Trends in submarine and anti-submarine warfare

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Introduction

Thank you for the opportunity to talk here today. I have to confess that the program today is a little bit daunting, and my topic is way too broad to fit the time allocated. So let me apologise in advance for what's bound to be a 'once over lightly'.

I see several big questions that have to be grappled with before any government could be confident when approving a major project of the sort we're discussing today. [SLIDE]

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 each of the proffered solutions to questions 1 to 3, and how can they be mitigated?

These questions are of course what this conference is all about. I'll only tackle the last of them today, and only from the narrow viewpoint of possible technological changes. Even then I won't be offering hard answers, but will hopefully illuminate the issues.

Note that the order isn't sequential. The answer to each of the questions has to be informed by the answers to the others. And that's actually one of the biggest criticisms I have of the current development of military capability—it's too often practiced as a top-down process whereby materiel solutions are pushed along by requirements that follow from high-level strategic guidance. I think that's how the future submarine project ended up described the way it was in the 2009 defence white paper.

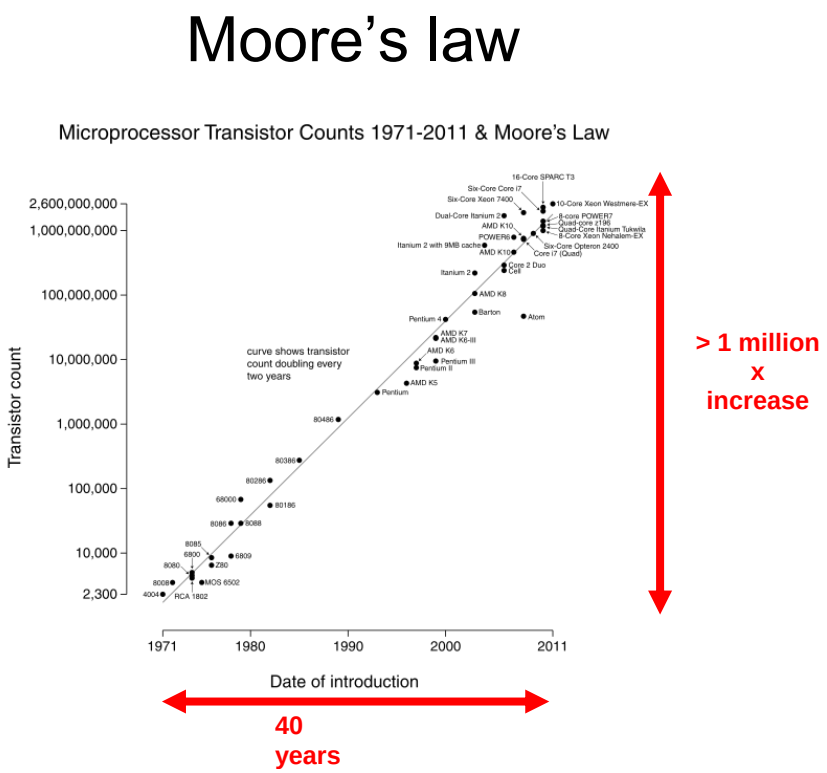
Instead, we have to think about all of those factors concurrently, and design a strategy, a military posture and force structure that makes best use of the scarce resources we have and the possibilities that technology and human capital provide, all with a view to retiring those strategic risks we judge to be both manageable and cost-effective.

But I think it's important for us to spend a little time reflecting on technology and the trends in modern warfare. Regardless of the form it ultimately takes, the future submarine is likely to be with us well after 2050, at least if previous platform lifetimes are anything to go by.

Technological trends

But let's hold that thought for a minute—the future submarine will be with us in 2050—36 years from now. Going back 36 years puts us back in 1978. My family got its first colour TV the year before that and I think the first live cricket telecasts from England were around that time. And those things seemed like a big deal. Personal computers, mobile phones and computers in cars were fanciful notions. A smart phone connected to the world of information and entertainment was science fiction.

I mention those things because I want to talk today about the potential impact on submarine operations of the exponential growth trend in computer power and bandwidth. This figure illustrates what's known as Moore's Law.



The next 40 years will likely see the same factor of increase in our ability to capture, process and move information around. Not the same increase, but the same ratio: another factor of over 1 million. Computing power in 2054 will be around one trillion times what was available in 1974.

