POLICY ANALYSIS ASPI

ASPI AUSTRALIAN STRATEGIC POLICY INSTITUTE

Subaqueana australis—the future evolution of Australia's submarines

93

by Andrew Davies

11 November 2011

Introduction

Earlier this year ASPI pointed out the increasing urgency of making some decisions about the future submarine project. That paper suggested that the ongoing problems with the *Collins* class and defining and building its replacement should be tackled together. To do otherwise—especially if the future project is kept in stasis while the *Collins* problems are worked on—would risk a capability gap opening up sometime next decade.

This paper expands on those points and suggests a way ahead that would see Australia's submarine fleet managed not as a succession of essentially distinct projects and equipment types, but in a holistic capability-focused way. Fixing the *Collins* fleet need not be a separate activity to developing the future fleet. In fact, managed properly, work on *Collins* can form a risk reduction strategy for the future boats as part of an evolutionary process.

An evolutionary concept

The previous ASPI paper observed that there are four broad options for the future submarine (in likely order of cost and risk):

1. an off-the-shelf submarine (probably from a European design house)
2. more *Collins*, with a degree of modernisation but no large-scale changes
3. a '*Collins* plus' that draws on and extends the existing submarine design
4. a totally new bespoke design.

Options one and four remain viable possibilities but produce answers to very different questions. The current generation of European submarines are mostly under 2,000 tonnes displacement and lack the endurance required for long distance operations in the expansive Asia–Pacific theatre. They could be used as sea denial assets in the waters around Australia or be staged through friendly ports for wider deployments but are necessarily limited in their ability to deploy at long range autonomously.

The new bespoke Australian-unique design being championed in some quarters is envisaged as a long-range submarine with a sizeable payload that's suited to extended deployments in the wider Asia–Pacific region from Australian bases. While the *Collins* can do much of what is needed if that's the aim, the additional requirements described in the defence White Paper would require a submarine of greater size and complexity.

Somewhere in between those options is a design concept for a large conventional submarine —not yet in hardware form—which was recently made public by German submarine design house HDW. The concept seems to meet most of Australia's stated requirements and this option is potentially attractive—although a lot of work has to be done (and paid for) before it can be assessed accurately. However, the aim of this paper is to explore what might be done to build on Australia's current hardware and expertise, and it won't explore options one or four further; the interested reader will find articles in the reading list at the end of this paper.

The two intermediate options aren't mutually exclusive. Option 2 could easily be a precursor to option three. And remediation efforts on the existing *Collins* fleet—which look increasingly necessary with every year that passes—could form the first step of an evolutionary process. In what follows, we use the shorthand of calling the existing submarines '*Collins* Mark 1' (Mk 1). Later versions with the same hull design but with different mechanical, electrical or other systems are designated Mk 1b, 1c etc. '*Collins* Mk 2' is shorthand for a submarine that has an obvious lineage in *Collins*, and which incorporates many of the improvements on the Mk 1 line, but which differs substantially in other ways, including potentially the hull design—should such a change prove to be necessary or desirable. This nomenclature is somewhat arbitrary but serves here as a conceptual aid.

There's no 'one true way' to evolve a design. Figure 1 shows a linear process in which the current *Collins* fleet is upgraded as a first step and then a follow-on build begins to produce the evolved Mark 2 submarine as the eventual replacement for the Mark 1. There could be a substantial overlap in service between the Mark 1 and Mark 2 boats.

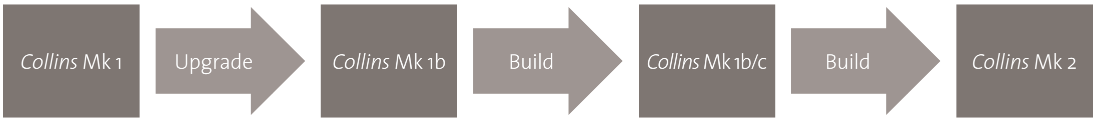
That's essentially the model pursued by Japan. Japanese boats are improved incrementally in a continuous build process and the move to a new class is made after many of the required technological and engineering changes have been demonstrated in preceding builds. There's certainly something to learn from their experience—Japan has a successful record of producing large conventional submarines. The Oyashio class (built 1994–2008) displaces 2,750 tonnes surfaced, and the later Soryu class (2005 onwards) 2,900 tonnes—similar to the *Collins* at 3,050 tonnes. The Soryu is the first Japanese submarine fitted with air independent propulsion.

