Ferrol, this seems to have been an unanticipated problem, despite spending more than \$200 million on pre-approval studies, including, presumably, a study of the effect of Australian design modifications.

The explanation for this surprising outcome lies in inexperience on both ends of the arrangement. This is the first time that Navantia has exported a design for building offshore, and it's used to preparing drawings for its own workforce. Workers in the Spanish yard are familiar with Navantia's design philosophy, the equivalent of 'shorthand' employed in its technical drawings and, most importantly, the tacit knowledge of ship production assumed by the designers.

In our local yards, the inexperienced Australian workforce struggled to translate Navantia's drawings into executable work. Exacerbating the problem, the local workforce also lacked critical skills at the production supervision level. In the case of the well-publicised problems with the poor quality of the blocks (prefabricated modules) built in Melbourne, Defence's 2010 advice to the Defence Minister is pretty clear:

... the poor build quality was largely the result of BAE Systems not having sufficient experienced production supervisors—workshop engineers and foremen—despite being one of Australia's most experienced shipbuilding organisations.

Source: ANAO air warfare destroyer audit report, 2014.

The future submarine project will face all of these problems and more. In the case of the AWD, we started a build with a first-time Australian shipbuilder and an inexperienced workforce. In the early days of a start-up build, low productivity is to be expected and should be allowed for in planning. But seven years on, productivity remains well behind planned levels. It's hard to avoid the conclusion that planning was overoptimistic and production management less robust than was required. As well as the disconnect between designer and builders, many design changes were made due to Australian requirements and materiel choices, and Defence's project management doesn't seem to have accurately assessed the impact of those changes.

It would be interesting to know how much extra capability has accrued from the changes, because they've certainly provided more than their share of difficulties. Cost/capability trade-offs are an important part of the development of any capability, not least those for which a 10% price variation amounts to hundreds of millions of dollars.

The recent announcement of remedial action on the AWD stemming from the White–Winter Report broadly reinforces the conclusions drawn from the ANAO report. Beyond that, it's difficult to say more because the government has chosen to withhold the White–Winter Report from the public eye—probably indicating the embarrassing depth of problems uncovered. It's regrettable that valuable data on such an important and expensive publicly funded project, with undoubted implications for future even larger and more expensive naval construction projects, is being withheld from view. Given the amount of new design work almost certainly required for the future submarine, it's hoped that the appropriate lessons have been learned, because if the future submarine is to come

anywhere near the articulated requirements, it won't have much in common with boats elsewhere. And if we stick with the expected European conventional submarine technology and an American combat system and weapons, we'll have to integrate subsystems from multiple suppliers.

We can at least reduce the number of problems if we refrain from pushing the envelope with our design, aiming for 'state of best practice' rather than 'state of the art'. In any case, it's clear that we'll be starting a harder journey from no better a local starting point than the AWD in terms of technical difficulty. The expertise and experience of external partners in integration work, and the ability to implement it in local yards, will be paramount. And the AWD experience makes a case for the designer to be a core member of any consortium.

Whichever of the arrangements discussed above are established, Australia will need the following elements of project management to be in place. First, senior engineering and design personnel from those firms chosen to provide major systems (including the hull and other structural components) must be readily available to the local yards for consultation in near real time.

Second, we need to recognise that we'll have to import production techniques as well as the design. There are at least a couple of ways to do that. One way is to import the shipyard foremen and production supervisors with the design, effectively training the Australian workforce under experienced supervisors who understand the design and production philosophy. Another approach—one that's been successful for other countries—is to take some of our workforce to the home yards of the designer to work alongside the already established workforce. This might also include building the first of class (or at least a substantial portion of it) in the overseas yard.

Third, for a program likely to last over two decades there'll need to be continuity of leadership and robust succession planning for both the contractors and government. To be successful, such a long-term undertaking requires a lot of institutional knowledge and a deep understanding of lessons learned along the way.

Finally, and as noted by the project office representatives who spoke at the ASPI conference, we need to ensure that we have a stable and suitably documented design, and a well-understood process for turning it into production work, before starting metal fabrication. While that might seem entirely obvious, the politics of providing shipyard jobs here in Australia has the potential to lead to shortcuts—which are bound to be troublesome and expensive in the longer term.

These requirements will be demanding on whichever submarine designer/builder is chosen, and will necessarily consume a lot of their engineering resources. In the case of companies that also build for export, the resources committed to an Australian build won't be available for work on boats for which build revenue will flow as well. We can therefore expect to pay for that opportunity cost.

The AWD project is the most recent example from which lessons can be drawn, and it hasn't been the most edifying experience. Earlier projects, both good and bad, can also provide valuable experience. The Anzac frigate project is generally seen to have been a success, with the later ships in the production run being produced efficiently by world standards. The Collins project contains many lessons, some positive and some not so positive.

Closing the gap

The challenge for the Australian Government is to somehow find a way from where we are today to one of the myriad possibilities implied in the foregoing discussion. No wonder Defence's preferred first step is to undertake consultations.

Without presuming what the forthcoming consultations might entail, there are a number of possible ways to progress the creation of a commercial entity to execute the submarine project. In order of increasing time and complexity, here are four (and a half) options among the many possible approaches. And of course there's always the 'old school' approach of going to the market to see who can best provide the required services and engaging them to do so.

Guessing contest

The most expedient way to proceed would be for Defence to talk with potential firms and then invite those deemed most convincing to join forces and create the submarine construction entity. Of course, the manifest lack of process and probity in such an approach means that this won't happen. Without some sort of orderly and transparent solicitation process that sets out the basis for selection, it would be a guessing contest with firms seeking to garner Defence's favour.

Beauty contest

Having talked to industry to scope the possibilities, it would be open to Defence to then formally solicit from firms their credentials for a role in the submarine construction entity as the designer, integrator or constructor. This is effectively what happened in the first stage of the AWD project, when the shipbuilder, combat system systems engineer and preferred designer were selected ahead of the actual design.

The advantage of such an approach is that bidders for the various roles get a clearer idea of the basis for decision-making. The drawback is that, rather than receiving bids for products at a price, the Commonwealth has to sort through what are effectively job applications based on claims of past performance and promises of future performance—as much a bragging contest as a beauty contest. Of course, if you're looking for partners to work with in delivering a class of vessels the size, performance and cost of which are yet to be nailed down, this is at least a necessary step in the process.

Design contest

The potential design contenders DCNS, TKMS and perhaps BAE Systems all have experience building submarines (albeit only nuclear vessels in the case of BAE). Saab hasn't built submarines, but has inherited much of the experience of Kockums. One way to more fully test the contender's credentials beyond a beauty contest would be to fund concurrent design studies to see how each would propose meeting the Australian design brief. Design needs to be viewed expansively as including cost estimates, production planning, schedule estimates, infrastructure requirements, training planning and the other elements required to deliver a capability.

Funded design studies have been used in the past in Australia and overseas, including in the early stages of the US F-35 Joint Strike Fighter Program and our own AEW&C project. The time and money spent would allow a better assessment of the designers and their compatibility to our way of doing business, and could be used to generate at least preliminary cost estimates.

MOTS-based contest

One of the dangers with all the strategies discussed so far is that they don't readily allow for a lesser risk/cost option. Instead, a designer or designers will be asked to work towards achieving the goals in a unique Australian design brief. And although this will allow cost-capability trade-offs to be made, it doesn't provide a fallback option if the costs and risks of the exercise grow too high. One way to remediate this would be to mirror the pre-second-pass phase of the AWD project, in which two designs were developed and taken forward for government consideration.