The implications of that are worth teasing out—especially when we're setting off to invest tens of billions of dollars in major platforms. There are threats and opportunities from emerging technologies, as there doubtless will be from future technologies we can barely conceive now. And while I'm going to try to predict some future technological applications, it's worth noting that I work for ASPI and not for Apple, so the odds are pretty good that others will have more and better ideas.

Submarine and anti-submarine technologies

To bring this back from the abstract to the concrete for my purposes today, let me use a physicist's trick of 'limiting cases' to explain why that's relevant to a discussion of the future submarine. [SLIDE] The two limiting cases I imagine are (1) the invention of a new sensor that renders submarines easily detectable in all circumstances and (2) new submarine technologies that make them practically undetectable. In the former case we'd clearly be silly to invest further in submarines and in the latter we'd be finding new ways to exploit their even better stealthiness and investing more heavily in a subsurface fleet, confident that they represented a low risk, high impact capability.

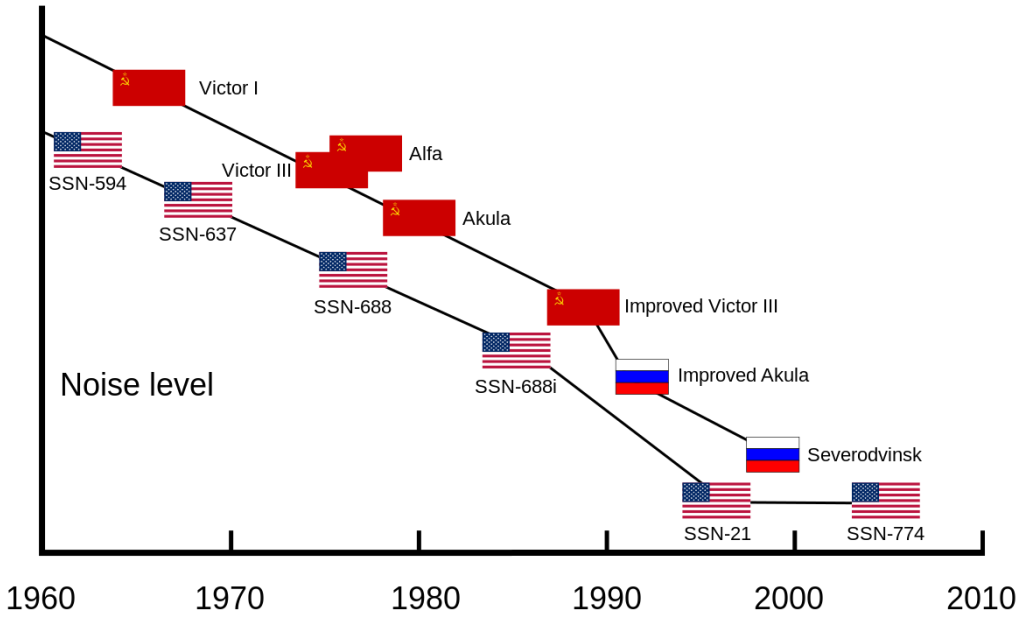
Neither of those limiting cases will be realised in the foreseeable future, so in practice we'll continue to balance the benefits, risks and costs of submarine operations. But my point is that we shouldn't be sanguine that the balance will stay in the same place. Major weapons systems have been overtaken by technological advances before, and will be again.

In particular, my main point today is that the future is more likely to be characterised by increased detectability of submarines than it is by decreased. Put another way: the risks of operating large submarines in contested spaces will likely be higher—possibly much higher—in the future than is the case today. That doesn't mean that they won't have a role, but it will be a significantly different one, and the submarines themselves will have to have different design features as a result.

