Senate Economic References Committee

Inquiry into Naval Shipbuilding

Submission

by

Mr Gary Johnston

Submarines for Australia

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Introduction

It is nearly two years since the government announced that the Shortfin Barracuda, to be designed and built by the French company, Naval Group, would be Australia's future submarine (FSM). The proposed acquisition remains controversial. As an Australian citizen who has observed over many years the ongoing waste and incompetence exhibited in many Defence acquisitions, I have been concerned since the outset at the huge cost and immense risks around the FSM project.

In an attempt to bring the problems with the submarine acquisition to the attention of our politicians and the community more generally, I have sponsored two major reports under the auspices of my website, *Submarines for Australia*. I should emphasise that I have no commercial interest in the SEA 1000 acquisition. I have sponsored these reports at my own expense solely in the public interest.

The first of these reports, by Insight Economics, was presented to the Committee by Jon Stanford and Hugh White in Adelaide in October 2017. The main purpose of this submission is to present the findings and implications of the second sponsored report, by Aidan Morrison, on the FSM's proposed propulsion system

Insight Economics Report: excessive costs and risks

The Insight Economics report, launched at the National Press Club in September 2017, demonstrated that Defence had clearly abandoned any notion of value for money in the acquisition. At over $3 billion each, the twelve submarines will cost as much as 50 large Soryu class submarines from Japan. Compared with the German proposal, the Shortfin Barracuda is twice as expensive and scheduled to be delivered six years later. This delay will mean that Australia will inevitably experience a serious gap in submarine capability in an era when our strategic circumstances are increasingly uncertain. This capability gap may well widen because of all the risks and almost certain delays associated with designing and building a modern submarine from scratch.

In addition, it is a major stretch to characterise the Shortfin Barracuda as a "regionally superior" submarine when, at this stage at least, it will not incorporate either of the two breakthrough technologies – Air Independent Propulsion (AIP) and Lithium-Ion batteries – that have transformed the capabilities of diesel-electric submarines (SSKs). By allowing SSKs to operate submerged for up to five weeks without having to come up and 'snort', they are able to emulate one of the major advantages of nuclear submarines (SSNs), lengthy submerged endurance, while also being capable of greater

stealth. In an era where submarine detection technologies continue to improve at a rapid pace, this is of critical importance in terms of a submarine's combat effectiveness when operating in contested waters.

Some key questions

To my mind, therefore, some key questions remain. Why did Defence choose this extremely risky submarine that would cost so much more than the other contenders and take so much longer to deliver? How could they select a submarine that did not have AIP and believe it could still be classified, in two decades time, as 'regionally superior'?

Since almost all detailed information relating to Defence's capability requirements for the FSM and, therefore, its technical characteristics, are highly classified, finding an answer to these questions requires the deductive powers of a modern Sherlock Holmes. We believe, however, that the answer lies in Defence's desire to acquire a "nuclear submarine with diesel-electric motors" as well as one that is highly stealthy.

The first clue lies in the main reason given for rejecting the German contender for the FSM, the Type 216. Well-sourced reports suggest that this was because of an unacceptable radiated noise signature on a particular frequency. This is curious on a number of counts. First of all, German conventional submarines have captured the lion's share of the global market and are particularly noted for their outstanding acoustic performance. Secondly, it stretches credibility to believe that Defence could have identified a radiated noise problem on a submarine yet to be designed and, moreover, a problem that was incapable of being fixed. It seems that something deeper was at work. It suggests that Naval Group offered a different technology, one that was not available on the Type 216.

Pump-jet propulsion

In that regard, and this is the second clue, we know that Defence had been undertaking research on pump-jet propulsion. We also know Naval Group gave a presentation to Defence in France in 2015 that demonstrated the very low acoustic signature of their nuclear submarines, which are propelled by pump-jets. Reportedly, the Australian visitors left this presentation highly impressed.

No wonder, then, that when the Shortfin Barracuda emerged as Australia's new submarine, it boasted a pump-jet propulsor instead of a conventional propeller. Could this be the breakthrough technology that justified the selection of the Shortfin Barracuda over its German and Japanese rivals? In

the promotional material at the time, Naval Group even went so far as to declare the propeller "obsolete" for submarines.