Figure 1: A schematic representation of one possible route from the present *Collins* submarine to a more advanced model

But the strength of this approach is that the decision to move on to production of the Mk 2 boats can be informed by engineering information that's gathered during the upgrade process. Very little that's genuinely new needs to be incorporated in the first Mk 2. Conversely, taking a 'top-down' approach of defining the end capability that's required involves a leap of faith that the required technologies will be mature enough and that a myriad of systems integration problems will be able to be dealt with over the course of the development program. As ASPI has observed many times, this sort of optimism has seen many a major project run into cost, schedule and sometimes capability setbacks along the way.

An evolutionary approach provides a natural fall-back option if there's insufficient confidence in the design for the Mk 2, for whatever reason. Rather than pushing on and hoping that the inevitable problems will prove tractable, there's always the option of producing new build Mk 1 boats, either at the upgraded Mk 1b level of capability, or with further modest improvements as a 'Mk 1c'. In this way the size of the fleet can be maintained while the processes and technologies necessary for the evolution of the Mk 2 can be developed to maturity. This is an example of a 'spiral development' approach in which each iterative step builds on the progress made previously. (Figure 2 illustrates).

Figure 2: A two-step process to the *Collins* Mk 2



With this approach, capability steadily improves in a series of steps, albeit without a sudden dramatic leap from one class to another. But it does so with much reduced risk of a capability gap opening up due to the existing platform reaching the end of its operational life before its replacement is available—as occurred in the Oberon to *Collins* transition.[1]

And it makes the management of the overall submarine building and maintenance capability much easier if there's a constant flow of work—either new builds or refurbishment/upgrade work on existing boats. As ASPI wrote back in 2008:

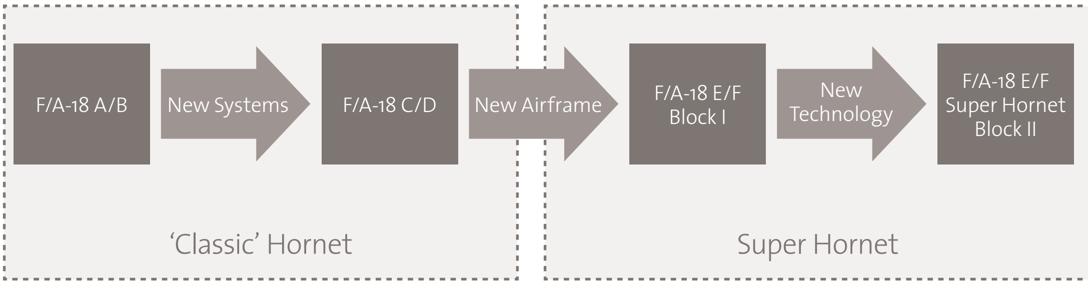
> By leaving an 'air gap' between the *Collins* and the next generation of boats, we've created a challenge for the future. And it's not just creation and maintenance of the workforce that's a challenge. Stopping and starting between classes has a financial impact as well.
>
> (*How to build a submarine*, p 19)

An example from aerospace

An example from the world of aerospace development shows how this approach can work in practice. The Block II F/A-18E/F *Super Hornet* that's in the process of being delivered to the RAAF is obviously an evolution of an earlier design—the 1980s vintage F/A-18A/B *Hornet* that it will replace—but it is a very different and far superior aircraft to its progenitor. The jump from the first *Hornets* to the latest *Super Hornets* wasn't a one-step process. Along the way the basic A-model *Hornet* was much improved with new sensor and mission systems to become the C-model.[2] C-model aircraft were mostly produced as new builds for the US Navy (USN), but Australia got a very similar result by upgrading its existing airframes.

The *Super Hornet* uses many of the design features of the *Hornet*—to the point where the aircraft are visually very similar—but is a larger airframe with many new features and systems. The Block II version incorporates new technologies including low visibility 'stealth' materials and shaping and a sophisticated new electronically-scanned phased array radar system. (Figure 3.)

Figure 3: The evolution of the Super Hornet



There's a trade-off to be made when evolving a design in this way. The *Super Hornet* won't ever have the full suite of capabilities of fifth generation aircraft such as the F-22 *Raptor* or a mature F-35 JSF. On the other hand, the development process of the *Super Hornet* was smoother and suffered less from cost and schedule overruns than either of those aircraft. And, as the RAAF is currently showing, the transition to an evolved form of existing equipment can be very rapid indeed due to the level of familiarity with platform characteristics.