Let's start with the submarines themselves. Work done over decades has resulted in some remarkable advances in radiated noise management to make detection by passive sonar more difficult. Against active sonars, submarine stealth is achieved by anechoic tiles and clever design to reduce the strength of reflected signals. Today's submarines are many decibels quieter than their predecessors and present lower target strengths to active sonars. But ultimately, large submarines are large, and there's a limit to what can be done to reduce propeller and flow noise, and target strengths can't be reduced below some physical limits—especially at low frequencies. Every decibel helps, and being hard to hear is always going to be better than being easy to hear, but I think it's fair to say that we're getting into diminishing returns—as this figure shows. [SLIDE]

Note the recent leveling out of performance as we nudge towards the limits of what's possible. Improvements are no doubt possible, but they'll be smaller than past ones, and will likely cost more. Those figures are for nuclear submarines, but the same laws of physics apply to conventionals—which also have to snort sometimes, a point I'll come back to later.

Figure: diminishing returns in submarine noise management



Source: US Office of Naval Intelligence data via Wikipedia.

ASW

So let's now turn to a discussion of detection technologies. I think we might be on the cusp of some revolutionary approaches to ASW that, together with the diminishing returns of submarine stealth, might shift the balance in underwater operations.

I don't expect that to go unchallenged, especially since that isn't the recent trend. For the last few decades I think it's fair to say that submarine technology has at least kept pace with ASW technology, if not gotten ahead. Here's a short list of things that have traditionally made life hard for ASW practitioners [SLIDE]:

- proliferation of submarine operators
- quieter submarines
- air independent propulsion (AIP) and reduced indiscretion rates
- the evolution of submarine weapons – terminal effectiveness and stand-off range
- the relative ineffectiveness of many ASW weapons
- the unchanged and difficult physics of seawater

Those factors, have spurred on the development of active sonar, especially low-frequency systems that allow long-range detection. I think that's the continuation of a trend that began at least a decade ago, and is a natural response to the evolution of quieting technologies in submarines. A modern diesel-electric boat operating on AIP is, quite simply, too dangerous to attempt to counter with a passive-sonar approach. In fact, I've been surprised that the focus on active sonar hasn't been stronger, although

the long-held reluctance to go active from surface combatants because of the problem of counter-detection from the submarine probably explains it.

But let's look at what Moore's Law is going to bring [SLIDE]:

- Increased processing power, so that sorting even weak signals from noise becomes faster and more reliable

- Networked processing power means that signals can be integrated over a wide area

- Increased bandwidth makes moving volumes of data between sensors and processors faster

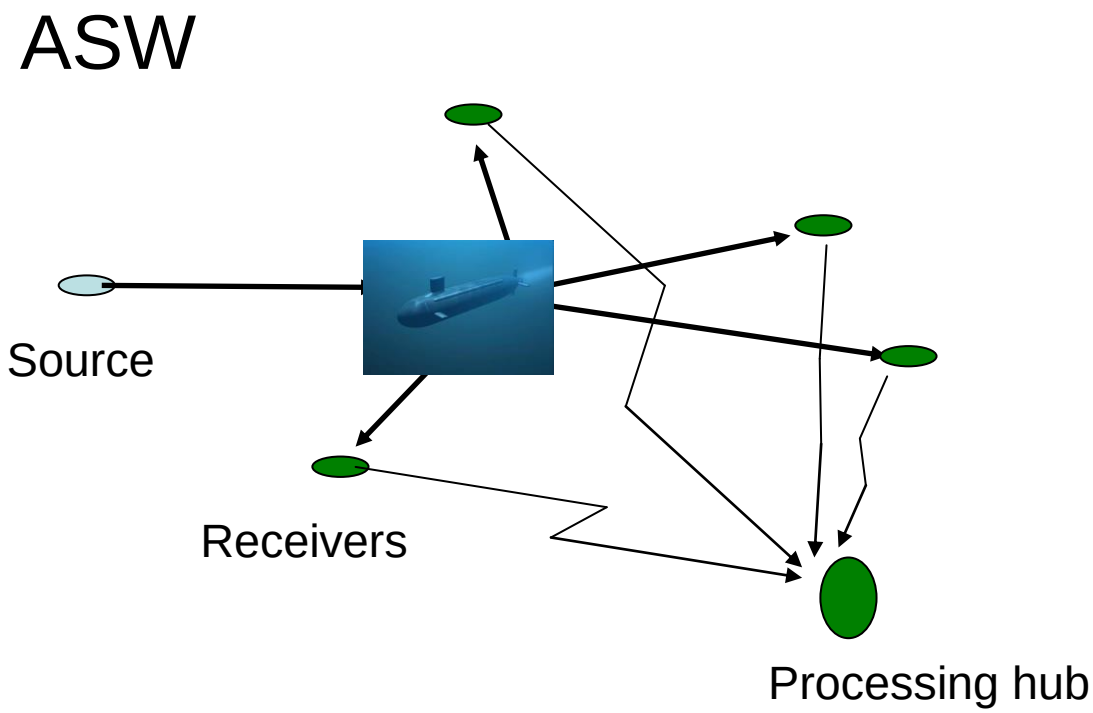
As well, the current trends in the development of unmanned platforms will continue apace, and Moore's law will see them increase in their ability to collect and process information, and they'll be able to forward the information collected to a central hub. [SLIDE]

