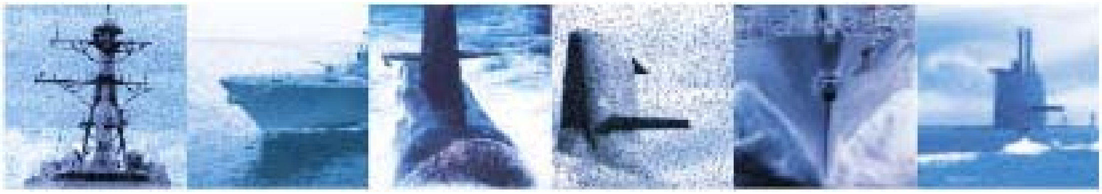
IMPROVING THE COST-EFFECTIVENESS OF NAVAL SHIPBUILDING IN AUSTRALIA

A submission to the Senate Foreign Affairs, Defence and Trade References Committee of the Australian Parliament, March 2006.



About ASC

This submission has been prepared by ASC Pty Ltd, Australia's largest high-end naval design and engineering company.

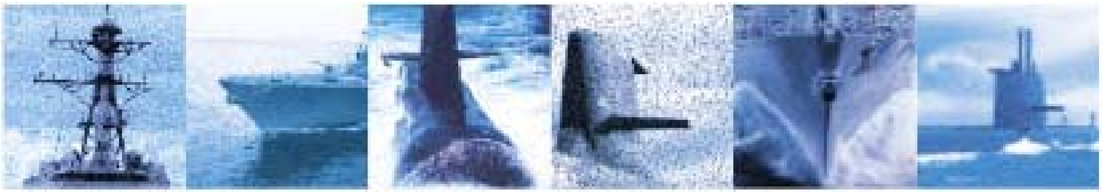
ASC (formerly known as Australian Submarine Corporation) was established in 1985. It was chosen in 1987 as the prime contractor for the design and construction of the Royal Australian Navy's (RAN) fleet of six Collins Class submarines – widely considered to be the best conventional submarines in the world.

Australian Submarine Corporation (as it was then named) was privately owned until late 2000 when the Australian Government took full ownership of the company. Substantial reforms followed to prepare the company for privatisation.

In December 2003, ASC signed a 25 year, $5 billion contract for the through-life support of the Collins Class submarines. This was followed by ASC's selection as the shipbuilder for Australia's $6 billion Air Warfare Destroyer program in May 2005.

ASC employs over 1,000 people who are predominately located in South Australia and Western Australia.

ASC is the only Australian shipbuilder that is a design authority. The maintenance and strengthening of this extremely valuable naval design capability will be of key importance to Australia's future in designing and building vessels for the RAN and for other navies.



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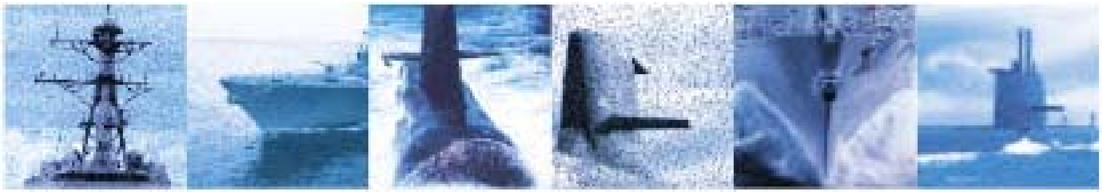


1. Executive summary

Australia's track record in shipbuilding suggests that complex surface ships and submarines can be built to a very high standard, and in a cost-effective manner, in Australia provided that certain key factors for success are present.

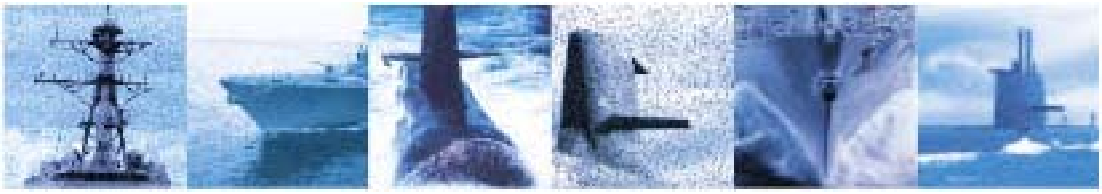
The key prerequisites for success include:

- high-end naval engineering capacities and capabilities to undertake the detailed design of vessels;
- the scale of demand for vessels is sufficient to win at least minimum economies of scale;
- the demand for new vessels is stable and predictable;
- capacity to manage the production and integration of both ship systems and combat systems;
- capability to use advanced ship design and production technologies effectively;
- securing access to key warship intellectual property;
- sourcing of competitive bids for all vessels of a class within an efficient contracting environment; and
- the Australian Government actively encouraging the development and maintenance of key maritime design, construction and support capabilities.

ASC has invested heavily to ensure that, as far as it is able, the key factors for success are in place.

To facilitate progress there is a need for the Australian Government to designate the following strategic capabilities for development and retention within the Australian maritime sector:

- naval design and systems engineering capacities adequate to research, plan, build, set-to-work and support complex warships and submarines;
- the ability to install, integrate and test selected maritime combat systems into warships and submarines; and
- the ability to trouble-shoot faults, design and undertake repairs, modify a wide range of naval systems and generally support naval vessels within Australia.

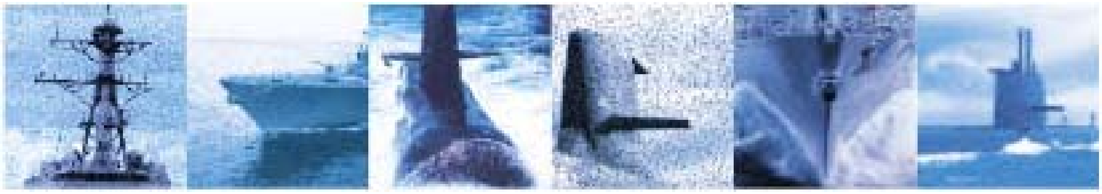


This submission also concludes that Australia would realise some substantial benefits if it were to adopt a new, more commercial, pattern of vessel capability management for all new RAN surface vessels and submarines. This would entail planning new classes of naval vessels from the outset to have shorter service lives, the avoidance of major mid-life refits, tendering the construction of all ships of a class and, where feasible, the maintenance of continuous processes of construction.