In the case of the future submarines, this could be achieved in several ways. For example, the successful design partner could be asked to concurrently adapt an existing design but only to the extent that it's within their engineering comfort zone and cost-effective to do so. Of course, where a modified design stops and new design begins is a difficult question (for example, was Collins a new design or a derivative design?) but it shouldn't be beyond human wit to come up with some heuristics to help delineate some boundaries. In effect, two design exercises would be done concurrently: one starting with our unique requirements, and another starting with—and not deviating too far from—an existing design.

Old school

The preceding options largely take as given the unashamedly interventionist approach of creating an entity to build the submarines. There was a time when things were simpler. At the risk of only a little oversimplification, the Collins and Anzac projects went to the market seeking solutions against a set of performance requirements. Consortiums formed, bids were lodged, and a winner was chosen.

Since that time, industry consolidation has reduced the range of potential bidders, and intellectual property has emerged as a sensitive issue. Nonetheless, there's something inherently attractive about the government working out what it wants and leaving industry to work out how best to deliver it, including the commercial arrangements between industry parties. Moreover, the outcomes of the experiment of having Defence on both sides of the contract in the AWD alliance hardly sells the idea of blurring the lines between customer and supplier. There's a lot to be said for a bilateral contract between the Commonwealth and a single prime contractor with a real balance sheet, rather than a thinly capitalised special-purpose vehicle deliberately brought into being as part of the acquisition strategy.

Apart from the vexed issue of intellectual property and the varying capacity of different US allies to integrate US systems, even the option of a funded design contest leading to a fixed-price contract would appear possible. So, how large an impediment is intellectual property? Until we ask, it's hard to know, given the self-interested claims and counterclaims. But it should be noted that the Collins is a European-designed submarine and it has a US combat system and US weapons. So we have a demonstration that a US combat and communications system can be fitted to a European-designed boat in Australia.

Next steps

The strategies outlined above are but a sample of the range of possible approaches that could be taken. Experience shows that getting the acquisition strategy right is every bit as important as any of the technical details in a defence project. In fact, if you get the former right, you should have the expertise and processes in place to help you manage the latter. Literally billions of taxpayers' dollars are at stake, not to mention a key ADF capability. It's critical that we get off on the right foot, as experience shows that it's much harder to change tack later. With that in mind, here are five suggestions for how to handle the manifest uncertainty surrounding the next steps in the submarine project.

Transparency

The submarine acquisition strategy is likely to be the centrepiece of a restructure of the entire naval construction sector in Australia—including a possible transition to monopoly continuous-build programs for both submarines and surface combatants. Before such a momentous decision is taken, broad consultation is called for, and we need to understand the real—as opposed to asserted—industrial and strategic payoffs. High on any agenda must be the question of how a monopoly supply situation would be regulated to ensure ongoing value for money. It'd be far preferable to make a decision about the wider shipbuilding sector in general, based on good-quality information, than to make a series of ad hoc decisions that severely constrain the choices for major projects such as the submarine.

A green paper from the government following the forthcoming industry consultations on the submarine program would be a good way to achieve this. If a systematic and comprehensive analysis of options is occurring within government, a green paper would be easy to produce. Conversely, if a green paper is a hard ask, we're surely in trouble. We certainly need a more convincing basis for decision-making than last year's Future Submarine Industry Skilling Plan, produced by the Defence Materiel Organisation.

Any project that's going to spend billions of taxpayers' dollars over decades will require bipartisan support, so efforts should be made to ensure that there's a political consensus. And the public deserves to have enough information to at least understand why and how the money is to be spent.

Probity oversight

The acquisition strategy for the future submarine program is sure to advantage and disadvantage potential industry participants to varying extents, so the potential for accidental and perceived bias can't be discounted. And if a 'new commercial entity' is the approach taken, then it'll be important to ensure that any conflicts of interest between the parties involved are closely managed. It's routine to appoint a probity adviser for major defence programs, and in the case of the AWD project no less than a retired Chief Justice was appointed to the role. In fairness to all parties, and to protect the Commonwealth's reputation, a similarly high-profile independent probity adviser should be appointed as soon as possible to oversee the propriety of the many actions and decisions that lie ahead.

Risk

The future submarine project will entail risks on multiple levels. The efficient management of risk will be essential to the successful execution of the project. Defence is only partially equipped through the Defence Science and Technology Organisation to understand the many technical risks inherent in the project. And a clear understanding of the commercial risks to the government and its counterparties is vital to the crafting of an acquisition strategy.

The Commonwealth is exposed to risks (cost, schedule, reputation and capability) in any procurement, and especially so for projects whose scale rivals or exceeds the assets of suppliers. The mitigation—which can only ever be partially effective—is to structure the arrangement so that the participants are exposed to substantial financial risk (as well as the reputational risk they inevitably bear), thus providing strong incentives to get things right. Of course, this will come at a cost: firms will build a risk premium into their price, effectively selling partial insurance to the Commonwealth.

On the other side of the coin, firms face risks in dealing with the government as a customer, such as uncertainty about the extent of the government's commitment to support an ongoing submarine build and sustainment enterprise in Australia. While eventual cash flow to investment ratios may be high, the initial capital investment will be substantial. The risk of a future change of direction—for example, limiting the build to fewer than 12 boats—will weigh heavily on the minds of firms contemplating buying in. A similar calculus will apply to individual staff, who will probably demand a wage premium to leave established firms or relocate to be employed by the new entity. Uncertainty from the government means risk for suppliers, with the result of a further risk premium being added to suppliers' prices.

An apportioning of risk will be intrinsic to the future submarine acquisition strategy—for better or worse. Glib generalisations that 'risks should be held by those best able to manage them' oversimplify the potential for cost-shifting and other unintended consequences, especially in complex contracting arrangements such as those in place for the AWD.

Given the centrality of contracting and risk apportionment for any commercial arrangement adopted for the new submarines, the government should seek external advice from beyond the defence sector. Fortunately, the Australian resources sector has extensive experience in multi-billion-dollar projects to draw upon.

Government-to-government consultations

With so much ambiguity surrounding the availability and compatibility of various international partners, the government should engage with its counterparts at the political level to achieve maximum access and cooperation on the future submarine project from our friends and allies. We also need to know exactly what the practical limits are on technology access and the extent to which 'two/three eyes' restrictions are real impediments. There's too much at stake to allow our options to be curtailed by untested assumptions and bureaucratic inertia at the working level. In the absence of negotiations at the political level, we'll never really know what's possible. In the case of US sensitivities, this is important enough a topic for it to be elevated to AUSMIN discussions—and, if significant British input is being seriously considered, the AUKMIN talks are the suitable venue.

Leadership

Somebody needs to be put in charge of the future submarine project near to or at the political level. At the moment, a number of people have responsibility for specific aspects of the project, but no one person has responsibility for driving and coordinating its many interdependent parts—not just the project management (the day-to-day running of which sits naturally within Defence with the General Manager Submarines and the SEA 1000 project lead) but also the politics of the project. The government needs to understand exactly what it's being asked to decide at every point. A strategic-level policy appointment needs to be made, with responsibility for guiding the project through government, leading international engagement, coordinating activities within Defence, ensuring interdepartmental collaboration and engaging with industry at the highest level.

A final comment

Around the world we've seen a steep increase in the cost and duration of development programs for cutting-edge military platforms. A unique Australian submarine would be no exception and there's always the possibility that the government will weigh up the issues we describe in this paper and decide that the likely costs outweigh the prospective benefits. In that they'd need to decide whether offshore procurement options are able to deliver the required capability, or find an acceptable compromise between capability and risk.