Pump-jets are now commonplace among the world's nuclear submarines, where they offer superior acoustic performance at higher speeds and under strong acceleration. But these acoustic advantages can be offset by efficiency disadvantages, depending on the speed at which the vessels operate. It is generally accepted that pump-jets are much less efficient at lower speeds. On SSNs, which have virtually limitless power, this would not be a concern. Indeed, the inefficiency of a pump-jet can be a distinct advantage for a SSN, which needs to keep its reactor running at all times.

But for conventional submarines, which travel at lower speeds than SSNs and rarely need to accelerate very quickly, there may be no significant acoustic advantages to be derived from pump-jets. Of much greater importance for a SSK, where the conservation of power is critical, is the efficiency of the propulsion system and the ability of the submarine to remain submerged for extended periods of time. The received wisdom is that any acoustic benefits of pump-jets for a SSK are significantly outweighed by the penalty of the inefficient use of precious electrical power. Perhaps this is why no operational conventional submarine currently uses pump-jets.

Despite Naval Group's dismissal of the propeller as being obsolete, rumours of its death seem to have been greatly exaggerated. Two years later, Naval Group still appears to incorporate propellers in all its designs of conventional submarines. Of the many nations currently building SSKs globally, not one has discarded propellers in favour of pump-jets.

Indeed, it was highly suggestive that when Naval Group's Executive Director visited Australia in October 2017, he suggested that, rather than pump-jets, the FSM may use conventional propellers and, perhaps, also incorporate AIP. Defence, however, immediately rejected propellers in favour of the pump-jets that Naval Group had offered under the competitive evaluation process (CEP). According to Defence, these were efficient across the whole speed range as well as being acoustically superior. Monsieur Billig's response was that ultimately it was up to the Australians what propulsion system they preferred.

This made us smell a rat. Nobody else used pump-jets on conventional submarines and the French seemed to be backtracking at high speed. Could Defence have made a technical miscalculation, this time on the nation's biggest ever defence project? It was difficult to believe, but bitter experience suggested it could not be ruled out.

Aidan Morrison Report: a technical miscalculation

I then decided to sponsor a second report, this time on the implications of using a pump-jet on a conventional submarine. This is a complex technical issue where the information is highly classified, with most of the experts around the world being contracted either to defence departments or naval shipbuilders. However, one Australian physicist, Aidan Morrison, has experience in this field. His detailed report was recently released and is available at https://s3-ap-southeast-2.amazonaws.com/submarines-paper/Final.pdf

Taken overall, Morrison's findings are quite devastating in terms of the total lack of justification for the use of a pump-jet on a conventional submarine. Even in terms of the acoustic signature, Morrison finds little to recommend the pump-jet for a SSK:

> "It is extremely unlikely that at some very low speeds, where conventional propellers experience no cavitation and enjoy steady, smooth flows over the blades, that a pump-jet could actually have a lower acoustic signature, even in terms of radiated noise ... Consequently, the claim that pump-jets are generally acoustically superior should be treated with some caution. This claim has strong grounds wherever a conventional propeller might experience cavitation, such as at higher speeds. But at some very low speeds it is unlikely to be true."

The scenarios in which a pump-jet may provide better acoustic performance will occur rarely, if at all, for a SSK operating on patrol in contested waters where the need for sustained silent operation is paramount. As Morrison says, "the selection of a pump-jet on a diesel-electric submarine on acoustic grounds is consequently a strange choice, as it amounts to elevating a tactical scenario which demands a short, high-speed burst above all other circumstances where a long, silent dive at low speed is required".

If there are any acoustic benefits from using a pump-jet on a SSK they are insufficient to justify a system that is prodigal in its use of precious reserves of power. Morrison's findings directly challenge Defence's statement that pump-jets are efficient through the whole speed range (Table 1).