A review of recent overseas naval shipbuilding experience and the results of detailed economic modelling conducted to support this submission suggest that planning all new classes of RAN major vessels using this pattern of more commercial vessel capability management would result in:

- a more internationally competitive naval shipbuilding industry;
- a RAN with a younger, more available and more capable fleet;
- Australia developing some of its own ship designs and systems, intellectual property (IP) and other shipbuilding IP;
- Australia, given appropriate parent navy support, being able to successfully export a range of high value naval vessels; and
- far higher levels of sustainable employment in the industry.

Moreover, this analysis suggests that these benefits can be sought at no net cost to the Australian taxpayer.



2. Structure of this submission

This submission initially focuses on the foundation factors that drive the cost-effectiveness of naval shipbuilding in Australia. The submission will then address the questions listed in the terms of reference.

In consequence, the sequence of this submission is as follows:

- key factors for cost-effectiveness in Australia's naval shipbuilding industry;

- experience of the primary Western naval shipbuilders in Germany, Britain, France, Italy, Spain, Japan and the United States. Key questions in this section relate to the scale of foreign naval shipbuilding, the length of production runs of various classes of ships, the average service lives of recent warships and the nature of these country's shipbuilding industry structures;

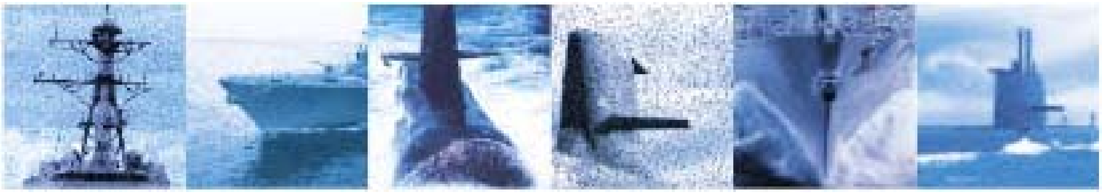
- what has and has not worked in Australia's shipbuilding industry in the past, including where and when Australia's naval shipbuilding has been highly cost-effective and competitive, and why;

- responses to the specific questions posed by the Senate Foreign Affairs, Defence and Trade References Committee;

- various arguments supporting the notion that Australia has some 'no cost' options for markedly improving the cost-effectiveness, international competitiveness and the future scale of Australia's naval shipbuilding industry. In addition, this submission suggests that if the Australian Government is prepared, over time, to change some aspects of its approach to building and sustaining the RAN there is potential for the RAN to have a more modern and capable fleet, for Australia's naval shipbuilding industry to be much larger and contributing more significantly to the Australian economy;

- discussion about the difficulty and cost-ineffectiveness of introducing a new pattern of fleet management to the naval vessels that are currently in service. However, there are substantial advantages for Australia in introducing a new fleet management model for all new classes of major surface combatants and submarines; and

- a series of recommendations and practical measures that would produce a far superior outcome for the RAN, for Australia's shipbuilding industry and, more broadly, for the Australian economy and society.



2. Pre-conditions for cost-effectiveness in naval shipbuilding

In order to evaluate the various options for improving the cost-effectiveness of naval shipbuilding in Australia, it is important to appreciate that there are several key factors that drive efficiency in this industry sector.

These drivers include:

a. Capacity and capability to undertake detailed design of naval vessels

High-end design engineering skills are critical to the cost-effective production of surface ships and submarines.

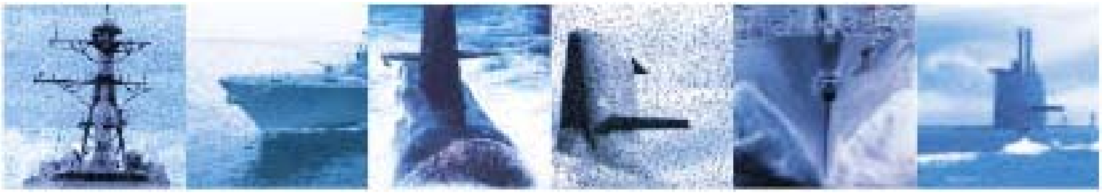
It is essential that a shipbuilder has these capabilities so that vessel designs can be developed and tailored to meet the customer's specific requirements. Such capabilities also permit the builder to modify and adapt a ship during build and/or in service progressively, speedily and cost-effectively, as required.

These design engineering capabilities are critical during the most complex phase of a shipbuilding program - the start-up design to production phase - which occurs once per ship class program. This critical phase has a profound influence on the likely success of the program and it is during this phase that high-level engineering skills are employed, and the foundations set, for the later systems integration and test and evaluation processes.

Even within a relatively large shipbuilding program, these skills can atrophy if not further exercised. A key characteristic of cost-effective and successful shipbuilding programs is that there is ongoing scope to exercise and mature these critical high-end engineering skills so that they are available to be applied to the next shipbuilding program.

Possessing these high-end design engineering skills provides scope for owning a vessel's functional and structural design intellectual property. This major advantage provides the shipbuilder with the freedom to export any vessels and designs without confronting crippling licence fees and other constraints from foreign design owners. Export opportunities, in turn, have the potential to generate further economies of scale.

In addition, strong design engineering capabilities permit the shipbuilder to plan with far greater efficiency and production / construction arrangements, materials selection, workforce skills requirements and matters that bear on the through-life support of the vessels. Possessing these high-end design engineering skills is essential for a shipbuilder to optimise production efficiencies.



b. Scale of demand

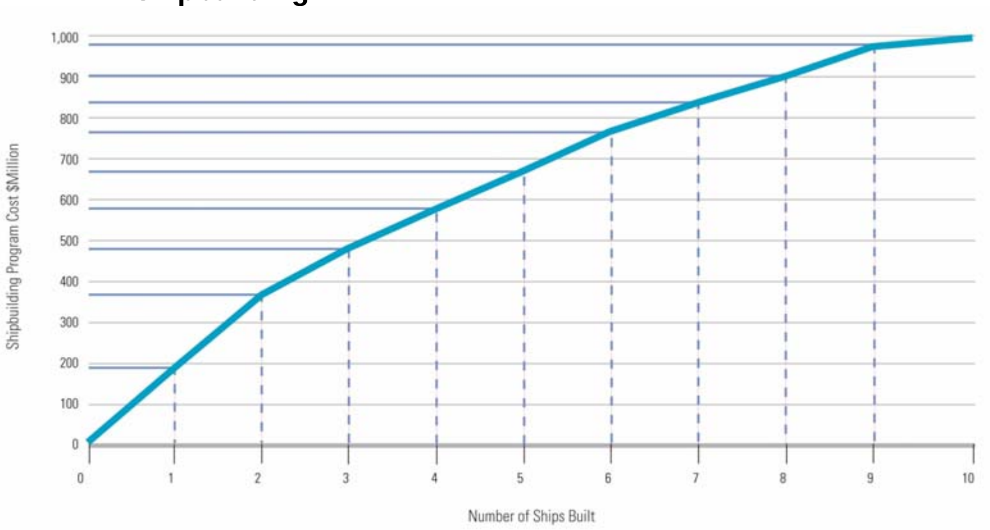
The unit costs, and hence the relative efficiency of production, change markedly if a government wishes to produce a class of ten ships rather than one or two ships. In order to win economies of scale, there needs to be sufficient demand to permit ship production programs to progress up the learning curve to its flatter sections.