Further reading

ASPI has been writing about the future submarine program for some time now. The interested reader will find some of our previous thoughts in the following publications.

Sean Costello and Andrew Davies, *How to buy a submarine: Defining and building Australia's future fleet*, ASPI, Canberra, 2009. <https://www.aspi.org.au/publications/strategic-insights-48-how-to-buy-a-submarine-defining-and-building-australias-future-fleet>

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ALLIANCE CONSIDERATIONS

The alliance dimension of Australia's future submarine

Benjamin Schreer

A key consideration for Australia's future submarine (FSM) is its potential US alliance contribution. For sure, the ANZUS dimension won't be the only driver behind the new boats, as there could be future contingencies (for example, another Indonesia crisis) in which the Australian Government might be unable to count on US support. That aside, however, Australia's defence strategy and posture are likely to remain closely aligned with those of its US ally. Barring a US strategic withdrawal from the Western Pacific—a possible but unlikely scenario—Australia will continue to rely on America for protection against major disruptions in the Asia-Pacific security order. With the exception of leadership of limited military operations in Australia's own backyard—the South Pacific—the ADF will continue to focus on providing niche capabilities to US coalition operations in other parts of the Western Pacific and, in the future, the Indian Ocean.

Therefore, it's important to ask what the US is likely to expect from a future Australian submarine capability. While US official announcements about expectations of allied submarines are virtually non-existent, it's possible to reach some conclusions based on a number of key assumptions.

This paper's bottom line is that it's prudent to assume that the US would like Australia to maintain a sophisticated submarine capability with a high degree of interoperability with US forces. The FSM will be seen as an integral part of highly capable Australian forces able to operate alongside the US in parts of the Pacific, in the eastern Indian Ocean and with deployed coalition forces. However, because of the relatively limited size of any realistic Australian submarine force and other strategic considerations, it's unlikely that the US would regard Australian submarines as playing a decisive role in the early stages of a potential conflict with China, for example in the South China Sea and the East China Sea. Rather, it would expect the FSM to be able to operate in Australia's immediate region up to and beyond the Indonesian archipelago.

The future operational environment

Australia is one of the few Asia-Pacific countries capable of operating such a complex capability as part of US coalition operations. Assuming nuclear boats still won't be a realistic Australian political option in two decades from now, the ability of modern diesel-electric submarines to collect sensitive intelligence in waters close to potential adversaries, insert special forces in denied maritime environments, conduct offensive mining operations, hunt down hostile submarines, threaten surface ships, and, potentially, launch land attack cruise missiles (LACMs) against onshore targets, make them attractive for the US. The FSM would therefore be a welcomed complement of the US Navy's (USN's) fleet of nuclear attack (SSNs), ballistic missile (SSBNs) and cruise missile submarines (SSGNs).

Any debate about the FSM and US coalition operations needs to recognise that the US military regards China's People's Liberation Army (PLA) as the most serious long-term strategic challenge in the Asia-Pacific region and

beyond.¹ Currently, the USN still dominates the undersea domain in the Western Pacific. About 60% of its submarine force is deployed in this area: 30 SSNs, 8 SSBNs and 2 SSGNs. In contrast, the PLA Navy (PLAN) is still in the very early stages of operating nuclear submarines, its conventional boats are relatively easy to detect, and its antisubmarine warfare (ASW) capabilities remain limited. However, this picture is likely to change. Over the next 15 years, the total number of the USN's SSNs (Los Angeles class and Virginia class) is set shrink from 55 to 42 boats before rebounding slightly, assuming funding availability. There are also no plans to replace the four SSGNs after their retirement between 2026 and 2028. Each SSGN can carry up to 154 Tomahawk LACMs.

The USN is likely to seek to maintain the current capability through steps such as further upgrading the technology aboard existing and new boats. And, when combined with well-developed doctrine and vast operational experience, its submarine force in the Western Pacific will remain second to none in the decades ahead. However, as they say, 'quantity has a quality of its own', and the PLAN has embarked on a long-term trajectory to modernise and increase the size of its fleet of conventional and nuclear submarines. It plans to operate up to 78 modern submarines by 2020, and that objective appears quite realistic. Therefore, while the US submarine force in the Western Pacific will quantitatively decline, China's will quantitatively *and* qualitatively increase.

Moreover, the PLAN is also investing in unmanned underwater vehicles (UUVs) and offensive mining capability, and has started to address some of its ASW limitations. The goal is first to increase its chances of detecting and engaging submarines in China's exclusive economic zone, before gradually expanding this area further into the 'first' and 'second island chain'. Obviously, it's impossible to determine precisely how the evolving race between China's and US/allied undersea warfare capabilities will play out. But it's reasonable to assume that the risk of detection for allied submarines in waters off the Chinese mainland will increase and that their ability to operate with relative impunity will diminish.

As well, it's tempting to perceive submarines as a stand-alone capability. However, while some of their missions (such as intelligence collection) can be performed independently of the rest of the force, their operational value should predominantly be assessed as part of a joint force. In a PLAN context, undersea warfare is integral for the PLA's emerging 'counter-intervention' strategy—'anti-access/area-denial' (A2/AD) in Western strategic parlance—that is, the ability to hold US and allied forces operating within the first and second island chains at risk, particularly through the deployment of cruise and ballistic missiles. Further into the future, submarines will also be key to protecting Chinese carrier strike groups, as well as serving as a sea-based nuclear deterrent.

For their part, US nuclear submarines will be part of an emerging operational concept to assure access for US forces even under conditions of a sophisticated A2/AD challenge. This concept is best known under the banner of 'AirSea Battle'. Apart from protecting US carrier strike groups, which will most likely operate further away from China so as to reduce their vulnerability to the PLA's growing anti-ship capabilities, US nuclear submarines' distant-strike capability will provide a strategic deterrent. Moreover, they'll assume the daunting task of operating within a contested A2/AD environment. Yet, as the Chief of US Naval Operations, Admiral Jonathan Greenert, stated, this mission will become much more challenging in the future:

Submarines will deploy and operate in conjunction with a family of unmanned vehicles, deployed from submarines and sensors by 2025 to sustain the undersea dominance that is a clear US asymmetric advantage. Large-displacement unmanned underwater vehicles (UUVs) will deploy from ships, shore, or Virginia-class submarine payload tubes to conduct surveillance missions. With their range and endurance, large UUVs could travel deep into an adversary's A2/AD envelope to deploy strike missiles, electronic warfare decoys, or mines. Smaller UUVs will be used by submarines to extend the reach of their organic sensors, and will operate in conjunction with unattended sensors that can be deployed from surface combatants, submarines, and P-8A patrol aircraft. The resulting undersea network will create a more complete and persistent 'common operational picture' of the underwater environment when and where we need it. This will be essential to finding and engaging adversary submarines, potentially the most dangerous A2/AD capability.²

Admiral Greenert didn't specifically identify China as the most likely adversary in such a scenario. But one would expect that US submarines will also assume the highly sensitive task in a crisis of holding major PLAN surface combatants at risk as they operate close to the shore or prepare to leave port. For example, closing off Hainan Island which is the key Chinese naval base for power projection into the South China Sea would certainly be a mission for US submarines in times of war.

What role for Australian submarines?