- remotely operated or autonomous systems with enhanced local processing power and the ability to transmit collected data to a central processing point.

The first and last on that list are the ones where I think a revolution in ASW awaits us—greatly enhanced processing that allow us to work with low signal to noise ratios combined with the ability to disperse sensors and processors across a wide area to collect those subtle signals. Using small and relatively uncomplicated platforms to do that would allow them to be deployed in large numbers, which could greatly complicate the job of submarine commanders.

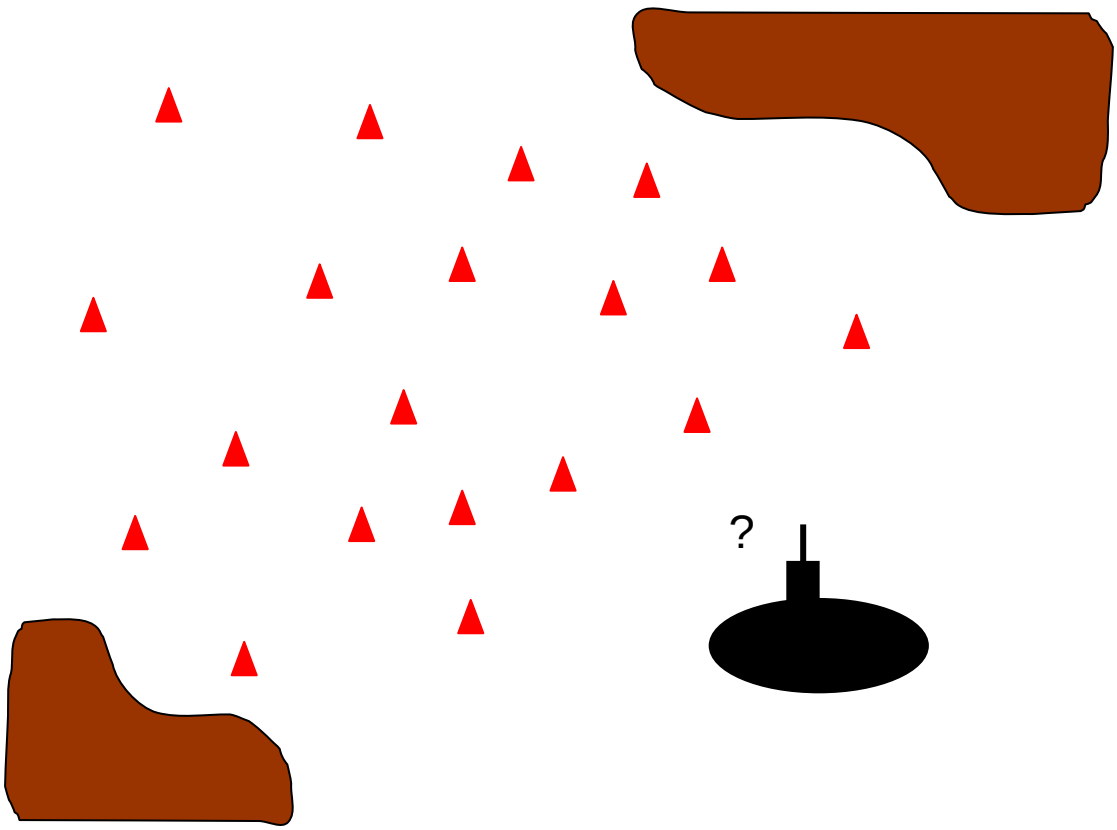
And not all of the sensors need to be broadcasting their presence. Multistatic detection means that some platforms can continue to operate passively while others provide the noise source. In many instances I think that network-centric warfare is an oversold concept, but in this instance I think there's tremendous mileage to be had.