As Figure 1 shows, the most expensive ship in a class is the first one built – in this case the first ship costs just under $200 million. When building the first ship, many elements of the project are new and there are inevitable difficulties in correcting design drawing errors, in transitioning design to production and in having the many systems and equipments working effectively together as a total ship system.

In the second ship, some of the system challenges have been resolved and, while difficulties are still likely to be encountered, this vessel is likely to be built quicker and at a lower cost – in Figure 1 the additional cost of ship two is about $180 million bringing the total program cost, at that point to just under $380 million.

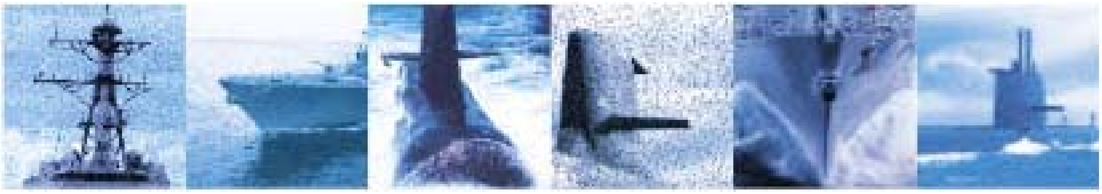
The third and fourth ships of a class are likely to be built even more efficiently – Figure 1 shows the third ship costing $130 million and the fourth only $100 million.

Figure 1 Economies of scale and learning curve effects in naval shipbuilding



Therefore when a sufficient number of ships are ordered to permit shipbuilders to get onto the higher and flatter parts of the learning curve, the costs of production per ship begin to fall significantly. These efficiencies typically start to mature following the production of 2-4 ships within a class, with further efficiencies rising at about 5% per ship thereafter.

Alternatively, when vessels of each class are bought in small numbers, production remains on the steep part of the learning curve. Unit costs then tend to be relatively high and international competitiveness relatively low.



The scale of demand for ships of a particular class is one of the most powerful drivers of shipbuilding efficiency.

c. Stability and predictability of demand

In order to achieve high efficiency, shipbuilders need relatively stable periods of predictable demand with long lead times. This enables:

- investment in efficient production systems optimised for the expected level of production;
- investment in new staff and efficient training and development;
- sufficient time to permit detailed design, production / construction planning and scheduling before ‘cutting steel’;
- the ordering of materials and sub-systems in a phased manner and at attractive prices; and
- the strengthening of a total team experience, including a deepening of skills, knowledge and experience.

Production efficiencies suffer badly when shipbuilders are required to build more ships than they can readily manage in a short period of time and then endure periods of very low or no shipbuilding until the next production run is ordered.

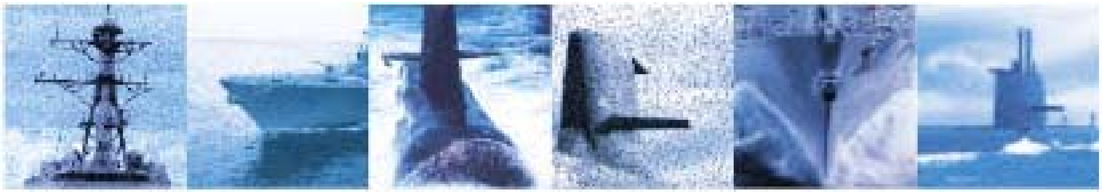
Repeated feasts and famines are bad for the health and efficiency of shipbuilders.

In addition, the most complex phase of a shipbuilding program is the start-up design to production phase which occurs once during each ship class program. This critical phase has a profound influence on the likely success of the program. It is during this period that the high-end engineering skills are employed and the foundations set for later integration, test and evaluation. Even a shipbuilding program of 10 ships can result in these skills atrophying if not further exercised.

A concurrent (with acquisition) commitment to a through-life support contract can provide an opportunity to transition some of these skills to the engineering of that activity so that complete loss of capability is held at bay. However, a key characteristic of cost-effective successful shipbuilding programs over time is that there is ongoing scope to exercise and mature high-end engineering skills so that they can be applied to the next shipbuilding program.

d. Capacity to manage the production and integration of surface ship and/or submarine hulls and ship systems

A successful shipbuilder must first master the production and integration of the ship hull and its essential propulsion and household systems, including propulsion, power generation and distribution, water supply, suitable accommodation, etc. These basic features, while important, account for 40-50% of the cost of a modern warship.



What is far more expensive, and generally as complex, is the effective integration of a warship's various systems, including various sensors such as radars, sonars, infra-red sensors, electronic sensors, situation awareness systems and decision systems and weapons systems, such as missiles, guns, torpedoes, helicopters, etc. The ability of all these complex systems to work effectively as a whole, safely and in harmony within the power, cooling, weight, space and other constraints of the vessel is very complex and accounts for 50-60% of the total value of a warship.

A successful shipbuilder must be able manage this process and see the complete system set-to-work and tested with high effectiveness.

e. Capability to use advanced design and production technologies and systems effectively

An efficient shipbuilder must be able to employ creatively advanced technology and associated systems to design processes for constructing parts of a ship in a logical sequence, to manage the complexity of bringing the thousands of sub-systems together in a workable and harmonious manner, and to test and set-to-work sub-systems and then the entire ship system. Indeed, the fewer the number of complex ships to be built, the more importance is placed upon the ability to effectively design all aspects of the vessel and then employ advanced techniques to model, plan and schedule production / construction so that mistakes can be avoided and opportunities for improvements can be incorporated before any steel is cut.

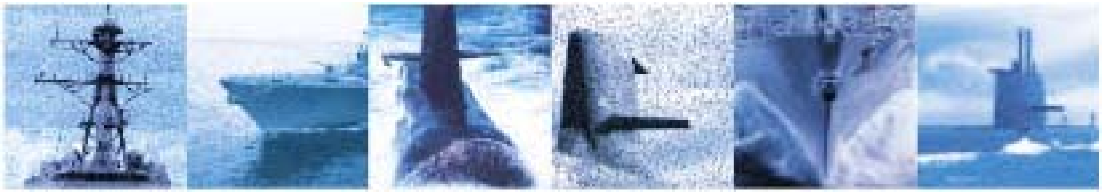
This approach requires highly skilled and experienced personnel who can work well in teams and who can also employ advanced integrated planning and management methodologies. It also requires skilled tradespersons with the ability to undertake the physical integration and set-to-work of the various mechanical, electrical and electronic ship systems.