Against this background, it's tempting to conclude that the operational value of Australian submarines will increase in the future as the US submarine fleet winds down in numbers and China's undersea warfare capabilities grow. The 2009 Defence White Paper appeared to reflect such expectations by stating that Australia's:

future strategic circumstances necessitate a substantially expanded submarine fleet of 12 boats in order to sustain a force at sea large enough in a crisis or conflict to be able to defend our approaches (*including at considerable distance from Australia*), protect and support other ADF assets, and undertake certain strike missions ...³

The implication was that the FSM could be also be used in an offensive role in the South China Sea and the East China Sea to support coalition operations because of their envisaged range, stealth and 'strategic strike' capabilities. Some Australian academics have been more blunt, stating that 'Australian submarines might well have to operate directly off the Chinese mainland to achieve operational objectives in Southeast Asia and the approaches to Australia.'⁴

However, there's good reason for caution against such a role for the FSM, including in an alliance context. Proponents assume that the FSM's stealth characteristics in combination with technological breakthroughs in submarine technology (such as further reductions in sonar signatures) will still make them very difficult to detect, even in more contested waters. Yet, my colleague Andrew Davies isn't alone in believing that future submarines could find it much harder to retain their advantage over enemy ASW capabilities.⁵ Admiral Greenert also expects that 'the rapid expansion of computing power ... ushers in new sensors and methods that will make stealth and its advantages increasingly difficult to maintain above and below the water.'⁶ That's why, according to him, the US needs to project naval power from greater distances or minimise the risks for manned stealthy platforms (that is, submarines): 'US forces can take advantage of those developments by employing long-range sensor, weapon, and unmanned-vehicle payloads instead of using only stealth platforms and shorter-range systems to reach targets.'⁷ In short, the US expects much greater challenges for its submarines operating in waters close to China's mainland. And unlike diesel boats, US nuclear submarines stand a good chance to outrun an enemy's ASW surface fleet given their speed of over 30 knots.

However, even leaving the question about the future balance between submarines and ASW aside, it's doubtful that future Australian submarine operations in this area would deliver operational and strategic utility in a US coalition context. Operationally, it's hard to see Australian submarines contributing to any critical coalition objectives in the South China and East China seas. The underlying assumption for such a function is that the US would want Australia's submarines to operate in this space, but it's questionable that the US has ever had enough confidence in Australian submarines performing such high-risk operations. And it's even more difficult to see any future utility in having Australian submarines hiding off Hainan to threaten Chinese vessels as they leave port or hunting down PLAN submarines in open water. Given the enormous stakes in a future crisis involving the US and China, it'd be prudent to assume that the US would want to reserve this critical role for its own undersea force in order to maintain a single line of command and control, especially escalation control. In other words, the US would be likely to regard Australian submarines as an operational liability, particularly since their small numbers would mean that they wouldn't make a significant difference to the outcome of the conflict. There's a reason why both Japan and South Korea will have more than 20 boats.

Finally, as the PLA increases its A2/AD capabilities within the first and second island chains, the ability of submarines to conduct long-range strategic strikes against targets on the Chinese mainland to create a deterrent effect becomes even more important for a US coalition posture. But this function is effectively reserved for nuclear boats; with their slow speeds and restricted payloads, diesel-electric boats don't offer a credible 'strategic strike' option against an opponent such as China. In sum, seen from a US perspective, there's limited utility for future Australian submarine operations in waters close to China. And it's similarly unclear what Australia would have to gain tactically, operationally and strategically from such operations. To be sure, in the past Australian submarines have operated off the Chinese coast to collect intelligence. But as the risk of detection increases significantly in the decades ahead, the potential benefits from such operations are unlikely to outweigh the risks. As well, 'strategic strike' with conventional boats against a nuclear China is a non-starter: only nuclear submarines would possibly provide such an option.

However, all of this doesn't mean that the FSM won't be useful in a future US coalition. Emerging US operational concepts such as AirSea Battle and its proposed alternative, 'offshore control', see a critical role for US allies such as Australia in the context of a 'distant blockade' during times of war. Australian submarines would be well placed to operate in critical Southeast Asian maritime chokepoints (such as the Indonesian archipelago) as well as parts of the Indian Ocean. In principle, they could threaten hostile military and civilian vessels—an instrumental component of a maritime blockade. Such a focus of the FSM as part of a complementary division of (submarine) labour in different Asian maritime theatres would be a more sensible contribution to a future US alliance deterrence posture.

Therefore, in a future coalition, Australian submarines could assume a much greater role closer to home. When weighing the submarine options, the Australian Government should also consider that the US is likely to expect allies to assume greater responsibility as 'first responders' for their own defence and to create 'friendly' A2/AD envelopes to defend their sovereignty and provide forward sanctuary for US forces.⁸ In other words, also in an alliance context, the FSM could protect Australia's approaches and operate in the near neighbourhood. In the future, Washington would certainly also value Australian submarines providing safety for US nuclear boats operating from upgraded facilities at HMAS Stirling in Perth.

Only one niche capability

Last, from a US perspective the FSM will be evaluated within the context of overall ADF capability. That is, submarines will be but one and quite possibly not even the most important military niche capability. Apart from bigger ticket items such as tanker aircraft, electronic air warfare (Growlers) and state-of-the-art maritime surveillance platforms (P-8s and Tritons), the US is likely to place increasing importance on less prominent but equally critical capabilities to enable coalition operations under A2/AD challenges. These include mine warfare, special forces, missile defence and airborne/seaborne stand-off precision strike.

Consequently, the US would probably expect the ADF to acquire the FSM at acceptable costs and to avoid the risk of an imbalanced defence force. The current ambition by some in Defence and industry to build up to 12 large new boats (as a precursor to a continuous build program) could undermine that objective because of the significant financial costs involved in development, build, operations and maintenance. Arguably, the US could well live with a lower number of new Australian submarines (let's say six to nine) if the result would be a balanced ADF able to make niche contributions across the military spectrum.

To conclude, while the FSM will certainly be an important contribution to the US alliance, its value shouldn't be overstated. Operating 'up threat' in the South China Sea or the East China Sea won't necessarily be the best option. The changing operational and strategic landscape within which Australian submarines will have to operate could lead to them taking on a more distant role during coalition operations. It will be important for Australia and the US to consult closely on the future of coalition submarine operations to determine what exactly the US expects from this capability and what Australia would be willing and able to provide.

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- 6 Jonathan W Greenert, 'Payloads over platforms: charting a new course', *Proceedings Magazine*, vol. 138, July 2012, www.usni.org/magazines/proceedings/2012-07/payloads-over-platforms-charting-new-course.
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About the author

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REGIONAL SURVEY

Asia's submarine capability, 2014

Harry White

Australia

After some early troubles, exacerbated by inadequate support arrangements, Australia's Collins class boats are proving highly capable. They have the size to allow extended bluewater deployments and their crews are well trained and have accumulated a wealth of practical experience, although crew retention problems have diluted this advantage somewhat. The fleet's main drawback is its small size, limiting the possible number of concurrent deployments. The ADF's current capability shortcomings in antisubmarine warfare also work against the maintenance of crew proficiency.

Australia's also in the early stages of a decision to acquire a new generation of submarines, as outlined in the 2009 and 2013 Defence White Papers. The current aim is to produce a boat with the range, endurance and habitability of the Collins, but with lower signatures and improved sensors. The 2009 ambition was for an expanded fleet of 12 boats, although the current government hasn't endorsed that number. There's considerable pressure from industry for an Australian build, but offshore procurement remains a possibility.

China

China places considerable emphasis on the modernisation of its submarine force. The PLA Navy currently fields a large fleet of conventional attack submarines (SSKs), and is increasing the size of its nuclear-powered fleet of attack submarines (SSNs) as well as developing a strategic missile capability (SSBNs). The SSKs will play an important role in any anti-access/area-denial strategy, and the SSNs will allow for power projection further afield. The US Pacific Command estimates¹ that the combination of China's Type 094 SSBN and JL-2 submarine-launched ballistic missile will provide it with an at-sea nuclear deterrent, '... probably before the end of 2014.'