The downside to such an evolutionary approach is that the maximum achievable capability is likely to be limited by inherent properties of the platform. At some stage the *Super Hornet* will run out of development potential—although that hasn't happened yet and there's a forward 'road map' of further development—and a move to an entirely new platform will be required to keep capability at competitive levels.[3]

Of course, there's a limit to how far this analogy can be pushed. Submarine design is in some ways a less forgiving discipline than aerospace engineering—design margins are tighter because the interaction of systems within a submarine hull requires very careful management in terms of space, weight and physical distribution. And it's much harder to 'bolt on' a new system to the exterior of a submarine—compared, for example, to the addition of a new fairing on a *Super Hornet* for an infra-red search and track sensor.

But some general principles apply. Having produced solutions to difficult problems once, it's sensible to get more mileage from them. With the *Collins* program we have already gone through the pain of integrating an American combat system and USN weapons into a hull that has its origin in a European design house. Starting from scratch with a new design would potentially require a lot of that effort to be repeated.

The Tsar(s) of all submarines

Whatever decision is made about the future of Australia's submarine capability, it will be important to get in place the right management structures. Large projects, which are likely to make significant demands on government funds and run over successive administrations, need a support base that transcends party politics. And complex projects require strong leadership—in government, organisational and technical areas.

Table 1 shows five selected ambitious but successful government-sponsored projects from the last seven decades, including the management and technical leads responsible for steering the project. There are some common features that bear pointing out. In each case there was strong political support from the highest levels and there was a national imperative driving the effort. Many of the names in the technical leadership columns are immediately recognisable as world class figures in their respective fields. Two skill sets were required to achieve successful outcomes; adroit project management and oversight to smooth the path through government processes and first-class technical leadership. Both worked to create an environment that allowed scientists and engineers to pursue innovative solutions and—importantly—to experiment where necessary and make trades between objectives and engineering realities.

Table 1: Selected major projects 1941–1972

Project	Political support / rationale	Project management / oversight	Project technical lead	Notes
Manhattan Project (1941–45)	Presidential/War imperative	Major General Leslie Groves	Robert Oppenheimer	Concurrent development of two different technical approaches
USS *Nautilus* (1951–55)	Bi-partisan Congressional approval/ competition with Soviet Union	Admiral H. Rickover	John M. Burnham	World's first nuclear submarine—in less than five years
Snowy Mountains scheme	PM Chifley and bi-partisan support for 'nation building' project	Snowy Mountain Authority under Act of Parliament	Sir William Hudson	Made a defence issue by PM to bypass state quibbling and bring it under the federal government
U-2 and SR-71 spy planes (1953–64)	Instigated by President Eisenhower/Cold War politics	CIA (Richard Bissell)	Clarence L 'Kelly' Johnson	Engineers allowed quick resolution of problems
Apollo program (1961–72)	Presidential and bi-partisan support/ Cold War politics	Director NASA	Dr Wernher von Braun	High degree of engineering independence; competing approaches rigorously evaluated

The results speak for themselves—the USS *Nautilus*, the world's first nuclear submarine was launched barely four years after funding was initially approved. The extraordinary SR-71 *Blackbird* reconnaissance aircraft was less than five years in development. By way of comparison, HMAS *Collins* was commissioned fifteen years after project initiation.

If we look at Australia's future submarine project as it's currently structured, it's hard to identify any of the success factors that are a common feature of the projects in the table. There's far from unanimous support within the Australian polity for the strategic arguments that underpin the expansion and enhancement of the submarine capability, although both sides of politics are broadly committed to the plan for twelve submarines.

There are two elements underpinning the national imperative case for a major development project. First, that the ADF needs to be able to operate submarines at long distances from Australia because of our strategic geography and circumstances. Second, that the world market cannot provide such a submarine. Neither case has been made authoritatively, resulting in continuing uncertainty for decision makers.[4] Within the defence commentariat there are competing—and vocal—schools of thought proposing a range of technical solutions. And, of course, the regularity with which shortcomings of the *Collins* fleet make their way into the press isn't helping matters. In that environment it's extremely difficult for the project lead within defence to get the priority that a project of this size warrants.

The apparently moribund state of the project—at least as far as government decisions are concerned—in the several years since the project's genesis reflects a management structure that's underpowered and unable to marshal the support required to move the project along. A project of this sort—large even by the standards of Defence or the biggest companies—needs project management skills of the highest order and world class technical leadership. Both of those qualities need to be paired with a proven track record in delivering big projects. In short, the project needs the calibre of people in columns three and four of the table above.