Shipbuilders weak in any of these fields will either suffer serious inefficiencies or be forced to purchase or hire supplementary skills at considerable expense.

f. Access to warship intellectual property

In order to build sophisticated warships, a builder must secure commercial and security rated access to a wide range of warship design, technology, hardware and software systems. Some of this is available through the negotiation of commercial partnerships and supply contracts but some can only be acquired by having appropriate national security clearances and government-to-government 'fathering' agreements, for example the United States / Australian agreement for the AEGIS air warfare destroyer weapons system. Securing and maintaining such access requires the successful negotiation of appropriate agreements and the implementation and maintenance of many commercial and security systems and practices.

Failure to achieve appropriate security clearances and agreements with governments and other high technology systems providers, and failure to build confidence that information acquired will be protected, leads to denial of critical technologies and systems.



g. Competitive bidding

A key driver of efficiency in shipbuilding, as it is in most other businesses, is the knowledge that contracts must periodically be won competitively against credible rivals. Customers are constantly judging shipbuilders on their performance and those who routinely deliver late, or at an inflated cost, are likely to become vulnerable when tenders are sought for a new class of ship.

While competition is required for shipbuilding efficiency, it is desirable to structure tender competitions for multiple ship buys; preferably for all of the ships required of a particular class. Bidding for significant numbers of vessels enables shipbuilders to aim for the flatter sections of the learning curve, encouraging them to invest in advanced personnel, systems and facilities, which generally results in both high efficiency and relatively low vessel unit costs.

The Australian Government seldom acquires sufficient numbers of a warship class to require multiple batches and/or builders.

h. The correct contracting environment

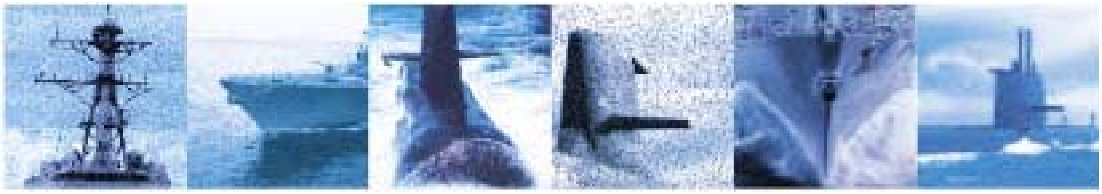
The contracting model for undertaking effective and successful design and construction of sophisticated naval vessels would usually vary from some sort of cost-plus incentive arrangement during the higher risk design and technology development / application phase of the program, to more of a fixed price arrangement once the design and technology issues have been resolved.

Irrespective of the actual contracting mechanism, once the shipbuilder has been selected, cost effective and successful naval shipbuilding programs are usually characterised by a navy / shipbuilder team approach where there are both positive incentives for the builder to perform and also a clear commitment on the part of the navy to work through any issues that arise, particularly where complex technologies are involved.

i. National government actively encouraging the development and maintenance of key maritime design, construction and support capabilities

Governments can provide policy clarity and a range of practical assistance to naval shipbuilders that can make a substantial difference to industry planning and investment, operating confidence and export success. For example, clear statements concerning the national government's strategic requirements for naval research, design, development, construction, modification, repair and support make a positive impact. Facilitating exporting opportunities through practical diplomatic demonstrations in addition to other assistance can also contribute substantially to industry success.

National governments are not disinterested bystanders of national naval shipbuilding and repair industries: they should have a strong and enduring interest in the industry's success.



4. Lessons learnt from foreign experience

Brief details about the naval shipbuilding industries in Germany, the United Kingdom, France, Spain, Italy, Japan and the United States are set out in Attachment A.

Key issues arising from comparing naval shipbuilding in Australia with naval shipbuilding in other Western countries reveals some interesting findings:

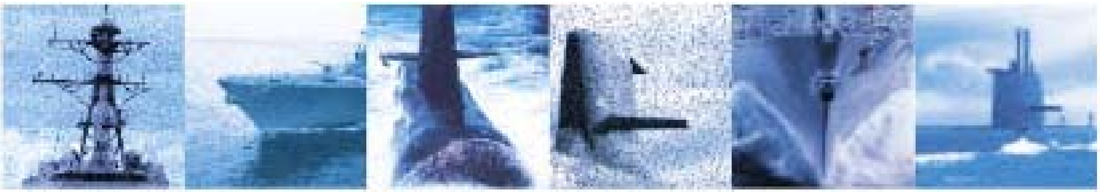
Over the last fifteen years, since the end of the Cold War, demand for warships has fallen markedly; production in most countries has been rationalised and the overall scale and profitability of the sector has declined internationally. The various means that have been employed to adapt to these changed circumstances have varied markedly between countries.

In France, Spain and Italy the problems posed by reduced demand have been further compounded by government ownership subsidies and associated highly-regulated business environments. In these countries there has been a heavy focus on domestic production, while shipbuilding efficiencies have generally been modest. International collaboration on new ship programs has been used to help keep these industries alive and export performance has generally been weak.

In Germany naval shipbuilding is undertaken alongside civil shipbuilding in the yards of a privately-owned national conglomerate that is encouraged to compete vigorously for export contracts by the national government. This approach has produced a high quality industry that, during the last decade, has built 2-3 surface combatants and 1-4 submarines each year. Importantly, the German Navy is now considering the abandonment of major mid-life ship refits of at least some new vessels. The rationale is that by planning a modest 15 year service life for new ships, high levels of operational capability can be maintained at sea and, because of the relatively early replacement timetable, longer – almost continuous – production processes are possible in industry, which will deliver significantly lower ship unit costs.

In the United Kingdom the naval shipbuilding industry has been starved of orders for almost a decade. This has forced a marked consolidation and is posing challenges for both the industry and the government as the Royal Navy now starts to order a new generation of highly-capable vessels. The British shipbuilding industry is, in consequence, starting to prepare to meet the emerging domestic requirements. However, the famine and potential emerging feast of domestic orders has seriously handicapped the United Kingdom's industry efficiency and its export edge.