India

Like China, India is continuing its efforts to improve its submarine capability, in keeping with its ambition to become a major naval power. The core of the subsurface fleet for the Royal Indian Navy is nine modern Russian Kilo boats that have been upgraded with Russian cruise missiles and wire-guided and wake-homing torpedoes. It also has four German-designed Shishumar class diesel-electric submarines (a Type 209 derivative), one leased Russian nuclear submarine (and is in talks for a second) and an indigenously designed and built SSBN, the *INS Arihant*.

But despite significant investments in capability, expertise and domestic production and maintenance capacity, India's program has been troubled. There have been long delays in the delivery of six French-designed and Indian-built Scorpene class submarines. One Kilo class boat exploded and sank, and India's Chief of Navy resigned

after a fire inside another. The Indian Navy also continues to struggle with readiness and maintenance, and delays in procurement programs cast doubt over its future readiness, as most of its fleet is nearing the end of its lifespan.

Indonesia

Indonesia's current capability is limited, but it has ambitions for an overhaul of its submarine capability. It has two 1970s-vintage German Type 209 boats operational. In December last year, Indonesia's Defence Minister suggested² that there was a plan for a 'massive' increase in submarine capability. The first of three improved Chang Bogo class boats (another German Type 209 derivative) is under construction in South Korea now, and commissioning is due by 2018. Indonesia announced in February that it would produce one of the Chang Bogo class boats indigenously by 2018, but that schedule appears optimistic. At various times over the past decade, Indonesia has reportedly considered the purchase of Russian Kilo class boats, though there have been no concrete signs of such a deal because of the high cost.

A critical factor in the capacity of an Indonesian submarine fleet will be the rigour that's applied to the development of training and doctrine, the support arrangements put in place and the amount of operational experience that's gathered. They're starting from a very low base and, based on observations of other Indonesian defence acquisition programs, the capability might not match the sophistication of the acquired technology for some time.

Japan

Japan's 17 large conventionally powered boats are technologically sophisticated in their stealth and capability. They've been restrained to some extent by Japan's Constitution, although that may change following the Abe Government's reassessment of the role of Japan's armed forces, but they're strong performers in exercises. They can remain on station away from base facilities for long periods, giving them a strong bluewater capability.

Japan has announced plans to build up its submarine force to 22 boats within the next 10 years, probably in response to China's growing military power. That will ensure that Japan retains the third most formidable undersea capability in Asia, after the US and China.

Malaysia

Malaysia ordered two French Scorpene class submarines in 2002, both of which were commissioned in 2009. This development was probably in large part a response to Singapore's growing capability. After some teething problems (the government said in early 2010 that defects made it unsuitable for one of the boats to dive), the Malaysian Defence Minister has since said that they're fully operational. However, the small size of the fleet and question marks about the depth of support and training arrangements mean that doubts about their operational effectiveness remain.

Russia

The Russian Federation Navy has significantly declined in quality since the end of the Cold War, but is engaging in what appears to be a substantial revamp of its still-formidable submarine capability. While estimates vary, they have about 12 nuclear-powered ballistic missile submarines, approximately 25 nuclear attack submarines (all nuclear submarine capability is split between Russian Northern and Pacific fleets) and roughly 20 conventional Kilo and Lada classes. Russia has announced plans to modernise much of its existing fleet. There are also new generations of likely very capable SSBN, SSN, and SSK submarines reported to be in build, which will boost fleet numbers in coming years. In particular, the Russian Pacific Fleet is expected to receive about half of new-generation Borey class SSBNs, several Severodvinsk-M class SSNs and the improved Lada class SSKs. This investment in capability is significant for Asia, both directly through the presence of the Russian Pacific Fleet, and because of the influence Russia could have on the region through export of their sophisticated hardware and operational expertise.

Singapore

Singapore has a small but sophisticated conventionally powered submarine capability, consisting of six very capable Swedish-made boats: four Sjöormen class and two newer Archer class. The Archers are an upgraded Västergötland class diesel–electric submarine with air-independent propulsion. The second Archer class boat was commissioned in 2013. Combined with Singapore's attention to doctrine and operational expertise, these boats have provided the small nation with one of the region's most formidable undersea capabilities. In further modernisation plans, two Type 218 submarines are currently under contract from German builder TKMS for delivery in 2020.

South Korea

South Korea is another of Asia's very competent submarine operators. The core of the fleet is nine Chang Bogo SSK boats (South Korean derivatives of the German Type 209). South Korea's Daewoo Shipbuilding & Marine Engineering, which built eight of the submarines, is also building three more of the type for Indonesia. South Korea is building nine more modern Type 214s with help from German manufacturers, as was the case with the Type 209s. Four are already in service. On the planned schedule, this will provide a very capable conventional fleet of 18 modern boats before the end of the decade. Using the skills gained from the manufacture and technology transfer from these two classes, South Korea aims to develop a series of indigenous submarines, slated to begin construction before the end of the decade.

Taiwan

Taiwan would dearly like to upgrade and expand its submarine capability, which consists of just two 1980s-vintage boats, after a plan to have the US produce eight conventional submarines failed in the early 2000s. In April 2014, Defence Minister Yen Ming told a legislative committee³ that the US was willing to help Taipei 'build the submarines together'. That would significantly boost Taiwan's maritime deterrent capability, but would come at the cost of a severe deterioration of relations with Beijing for both Taipei and Washington.

United States

The US remains the most capable operator of submarines around the world, and along with China is the major player in undersea warfare in the seas of Asia and the Western Pacific. It operates an all-nuclear submarine fleet, including 14 nuclear ballistic missile submarines, four converted guided missile submarines (SSGNs) and 55 attack submarines. The highly capable Virginia class SSN is currently in production. Around two-thirds of the US Navy's submarine force falls under Pacific Command. It is an extremely capable force and will continue to be the most capable one in the region for the foreseeable future. While an increase in the build rate of Virginia class boats has recently been approved, fiscal constraints on US Government spending are having an effect on the submarine force, and the current 30-year procurement plan would see SSN numbers drop to the low 40s late next decade. A decline in numbers could potentially place significant pressure on US undersea dominance in Asia as the quality and quantity of Chinese boats increases.

Vietnam

Vietnam has taken early steps in building up a serious subsurface capability, ordering six new Russian-built Kilo class SSKs. Two have arrived and a third is slated to arrive before the end of 2014. The first operational testing in Vietnamese waters began earlier this year, and although it's potentially a significant capability, it will probably take some time for Vietnam to develop the doctrine and experience to make the best of its new platforms. The purchase is probably driven both by an increasingly tense relationship with China and by the increase in submarine capacity of other countries in the region.