While there's no doubting the application and knowledge of those currently involved, a team headed by a two-star naval officer simply lacks the organisational clout and the authority of its conclusions to overcome resistance encountered at various levels. If it's serious about delivering on its stated ambitions, the government should 'head hunt' a couple of individuals for the positions of project head and technical team leader. And they should be people who have a proven track record in delivering complex projects. In the case of the technical lead, experience in a successful submarine program is essential. Such people won't be cheap—but they aren't likely to cost more than a small fraction of the project's total budget, and would be a solid investment at this point.

Collectively, the project management should be responsible for configuration management of the current and future submarines, so that the national submarine capability can be managed holistically, rather than as two separate problems. Of course Navy, as operator of the fleet, must be involved at a high level as well. The two-star naval officer position should therefore be retained as the Chief of Navy's representative.

Technical leadership is crucial, but it has to be backed by a depth of knowledge within the project team. ASPI opined in its 2008 paper *How to buy a submarine* that the technical know-how within Defence seems insufficient for the task. That judgement has since been borne out by successive independent reports into naval projects and capability management that have identified a lack of engineering know-how as a root cause of many problems. In our 2008 report we proposed subsuming the technical design capability currently resident within the government-owned ASC company into the project office. That remains an attractive option and is probably the fastest way to build up the Commonwealth's in-house capability. Given ASC's long-standing relationship with Swedish submarine design house Kockums, this approach could be problematic from an intellectual property point of view if a design from another submarine manufacturer was selected. But those problems would largely be avoided if the 'evolved *Collins'* approach described was chosen.

Conclusions

The future submarine project is rapidly reaching a point where something of a scramble could be required if a future capability gap is to be avoided. At the same time, the current *Collins* fleet is suffering from a series of maintenance problems, some of which were essentially designed in. Remediation work is almost certain to be required if the fleet is to make it through to its designed end of life sometime in the middle of the next decade.

These problems may have the same solution. Work to remediate the current fleet could form the basis for an evolved design that could be developed progressively. The first iteration might involve new propulsion components—long the Achilles heel of the *Collins*—and further evolutions might introduce new sensors and other systems. In time, and when a technically mature design is available, a new class of submarines could emerge. But, critically, the systems in the first of class would have already been proven in an operational boat.

To have the best chance of successfully achieving this, the project leadership and the technical knowhow of the project team must be as strong as possible. That doesn't seem to be the case at the moment.

Further reading

How to buy a submarine: Defining and building Australia's future fleet, ASPI Strategic Insight 48, October 2009. http://www.aspi.org.au/publications/publication_details.aspx?ContentID=228

The Submarine Institute of Australia has been a vocal advocate of a new design submarine for Australia. Papers summarising their views can be found on the 'Submarine 2020' page of their website. http://www.submarineinstitute.com/sia-projects/Submarine-2020.html

All of the projects listed in Table 1 are worth reading about in their own right. A particularly good place to start is the Pulitzer Prize winning *The Making of the Atomic Bomb*, by Richard Rhodes.

Notes

1 See A. Davies and M. Thomson, *The once and future submarine—raising and sustaining Australia's underwater capability*, ASPI Policy Analysis 78, April 2011. http://www.aspi.org.au/publications/publication_details.aspx?ContentID=291

2 The B and D models of the 'classic' *Hornet* were simply the two-seat versions of the A and C respectively—they didn't significantly differ in other respects.

3 There can be many evolutionary steps before this happens. The British *Spitfire* fighter first flew in 1936. The last model produced was the *Seafire* Mk47, which had no commonality at all with the Mk 1 version. Development ceased in the late 1940s only when the jet engine rendered the basic *Spitfire* design obsolete. Even then the Mk 47 wing was carried on to the first generation of British naval jets.

4 ASPI has discussed many of the alternatives in our own and other publications.

About the author

Dr Andrew Davies is ASPI's Operations and Capability Program director. He would like to acknowledge ASPI research analyst Andrew Rothe for his assistance with the compilation of Table 1.

About Policy Analysis

Generally written by ASPI experts, the POLICY ANALYSIS series is provided online to give readers timely, insightful opinion pieces on current strategic issues, with clear policy recommendations when appropriate. They reflect the personal views of the author and do not in any way express or reflect the views of the Australian Government or represent the formal position of ASPI on any particular issue.

ASPI
Tel + 61 2 6270 5100
Fax + 61 2 6273 9566
Email enquiries@aspi.org.au
Web www.aspi.org.au