In the United States the substantially reduced post-Cold War demand has also forced some industry consolidation and reduced the throughput of most shipyards. There have also been signs of indecision in the Pentagon with small numbers of the Seawolf and Virginia Class submarines ordered and significant delays experienced in finalising the characteristics of the next generation of surface combatants. Nevertheless, when production requirements have been reasonably large, and the



ordering pattern moderately stable – such as the Arleigh Burke Class destroyers - efficiencies have been gained and the industry's performance has been strong.

In Japan the privately-owned Japanese shipyards build both highly competitive commercial vessels and relatively small numbers of naval vessels. While Japan, like many other United States allies, reduced its surface fleet in response to the end of the Cold War, it still sustains stable and predictable submarine production which, for three decades, has run at a rate of one boat per year. When combined with a policy of avoiding major mid-life refits, and generally keeping submarines in service for periods of 17-20 years, the foundation has been provided for a very efficient submarine production process. In many respects the Japanese approach represents a virtuous circle that provides the Japanese Maritime Self-Defence Force with a relatively modern fleet of submarines that is being constantly refreshed with new boats, a predictable and highly efficient rate of production for the industry, and a relatively low unit production cost for the Japanese treasury.

Several key conclusions can be drawn from this brief review of international naval shipbuilding experience:

- naval shipbuilders are vulnerable to the scale and variability of demand. Those that can secure long term contracts for the production of significant numbers of ships of the same class generally achieve the greatest efficiencies;

- exports of completed ships are most likely when the scale of domestic production permits low unit costs and where the host nation owns key design and other intellectual property;

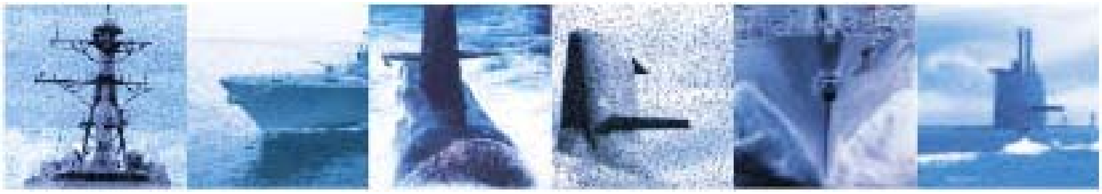
- active support from the national government has been a key factor in the success of nations' shipbuilding industries, particularly in specifying the maritime capabilities required in-country and in facilitating export activities;

- nearly every country applies very high levels of industry protection to naval shipbuilding and consequently there are usually serious constraints on international competition in this field;

- naval shipbuilders that are privately owned and relatively unencumbered by government regulations have competitive advantages;

- in both publicly-owned and privately-owned industries, mutual dependence between navy customers and industry suppliers in a period of reduced demand has often encouraged both sides of the market to adopt non-market arrangements, such as shipyards taking turns to deliver vessels and even swapping workload packages in order to share available work more efficiently;

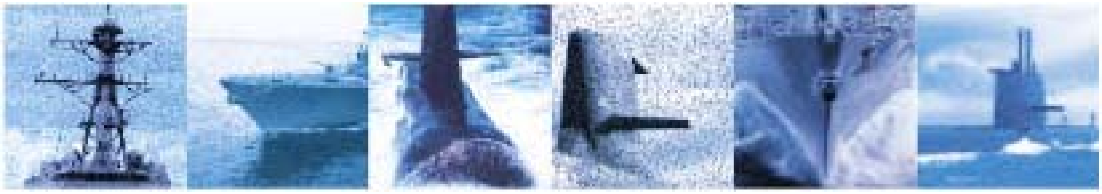
- the industries of different Western countries have varying levels of access to the most advanced intellectual property and defence systems. This has implications for the degree of naval modernity, the scope for allied interoperability and the overall level of industrial sophistication that is achievable;



- There are currently two competing philosophies that are driving naval ship acquisition and through-life support programs. First, there is the traditional approach of purchasing naval ships for service lives of 25-30 years (or generally 20-25 years for submarines) and undertaking a major vessel refit at the half-life point. This approach requires the annual acquisition of smaller numbers of vessels, it increases the average age of naval fleets and it places heavy reliance on the success of major half-life ship upgrades

  The emerging, competing philosophy – based on more sophisticated economic analysis - is to increase shipbuilder throughput and predictability. This increases production efficiency by phasing some classes of naval ships out of service (and frequently on-selling) after 15-22 years. This is common practice with many commercial vessel fleets and avoids costly and sometimes risky large scale mid-life refits, ensures that the serving fleet units are relatively modern and generally delivers lower unit acquisition costs; and

- naval shipbuilding is under severe stress in those countries where the key preconditions for success are no longer present. Many naval shipyards have been forced to close during the last decade and more remain vulnerable.



5. Shipbuilding efficiency in Australia – what works and what doesn't

It is very difficult to make direct comparisons between the cost efficiency of Australia's naval shipbuilding industry and those in foreign countries. In nearly every case Australia has built significantly different ships to those built elsewhere and, coupled with the fact that comparative pricing data rarely exists, assumptions about life-cycle costing and the relative costs of through-life support differ. However, anecdotal evidence suggests that when several ships of the same class are ordered simultaneously, and the full learning curve benefits can be won, the direct costs of naval shipbuilding in Australia are directly comparable with those overseas.

For instance, the Tasman Asia Pacific report, February 2000, on *The Impact of Major Defence Projects: A Case Study of the ANZAC Ship Project,* states that Tenix concluded that the premium for building the ANZAC ships in Australia was somewhere between -5 per cent and +5 per cent of the contract value. This report also noted that when the ANZAC ship contract was originally awarded, the Department of Defence considered that the premium for purchasing locally was about 3.5 per cent.[1] This assessed premium did not, however, take into account the substantial indirect benefits won via improved capabilities for ship maintenance and support, or the broader positive effects on the Australian economy; effects that the Tasman Asia Pacific report assessed as being substantial. Similar inferences can be drawn from the detailed review of the six-ship Huon Class minehunter project in a Tasman Economics report, 2002.[2]

The preconditions for success in naval shipbuilding in Australia are, not surprisingly, the same as those which apply internationally. ASC and other Australian shipbuilders have invested heavily to satisfy many of the requirements of success that were identified earlier in this submission, such as:

- capacities and capabilities to undertake detailed naval vessel design;
- modern facilities, including undercover construction and land level transfer to allow highly efficient outfitting on the hard stand;
- capacities to manage the production and integration of both ship hulls and ship systems;
- capabilities to use advanced design and production technologies and systems effectively;

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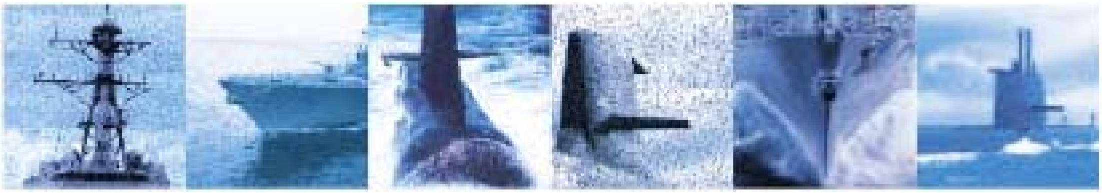
[1] Denise Ironfield *Impact of Major Defence Projects: A Case Study of the Anzac Ship* Project, Tasman Asia Pacific, Canberra, February 2000, pp.9,10.