Table 1: Regional submarine capability

Country	Current fleet	Future plans
Australia	6 Collins class conventional boats	A future submarine class, likely to be 6 or 12 conventional boats, and to be built in Australia.
Bangladesh	–	Will reportedly receive two Ming (Romeo) class submarines from China by 2019.
China	3–4 SSBNs, around half-a-dozen SSNs, and dozens of SSKs	Significant continued investment in all aspects of China's submarine force is expected.
India	9 Kilo class and 4 Shishumar class SSKs, 1 SSN and 1 SSBN	1 or more leased Russian SSNs, first of 6 Indian built Scorpenes, possibly with 2 more off-the-shelf boats delivered.
Indonesia	2 1970s-vintage German boats	3 South Korean Chang Bogo class boats, and possible purchase of Kilo class.
Japan	6 Soryu class and 11 Oyashio class, both types indigenously designed and built SSKs	5 more planned within the next 10 years.
Malaysia	2 Scorpene class SSKs	Malaysia will focus on consolidating its current capability for the foreseeable future.
North Korea	23 very dated Russian boats and a large number of coastal attack submarines	There's no immediate prospect for the improvement of North Korea's submarine capability.
Pakistan	2 Hashmat and 3 Khalid class conventional submarines	Possibility of purchasing 6 submarines from China, probably Yuan class.
Russia ^a	10+ ballistic missile boats, around 15 nuclear boats and 20 Kilo class	At least 4 new SSBNs, 4 new SSNs, new SSKs and significant fleet modernisation.
Singapore	6 Swedish submarines: 4 older Sjöormen class and 2 newer Västergötland class	Has ordered 2 Type 218SG submarines from Germany for delivery by 2020.
South Korea	4 Type 214, 9 Type 209 conventional attack submarines	5 more Type 214s to be delivered before 2020, and construction to begin on an indigenous class.
Taiwan	2 vintage Dutch SSKs	Some suggestion of US help in building submarines with Taiwan.
USA ^a	14 SSBNs, 4 converted SSGNs and 59 SSNs, many able to launch cruise missiles	Steady production of the Virginia class SSNs to continue. Construction of a new class of SSBN to begin by 2021.
Vietnam	2 new-build modern Kilo class conventional boats	4 more to be delivered in the next few years.

^a Russian and American submarine fleets operate much more broadly than the East Asian / Indian Ocean regions. Only a proportion of their fleets will be in the Indo-Pacific region at any given time.

Others

There's significant interest in submarine capability from other countries in Asia.

With the help of China, **Pakistan** is seeking to further build a sophisticated conventional submarine capability. Islamabad is reportedly in talks to purchase six submarines from China, in addition to the five conventional French boats that the Pakistan Navy currently operates.

As an indicator of future interest, and amid murmurings about a purchase of two Kilo class SSKs from Russia, a small number of **Myanmar** Navy personnel reportedly began submarine warfare training in Pakistan last year.

In 2011, **Thailand** announced plans to purchase two small (500-tonne) German Type 206A attack submarines, but the deal fell through in early 2014. The Royal Thai Navy has continued with the construction of a submarine base in anticipation of future purchases.

There are suggestions that the **Philippine** Navy is also interested in purchasing submarines before the end of the decade, and **Bangladesh** is reported to have signed a deal to buy two vintage conventional submarines from China.

North Korea, for its part, continues to operate a large number of small or outdated submarines, and won't have the resources available for any significant investment in its submarine capability in the near future.

Notes

- 1 <http://fas.org/blogs/security/2014/04/chinassbnfleet/>
- 2 <http://www.thejakartapost.com/news/2013/12/07/ri-looks-russia-submarines-with-multi-role-missile-systems.html>
- 3 <http://thediplomat.com/2014/04/us-to-help-taiwan-build-attack-submarines/>

About the author

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THE STRATEGIST BLOG

A realistic future submarine—at last

Andrew Davies (first published on *The Strategist*, 1 August 2014)

At the Defence and Industry conference this week, we got an official update on the status of the Future Submarine project (SEA1000) from the project head, RADM Greg Sammut and DMO's General Manager of Submarines, David Gould. That's welcome, as multi-billion dollar government projects should be exposed to public scrutiny to the extent possible consistent with commercial and security sensitivities. (I won't comment on other rumours doing the rounds.)

In a recent ASPI paper¹, Mark and I summarised the thinking that was on display at ASPI's conference in April. What we got this week showed encouraging progress in the three months since. I've been writing about the project for years now (like the F-35, it's a gift that keeps giving) and have lamented the apparent lack of coherence in planning. So credit where it's due; with a couple of exceptions which I'll come back to later, I think we've arrived at a sensible approach.

Firstly, RADM Sammut explained that the Integrated Project Team (IPT) in Adelaide is largely composed of industry representatives working in support of DMO's project office. This 'above the line' industry participation is vitally important if the Commonwealth is to be a smart buyer. Having relevant industry experience in-house will allow Navy/DMO to refine their requirements cognisant of their impact on project costs and risks.

A dramatic illustration of that—and a pretty newsworthy one in my books—is that there's been a significant stepping back from the 2009 Defence White Paper's wildly ambitious aims. There's no conventional submarine in the world with the range and endurance of the Collins class, but the 2009 aim was a 'significantly greater' performance. That led me (and others) to describe the projected submarine² as a 'conventionally-powered nuclear submarine' and to question the feasibility of the project.

This week we learned that the revised capability aims aren't very different from Collins in terms of range, speed and endurance. Capability enhancements will instead focus on sensor capabilities and stealthiness, both of which will make the subs more effective and survivable in the decades to come.

Another sensible step is to take the existing Collins combat system (a highly modified derivative of the USN's Virginia class system) and weapons into the new class, at least in the first instance. That will allow for a spiral development path, in which the new hulls, sensors and propulsion systems can be worked out without the concomitant risks of developing a new combat system. We tried that with Collins and it caused more grief than it was worth, so full marks there.

Of course, putting new sensors into the future boats will require them to be integrated into the combat system. Planning for that eventuality, we were told that Australian software developers were being contracted for 'out of cycle' software-development work (ie not in the USN development cycle). Getting Australian industry into

the high value-add end of systems integration, where competing in global markets is entirely possible, is also a welcome development.

David Gould described the next step of finding an industry design partner that'll take the design brief provided by the IPT and produce a detailed design. It wasn't 100% clear if the design partner would automatically become the build partner, but that would make sense, allowing for the transition from design to production engineering to flow with lower risk of things being 'lost in translation'. Mark and I had a fair bit to say about how this might work in the recent paper, so I won't labour the point here, other than to note that such an approach might have avoided some of the problems the AWD project had³.

Lest I seem uncharacteristically charitable, let me point out a couple of things that didn't sound quite right. As Manager of Submarines, David Gould has to worry about the existing fleet as well as the future one, and he noted that both types would be in service together for a considerable time. He explained that his preference was to have a single support contract to cover both. Presumably the thinking is that having in-house understanding of both designs would allow for a single support arrangement. I'm not totally convinced; unless the same design house is behind both (in practice meaning a Swedish choice), it seems to add complication in managing intellectual property—a significant problem in the past⁴.

Finally, there were hints in the presentation about the possibility of offshore builds, but no discussion of how (or where) that might happen. It's fair enough to be looking at foreign builds, as the costs and benefits of all options should be diligently explored. But then we were told that a local build (including the first of class) was important for knowledge transfer needed for future support. The mixed signals had some of the industry reps scratching their heads.

All in all, there were more steps forwards than backwards. It might be several years later than would've been optimal, but real progress is being made.

Notes

- 1 <https://www.aspi.org.au/publications/how-to-buy-a-submarine-part-2>
- 2 <http://thediplomat.com/2011/12/does-china-worry-australia/>
- 3 <http://www.aspistrategist.org.au/what-do-the-awd-problems-tell-us-about-the-future-submarine/>
- 4 <http://www.aspistrategist.org.au/australia-and-sweden-burying-the-hatchet/>

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The elephant in the conference room

Mark Thomson (first published on *The Strategist*, 30 July 2014)

The worst-kept secret at the DMO *Defence and Industry* conference this week was the government's active consideration of buying submarines from Japan. Although it was never mentioned in any presentation, Option J, as it has come to be known, was discussed in every corner and corridor of the Adelaide convention centre.