At a speed of four knots, not unreasonable for a SSK on an offensive patrol, its range and submerged endurance are estimated to be at least 50 per cent greater with a propeller than a pump-jet. The indiscretion ratio, that is the relative time it needs to spend snorting when it is highly vulnerable, is over 50 per cent greater with the pump-jet. At eight knots, the results are very similar, suggesting that if pump-jets can be more efficient than propellers it would only be at a much higher speed.

Table 1: Comparison between propeller and pump-jet efficiency

Propulsor	Submerged Range	Submerged Endurance	Indiscretion Ratio
	Speed: 4 knots		
Propeller	554 nm	138 hours	2.9%
Pump-jet	366 nm	91 hours	4.4%
	Speed: 8 knots		
Propeller	357 nm	45 hours	9.6%
Pump-jet	237 nm	30 hours	15.1%

Source: Aidan Morrison (2018), *A comparison of pumpjets and propellers for non-nuclear submarine propulsion*, January, page 7, https://s3-ap-southeast-2.amazonaws.com/submarines-paper/Final.pdf

No comparative analysis of submerged range and endurance for a contemporary SSK should exclude a consideration of AIP. Morrison's finding was that:

> "The model demonstrated clearly that all of the most pronounced advantages in dived range and endurance occurred at speeds around 3-7kt, generally within plausible speeds achievable with modern AIP systems. The addition of AIP … revealed that a difference in dived endurance of the order of one month, or thousands of nautical miles, would likely have emerged between the two propulsion systems."

The major conclusion to be drawn from this analysis is that, on the basis of Morrison's detailed modelling, there is no way that the FSM should be equipped with a pump-jet rather than an advanced composite propeller. Except in one or two very specialised operational scenarios, the acoustic performance will be no better and in some instances may be worse. At the same time the implications for the submarine's efficiency are very serious. As Morrison puts it:

> "In a comparison between two otherwise identical submarines, the one with the pump- jet will always have a lower dived endurance, a lower dived range, a worse indiscretion ratio, a lower overall endurance, and a lower overall range, than the one with a propeller. This will confer a substantial tactical and strategic advantage on the conventionally propelled submarine in a very broad range of operational scenarios."

Conclusion

We do not believe that the CEP was a genuinely competitive process. Successive governments – under Prime Ministers Rudd, Gillard and Abbott – told Defence that a low risk solution was required for the Navy's future submarine capability requirement. This instruction has been comprehensively ignored. We consider that Defence decided in about 2008 that the best solution lay in a very large and unique Australian submarine design – the

approach with the highest possible risk –and they have single-mindedly pursued this ever since.

Only the French proposal would allow the RAN effectively to design their own submarine, as they are now doing with assistance from Naval Group. The result is a submarine that will be quite eye-wateringly expensive, with an inadequate capability and one that will be delivered far too late. The government's proposed way of addressing that capability gap – new sonars for the *Collins* class – will not provide the RAN with a credible Submarine Force to provide for the defence of Australia in the 2030s and beyond.

One element in the quest for a unique Australian design was a desire to emulate nuclear submarines by using a pump-jet propulsor rather than a propeller. Only the French offered pump-jet propulsion. Our modelling demonstrates unequivocally that pump-jets are a bad and potentially disastrous choice for conventional submarines. No other country uses them. Surely Defence must have evaluated pump-jets independently without relying solely on a presentation by just one of the contenders, Naval Group? We know they had been working on the technology long before the CEP. But if they had a preference for a pump-jet, did they give all three of the contenders an equal opportunity to address it? If not, the probity concerns are clear.

Christopher Pyne tells us to trust the experts in Defence, but their track record tells against them. The accelerated CEP process for the FSM acquisition meant Defence could avoid most of the checks and balances that had been so carefully erected after the Super Seasprite fiasco. If a fundamental technical miscalculation on a $50 billion project has led Defence to select the Shortfin Barracuda on the basis of its pump-jet propulsion, at an additional cost both of many billions of dollars and of an extended gap in submarine capability, this would put every previous Defence acquisition disaster into the shade.

I believe that an urgent, comprehensive, independent inquiry into the submarine acquisition is required.

Gary Johnston is the owner of Jaycar Electronics and the Submarines for Australia website.