[2] *Impact of Major Defence Projects: A Case Study of the Minehunter Coastal* Project, Tasman Economics, Canberra, January 2002.



- access to key warship intellectual property; and
- skills to compete for shipbuilding contracts.

Moreover, Australian naval shipbuilders have some comparative advantages over their foreign competitors, such as:

- relatively low site costs;
- generally competitive labour rates;
- an aptitude for innovation and the ability to work across all the engineering disciplines involved;
- exchange rate advantages, although the large proportion of imported specialist equipments tends to balance this; and
- comparatively fewer security difficulties in gaining access to the most advanced IP, particularly from the United States.

Indeed, when all of the preconditions for success are present, available data suggests that the costs of building naval vessels in Australia can be comparable with, if not lower than, those of foreign naval shipbuilders.

The most serious problems preventing Australian shipbuilders from meeting high building efficiency on a routine basis are those relating to the management of vessel demand. In particular:

- the small scale of the demand for particular classes of ship, and hence production is frequently confined to the steep end of the learning curve; and
- the high variability of the limited shipbuilding demand that exists.

Plotting, in a general conceptual sense, the learning curves of the Australian destroyer/frigate, submarine, minehunter, and other naval ship programs of recent decades, highlights the fact that Australian shipbuilding programs have rarely been of a size to permit the full benefits of economies of scale to be reaped. As Figure 2 demonstrates, it was only in the case of the ANZAC frigates and, to a lesser extent, the Collins Class submarines and the Huon minehunters, that production was of a sufficient scale to permit the flatter parts of the learning curve to be reached. Even when relatively high efficiencies were achieved, this was generally from ship 4 or 5 onwards and so the real cost per vessel across the entire program was still relatively high.

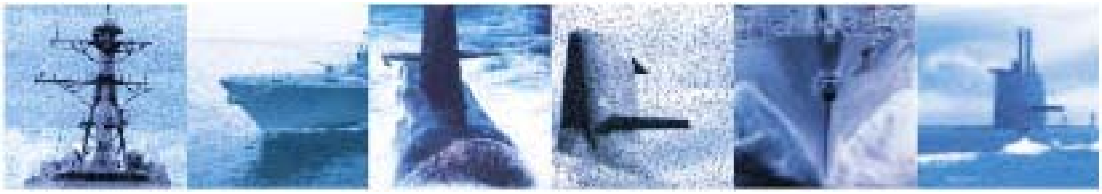
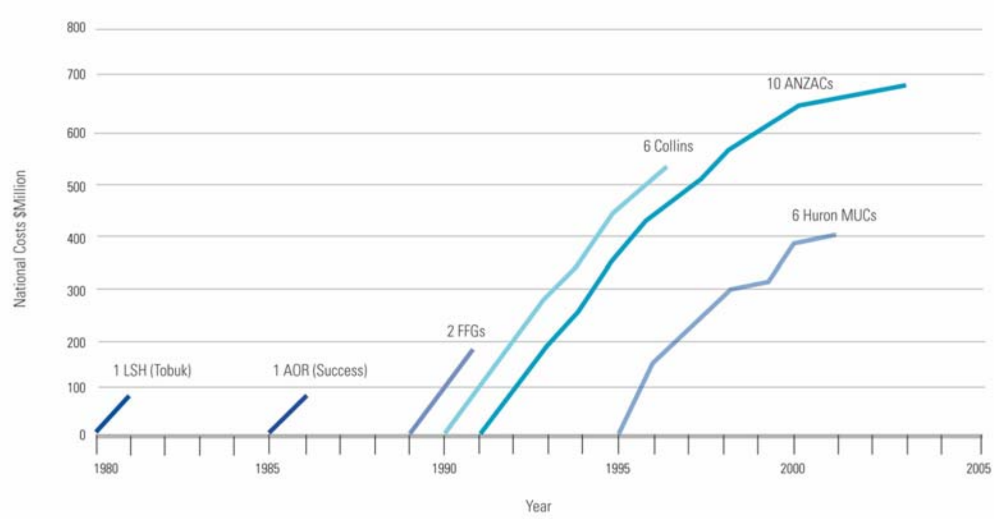
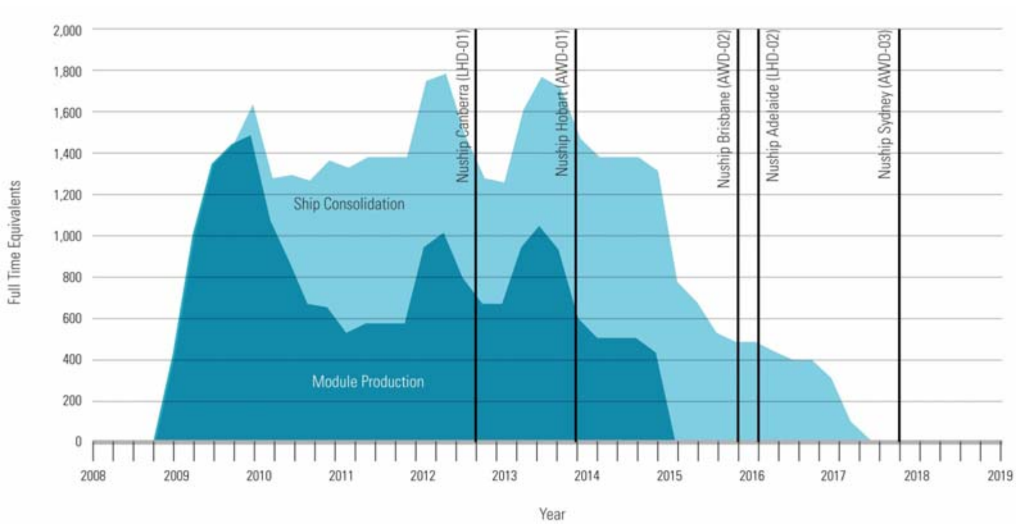


Figure 2: Learning curve effects of short production runs of Australian naval vessels