Good policy rarely results from secret deliberations shielded from public scrutiny, so I think it's time to discuss Option J directly, at a level beyond passing media speculation.

As recently as a month ago, the Abbott–Abe strategic cozying up seemed likely to deliver little more than access to Japanese submarine technologies—in particular, the propulsion system. But today it appears that the government is actually considering having replacements for the Collins built in Japan.

Before going any further, it's worth noting that would be a move laden with geopolitical consequences. The export of Japanese submarines to Australia would represent a much more rapid normalisation of Japan's defence posture than anyone has anticipated so far. It would alarm China and heighten Beijing's fears of containment by the United States and its US allies. Those are serious first-order strategic considerations not to be dismissed lightly or as somehow secondary to the reasons for acquiring submarines in the first place.

But for the moment, at least, I'll leave it to others to argue the strategic merits and risks of the proposal and focus instead on the question of whether Option J represents a credible path to the cost-effective delivery of submarines to meet Australia's needs.

It's commonly believed that Japan builds and operates capable submarines of a displacement commensurate with Australia's needs. Moreover, they do so through a mature industrial arrangement that exploits dual sourcing to deliver efficient construction and maintenance. So far, so good. The trouble is that, at least in the public domain, we know little about the range, endurance, sensor effectiveness and acoustic properties of the vessels.

Even on the basis of what we do know, if Japan is willing to sell us submarines, we should be looking closely at what they have to offer to see if it meets our needs, or might meet our needs with some modification. For example, we'd almost certainly want to equip the vessels with US weapons and combat systems.

The option of building submarines offshore will alarm Australia's domestic shipbuilders who have been waiting patiently to play a role in what was long promised to be a domestic program. I'm largely agnostic about building offshore, provided that appropriate steps are taken to ensure the availability of cost-effective and strategically necessary in-country support the fleet will need.

The fear among many people I've spoken to, and which I share, is that Option J is being driven at the political level in the absence of the due diligence needed for a multi-billion dollar critical defence acquisition. Japan isn't the only country that builds submarines. France, Germany and Sweden all have credible products¹ and a declared interest in helping Australia fulfill its submarine needs.

We need something more than a beauty contest—which appears to be all that's currently planned—that rushes to a decision. With three or four credible contenders we need to see what's on offer and use competitive mechanisms to secure the best possible deal for the Australia taxpayers.

The bare bones of what we should do is straightforward:

Step One would be to seek formal expressions of interest from prospective suppliers for both in-country and foreign-build boats, based around a clear statement of what Australia wants in terms of platform performance, US-system compatibility and, critically, efficient through-life support in Australia.

Step Two would be to select the two best contenders, or three if absolutely necessary, and conduct funded preliminary design studies. Preliminary design studies would allow decisions to be made on the basis of reasonable estimates of the cost and capability available from the selected firms.

Of course, the conduct of the second stage would be more complex than the simple picture I've painted. For example, for domestic construction, the involvement of local firms complicates matters somewhat. But the principle underlying my proposal is simple: in the absence of competitive pressure to contain costs and negotiate affordable through-life support we'll find ourselves at the mercy of the supplier for the next thirty years.

Note

1 https://www.aspi.org.au/publications/how-to-buy-a-submarine-part-2/SI72_Submarines.pdf

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China's emerging undersea capability and the implications for Australia's future submarine

Benjamin Schreer (first published on *The Strategist*, 24 April 2014)

At ASPI's recent Submarine Conference the strategic rationale for Australia's Future Submarine (FSM) was only lightly discussed. Presenters stated that the FSM worked best as an 'offensive platform' and 'up threat'. But that issue deserves a more detailed debate: it's central to answering the question about what we want the submarines to do. A hidden assumption of the 2009 Defence White Paper, which provided the vision for 12 new and large diesel-electric submarines, was that the boats would be able to operate for extended periods as far away as Northeast Asia, including off the Chinese mainland. Some analysts, including here¹ on *The Strategist*, support such a view.

But the future undersea environment off the Chinese coast will be markedly different from what it is today. A key reason for that is China's emerging submarine and anti-submarine (ASW) capability. To be sure, the current undersea balance between the US and China is still very much in favour of our major ally². Beijing is catching up though, and by the time Australia's new generation of submarines goes to sea that balance might have shifted. As a recent report³ by the US Congressional Research Service points out, while China's current submarine force is now quantitatively smaller than it was in 1990, it has 'greater aggregate capability than it did in 1990, because larger numbers of older, obsolescent boats have been replaced by smaller numbers of more modern and more capable boats'.

A staff report for the US–China Economic and Security Review Commission⁴ puts the trend towards a more formidable Chinese submarine fleet by 2020 into a table:

Table 1: 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 (SSN)	4	5	5	6	6	6-8	6-9
Nuclear Ballistic (SSBN)	1	1	1	2	3	3-5	4-5
Total	93	49	66	59	63	66-75	69-78

The report also notes the ongoing modernisation of the fleet, defining 'modern' submarines as those able to launch ballistic missiles or anti-ship cruise missiles (ASCMs).

Table 2: China's Submarine Fleet, 1990–2020, approximate percent '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%

That assessment is underlined by recent Congressional testimony from the US Navy's Office of Naval Intelligence⁵ (ONI). The ONI also expects that by 2020 the 'vast majority' of China's submarine force will be armed with 'advanced, long-range ASCMs'. Moreover, apart from the possibility that a new Type 095 SSN could be equipped with a land-attack capability, the testimony reiterates the Pentagon's expectation that the JIN-class SSBN will become operational in 2014, marking 'China's first credible at-sea second-strike nuclear capability' against the continental US, Hawaii and Guam. Should the Chinese Navy (PLAN) increase its JIN-class boats from three to five it could sustain a continuous SSBN presence in the Western Pacific or the Indian Ocean.

Finally, the PLAN has started to address more seriously its notorious shortfalls in ASW capability. For example, a recent article⁶ in the US Naval Institute's *Proceedings Magazine* (subscribers only) analyses China's deployment of a fixed ocean-floor acoustic network off its coast to monitor foreign submarine activities in its 'Near Seas'. While the authors note that it's not yet clear to what degree the 'generally weak' Chinese ASW capability will benefit from that network, they also stress that the PLAN is undoubtedly putting more effort into strengthening its ASW capabilities. As my colleague Andrew Davies points out⁷, major advances in ASW could greatly complicate Australia's future submarine operations close to China's shore.

Of course, it'll take time for the PLAN to turn its new platforms into actual capabilities. For instance, as I've discussed elsewhere⁸, effective command and control in SSBN operations will be a major challenge. But two decades from now the PLAN will be more proficient in undersea warfare as well as ASW. This will not only increase the detection risk for Australian submarines. As well, the undersea land-attack options canvassed in the 2009 Defence White Paper will become even more questionable. And while China's 'Near Seas'⁹ will remain the primary operational focus of the PLAN for the time being, Chinese submarines will increasingly patrol in waters close to Australia—requiring attention of the ADF's ASW capabilities, including submarines.

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 Jennings¹⁰ 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. While this could mean fewer and smaller boats, they would still make critical contributions to Australia's security and to allied operations by posing a credible threat to hostile surface and subsurface systems.