Let's have a look at how this might come together for ASW. Here's a schematic. [SLIDE] There's nothing too surprising here—in essence this is just a sketch of multistatics. Ships and helicopters and MPAs have been doing this sort of thing for years. The difference is that the nodes in the diagram might be much more numerous than was previously the case, and the detection capability could be very much higher.



As a simple example, this beast [SLIDE] is a device called ‘Bluebottle’, an unmanned surface craft under development by an Australian company Solar Sailor. It has its own power source in the form of wave and solar generation. As designed, it can carry SATNAV comms and could be configured with various sensors, acoustic or otherwise. In an evaluation of the system, the CSIRO described this technology as a ‘disruptive’ one for the practice of ocean surveillance. (I should say that I don’t know whether this system is the way ahead, but the Solar Sailor folks had the initiative to knock on my door, so I chose them as the example. And, anyway, if they don’t crack this problem someone else is bound to because there’s absolutely nothing in the way of a successful implementation of these simple ideas.)

If the cost can be kept down, there’d be nothing to prevent a grid of these systems being deployed, which would be especially effective in the choke points and littorals where diesel electric submarines are most effective. [SLIDE]



By sprinkling a few further out and having them feed into the network, it would make sneaking out to snort pretty fraught as well.

It seems to me that the combination of high-power processing and robotic systems is likely to make submarine operations—at least in the form of sneaking large platforms into contested spaces—much more difficult. And I think it probably complicates life for conventionals more than for nukes because they're more effective away from the blue water.

Not surprisingly, I'm not the only one to make these observations. Here's what ADM Greenert, Chief of Naval Operations for the USN, had to say a couple of years ago [SLIDE]:

> 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.

All is not lost though—technological advances tend to cut both ways, and the battle is often to the side that has the right combination of technical capability and imagination. ADM Greenert went on to say [SLIDE]:

> U.S. 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.

So… what does that all mean for us here today? I think it means a few things. First, the design of the future submarine has to be done cognisant of these trends, which will make penetration of adversary space or operations in contested chokepoints by the submarine itself very much harder. Basing our investment around traditional ideas of submarine operations isn't likely to be a winning strategy a couple of decades from now. Instead, submarines are likely to have to stand off further from any high-stakes situation and exert their influence from further away by deploying their own long-range remote or autonomous sensors and weapon systems.

And that leads directly to the second conclusion: there'll be a premium of flexibility of payload for the future submarine—even more than is presently the case.

Third, submarines might have to get more active in avoiding defences, including network disruption activities to make the collection, forwarding and processing of information more difficult for an adversary. At the very least, they'll have to operate in an environment where network disruption is coordinated with friendly platforms.

Finally, the ability to scoot out of harm's way if, for example, a swarm of UAVs with multistatic active sonar suddenly plop into surrounding waters will be a valuable asset.

The net summary is that future submarines will need to [SLIDE]:

- operate away from chokepoints and contested spaces but be able to project influence into them
- have a low indiscretion rate
- be a hub for a suite of long-range sensor and weapon systems
- be networked with other units, including electronic warfare platforms and systems
- be able to manoeuvre quickly in response to a rapidly changing threat environment

Decisions

Of course, that list pretty much says 'SSN', but that's not going to happen, so let me finish with a few thoughts on what it all means for Australia's future submarine.

The first decision—going back to my initial slide about linking materiel solutions back to overall strategy—is to decide whether our subs are going to play in the highest end operations. If we decide we need to, we're necessarily going up the risk reward curve for a conventional boat.

If that's the case, then I'd suggest that those criteria pretty much rule out an 'evolved Collins'. I don't think the Collins design would stretch to meet those high-level requirements.

That leaves us with two broad options [SLIDE]:

1. Go all out with the design of a large, fast, long-range boat that can operate at the highest level in a much more challenging future.

2. Temper our ambitions and settle for a fleet that can still operate effectively in less than the most challenging situations.

In other words, we have a really big decision to make right up front, and the stakes are pretty high. It's going to be an interesting ride.