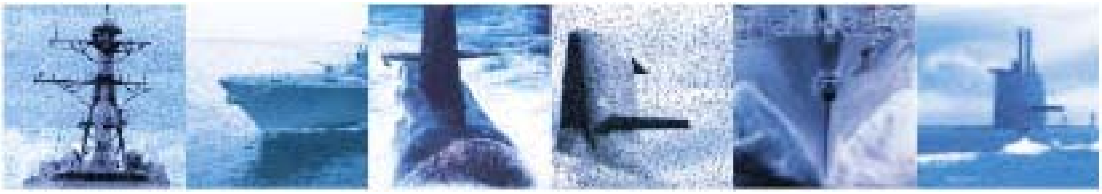


The high variability of demand can also have far-reaching consequences for the efficiency of naval shipbuilding in Australia. Figure 3 shows an early projection of the workforce requirements for producing the new air warfare destroyers and the amphibious ships in parallel, according to the assumptions that prevailed in early 2005. In this early schedule, the resource requirements rose extremely steeply following commencement of module production for the Amphibious Ship program and then for the Air Warfare Destroyer program. Then, in later periods, there were projected to be some distinct and rather sharp peaks in ship construction.

Figure 3: Naval shipbuilding industry resource requirements for amphibious ships and air warfare destroyers as planned in early 2005

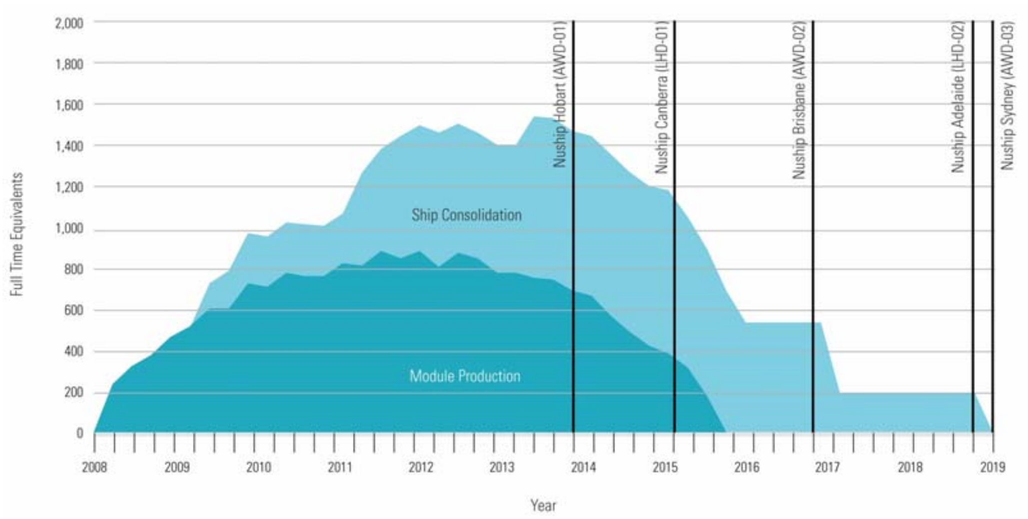


This type of 'feast and famine' distribution of workload makes the retention of quality staff difficult. Indeed, some production schedules would require numbers of some categories of skilled personnel that are simply not available in Australia.

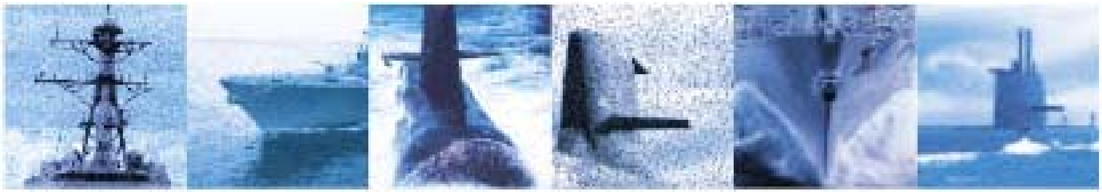


It is fortunate that in more recent months some re-jigging of the phasing of the Amphibious Ship and Air Warfare Destroyer programs has permitted the extremities of the resource requirements depicted in Figure 3 to be moderated. This less extreme and more refined projection of resource requirements is displayed in Figure 4.

Figure 4: Naval shipbuilding industry resource requirements for Amphibious Ship and Air Warfare Destroyer programs with notional levelling as at late 2005



If methods could be found to overcome, or significantly ameliorate, the limited scale and high variability of Australian naval shipbuilding demand, the performance of Australian industry should be highly competitive and truly world class.



6. Addressing the specific questions in the inquiry's terms of reference

a) The capability of the Australian industrial base to construct large naval vessels over the long term and on a sustainable basis.

The experience of the ANZAC, Collins and Huon programs clearly demonstrates that Australian industry is capable of successfully building some of the most complex naval vessels on a long-term and sustainable basis.

The keys to long-term success involve:

- the availability of high-end detailed naval design capabilities that can be employed to develop and tailor a vessel to meet the customer's specific requirements, and then facilitate the development of highly-efficient vessel production and support processes;

- encouraging high levels of productivity by, where possible, purchasing key classes of vessels in sufficient numbers so that the full range of learning curve efficiencies can be won. It may even be possible to maintain almost continuous low-rate production of major surface combatants (frigates and destroyers) and submarines; and

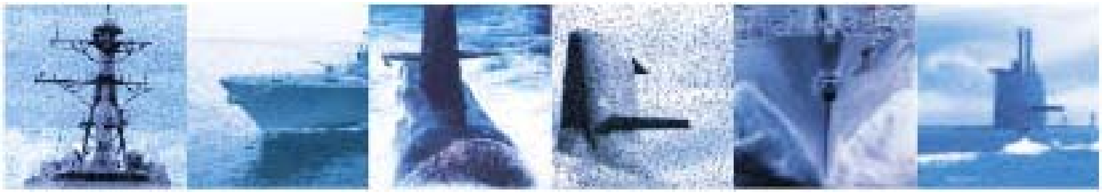
- ensuring that the phasing of major shipbuilding programs avoids workload feasts and famines, and encourages shipyard investment in key skills, production systems and processes so as to deliver consistent quality and modest cost outcomes.

b) The comparative economic productivity of the Australian shipbuilding industrial base and associated activity with other shipbuilding nations.

When all of the preconditions for success in naval shipbuilding are present, as discussed in the earlier sections of this submission, the available data suggests that the costs of building most categories of naval vessels in Australia can be comparable with, if not better than, those achieved in foreign countries. Data gathered from the ANZAC frigate, the Huon Class minehunter and the Collins Class submarine programs suggest that production of the last vessels in each program was very efficient and globally very competitive.

c) The comparative economic costs of maintaining, repairing and refitting large naval vessel throughout their useful lives when constructed in Australia verses overseas.