Notes

- 1 <http://www.aspistrategist.org.au/of-australian-strategy-and-submarine-design/>
- 2 http://web.mit.edu/ssp/publications/working_papers/Undersea%20Balance%20WP11-1.pdf
- 3 <http://fas.org/sgp/crs/row/RL33153.pdf>
- 4 http://origin.www.uscc.gov/sites/default/files/Research/Staff%20Report_China%27s%20Navy%20Extends%20its%20Combat%20Reach%20to%20the%20Indian%20Ocean.pdf
- 5 http://www.uscc.gov/sites/default/files/Karotkin_Testimony1.30.14.pdf
- 6 <http://www.usni.org/magazines/proceedings/2014-04/wired-sound-near-seas>
- 7 <http://www.aspistrategist.org.au/submarines-does-moore-mean-less/>
- 8 <http://www.aspistrategist.org.au/the-future-of-sino-us-strategic-stability/>
- 9 <http://nationalinterest.org/article/chinas-near-seas-challenges-9645>
- 10 <http://www.aspistrategist.org.au/the-submarine-choice/>

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Submarines by the dozen?

Andrew Davies and Mark Thomson (first published on *The Strategist*, 10 April 2014)

The press has made much of a perceived backing down from a plan to build 12 submarines¹. We say ‘perceived’ because no-one has actually said that. But it’s true there’s been some very careful language choices around submarine numbers, including by the Defence Minister, in his speech²:

... my primary focus is not on numbers but on the capability and availability of boats required to meet the tasks set by government.

And here in a doorstep³:

To [put] a number on submarines is a distraction. What we want is a long term capability that can be sustained as an enterprise, as an asset that can go long into the future building submarines.

It’s true that the focus ought to be on the delivery of defence capability that’s well-matched to strategy and to the budget. But talk at the conference, both from government and from the bureaucracy, has been about the need for an enduring industrial capability for submarines. While no-one has said so in as many words, an enduring submarine design and build capability all but mandates moving to a continuous build program—the case for which was laid out in detail in DMO’s Future Submarine Industry Skills Plan⁴ last year. Another criterion is avoiding any capability gap that might otherwise occur at the end of the Collins-class lifetime.

We think meeting both of those criteria is only really feasible if the fleet constitutes around 12 boats. We’ll explain why below, but first observe that France has 10 boats (and exports others), and still has management challenges in keeping its industrial capability intact. The UK’s fleet of 11 submarines (and no exports) has barely provided enough continuous work. By general consensus, Japan sustains its industrial submarine capacity pretty well through a rolling production model, but it has 16 in service and is expanding to over 20. Maybe we could come up with a model that works with fewer than 12 boats, but clearly we’d have our work cut out.

Other numbers here aren’t especially promising either. As we pointed out in our 2012 *Mind the gap* paper⁵, a Collins life extension will take them out to 2030 (and beyond that for a few boats). By then they’ll be around 30 years old—not unusual for naval platforms.

The recent success in improving Collins sustainability⁶ has seen a move to a ‘10 years on, 2 years in maintenance’ operating cycle (it was previously 8 + 2), allowing more efficient use of those expensive assets. Future boats could thus serve for 22 years as a minimum, and 34 if they do three cycles as the Collins class will come close to.

So if we had 12 submarines and kept them for the minimum 22 years, we’d need a new one every couple of years. If the number fell below 12, we’d have to slow down further, raising the question of what constitutes an efficient use of the investment required to sustain shipyard and design capacity. Such a slow production rate wouldn’t replace the six Collins boats in the right timeframe; we’d have to produce a batch of four to six fairly quickly and then slow down—but then it’d be hard to avoid having 10–12 boats at some stage.

Of course, 22 years is a remarkably short life-of-type for a submarine. So the question is whether the benefits of an ‘enduring capability’ justify the additional cost of replacing vessels more frequently?

A quick estimate isn’t encouraging; moving from a 34 to 22-year lifespan increases the capital cost of maintaining the fleet by more than 50%. Even with potentially higher productivity and potential savings from avoiding mid-life upgrades, it’s likely there’d be a substantial cost premium. Then there’d be the added costs of maintaining administrative and managerial overheads continuously, within both industry and Defence.

A continuous build program of ships and submarines would also lock the government into maintaining the size of the submarine and maybe surface fleets. Navy might see that as an added benefit; no need to make the case for

the next generation at replacement time. But from a broader defence perspective it would fix the minimum size of a large and expensive part of the force structure. And from a public policy perspective it would lock in a substantial chunk of what was previously discretionary spending.

Call it what you want—an enduring capability or a continuous build program—it means that we'd be creating either a private or publicly-owned monopoly submarine production entity. As the bad old days of government-owned shipyards demonstrated, ensuring productivity from a monopoly supplier is a far from easy task.

Finally, it's worth noting that the main rationale for an enduring capability is a desire to meet some ambitious and uniquely Australian requirements—the prime source of cost and schedule overruns in other defence equipment over the years.

Notes

- 1 <https://au.finance.yahoo.com/news/govt-backs-away-12-subs-024037944.html>
- 2 <http://www.minister.defence.gov.au/2014/04/09/minister-for-defence-speech-address-for-the-aspi-conference/>
- 3 <http://www.minister.defence.gov.au/2014/04/09/minister-for-defence-transcript-aspi-conference/>
- 4 <http://www.defence.gov.au/dmo/DoingBusiness/Industry/IndustrySupportPrograms/FSISP/>
- 5 <https://www.aspi.org.au/publications/strategic-insights-57-mind-the-gap-getting-serious-about-submarines>
- 6 <http://www.aspistrategist.org.au/reporting-some-good-news/>

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ACRONYMS AND ABBREVIATIONS

A2/AD	anti-access/area-denial
ADF	Australian Defence Force
AEW&C	airborne early warning and control
AIP	air-independent propulsion
ANAO	Australian National Audit Office
ASW	antisubmarine warfare
AWD	air warfare destroyer
FSM	Future Submarine
IPT	Integrated Project Team
LHD	landing helicopter dock
MOTS	military-off-the-shelf
PLA	People's Liberation Army
PLAN	PLA Navy
RAN	Royal Australian Navy
RSN	Republic of Singapore Navy
SE&I	systems engineering and integration
SMER	submarine escape and rescue
SSBN	ship, submersible, ballistic, nuclear (ballistic missile submarine)
SSGN	ship, submersible, guided missile, nuclear (cruise missile submarine)
SSK	hunter-killer conventional submarine
SSN	ship, submersible, nuclear (fast attack submarine)
TKMS	ThyssenKrupp Marine Systems
UK	United Kingdom
USN	US Navy
UUV	unmanned underwater vehicle

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Some previous ASPI publications



The submarine choice

Perspectives on Australia's most complex defence project

In April this year ASPI staged a conference called *The Submarine Choice*. In this book you'll find a summary of each of the talks that were given at the conference, and they contain a range of perspectives. As well, we've included some analytic insights from ASPI. Mark Thomson and Andrew Davies write on the complex suite of industrial options. Ben Schreer shares his thoughts on the role the Future Submarine might play in alliance operations with the United States. And, to show that Australia's submarines will have to operate in an increasingly contested environment, Harry White presents a survey of regional submarine capabilities and plans.

Although the delivery of the first of class might still be more than a decade away, this is now a rapidly moving endeavour. The conference was only a few months ago, but several new possibilities and perspectives have come to light, either through public statements by officials or in the broader discussion of what has always been a topic of significant interest to the defence and general press. Perhaps the timing of our conference helped to shape emerging thinking on the submarine choice. Certainly few procurement projects have been held to such close public scrutiny before even reaching first-pass cabinet consideration.

Interested readers can stay apprised through ASPI's publications, including short pieces on our blog *The Strategist*, where we'll present our perspectives on developments as they occur. To that end, we've included some recent blog pieces in this volume to help bring the story of the Future Submarine project up to date.