In the very broadest terms, there should be economies in maintaining and refitting a vessel if it has been built locally. Indeed, the detailed analysis of the economic impact of the ANZAC Frigate program concluded that the through-life savings as a



result of the ships having been built in Australia was in the vicinity of $518 million.[3] Aside from the dollar advantages, locally-built vessels can normally be repaired faster than those sourced from overseas.

However, beyond this generality, it should be noted that the challenges of repairing and refitting a foreign-built vessel depend on a series of variables and it is difficult to make clear judgements on these issues.

Key variables can include:

- the system complexity within the vessel. Generally, it is far more difficult for a new shipyard to maintain and repair a highly complex vessel (such as a modern submarine) than a comparatively simple ship (such as a small frigate or a support ship);

- the extent to which the builder has been involved in the detailed design phase of more complex vessels;

- the level of familiarity with the key systems on the particular ship and the relationship, if any, with the original equipment manufacturers of the systems on the ship;

- the level of access that is feasible to the foreign shipbuilder and the ship's original drawings and other technical data; and

- the level of access that is possible to the parent navy's technical staff and broader technical resources.

In sum, it will generally cost more to maintain, repair and refit a foreign-built vessel than a domestically produced vessel, but precisely how much more depends on the circumstances of the specific case and, in particular, the complexity of the vessel.

d) The broader economic development and associated benefits accrued from undertaking the construction of large naval vessels.

In recent years several reports have been prepared that have attempted to quantify the economic development and broader benefits of major naval ship construction programs. For instance, the major review of the ANZAC program concluded that it generated:

- between $200-$500 million in additional GDP per year. Over the 15 year construction phase this amounted to at least $3 billion in additional GDP;

- between $147-$300 million in additional annual consumption, or an additional $2.2 billion over the 15 year life of the construction phase; and

- about 7,850 full time equivalent jobs.[4]

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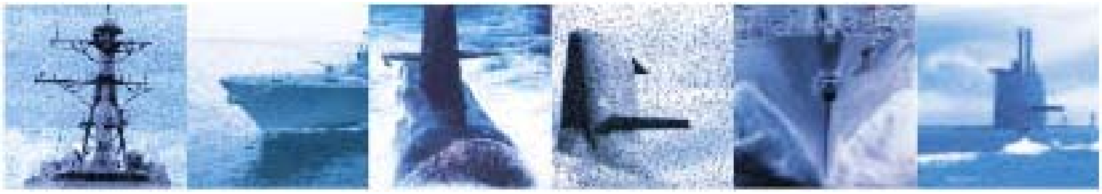
[3] Denise Ironfield *Impact of Major Defence Projects: A Case Study of the Anzac Ship Project* (Tasman Asia Pty Ltd, Canberra, February 200), p.50.



The major review of the Huon Class minehunter program determined that this project resulted in:

- $887 million added to GDP;

- $492 million added to consumption; and

- the generation of more than 1,800 full-time equivalent jobs each year. During the construction phase at least 3,180 jobs were created in the Newcastle area.[5]

In addition, these projects helped to build the innovation and export awareness of many participating companies and equipped them for follow-on work, often for foreign clients.

While these outcomes may be impressive, ASC believes that there is a way of significantly increasing and sustaining the economic development, employment and broader positive benefits of naval shipbuilding. This opportunity is discussed next.

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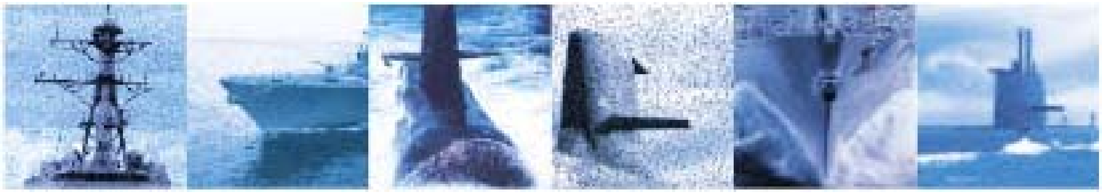
[4] Denise Ironfield *Impact of Major Defence Projects: A Case Study of the Anzac Ship Project* (Tasman Asia Pacific, Canberra, February 2000).

[5] *Impact of Major Defence Projects: A Case Study of the Minehunter Coastal Project* (Tasman Economics, Canberra, January 2002).



7. Towards improved fleet efficiency

This submission has emphasised that the major constraints on Australia's shipbuilding industry routinely achieving world-competitive levels of productivity include the scale of naval vessel demand and the variability of that demand. This submission argues that, by managing its demand differently, Australia may be able to largely resolve both of these perennial problems at a very low, if any, cost.

It is recommended that a more rational and commercial approach to a naval ship's life should be defined in terms of the net value it adds to defence capability rather than solely the capability's cost. This is because the value of a ship's capability varies in accordance with, for example, the age and design of the fleet and the vessel's capacity to deal effectively with emerging threats. This logic is entirely consistent with the kind of judgements made in defence capability development processes.

ASC believes that the consequences of balancing ship value with ship cost would be very positive and would result in:

- a far more competitive naval shipbuilding industry;
- a RAN with a younger and more capable fleet;
- Australia developing some of its own ship designs and systems, and other shipbuilding IP;
- Australia being able to successfully export a range of high value naval vessels; and
- far higher levels of sustainable employment in the industry.

In order to demonstrate the potential utility of this approach, this submission draws on modelling of the economic life of surface ships and extends that modelling to assess alternative means of managing the economic life of submarines. The methodology involved and the assumptions driving the conclusions are explained in greater detail in Attachment B.

In Figure 5 the standard pattern of surface warship capability management is displayed.[6]

[6] For details of the assumptions behind the modelling described below and the details illustrated in Figures 5 and 6, please see Attachment B.

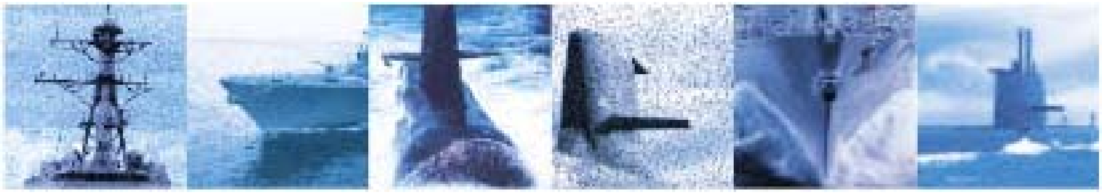
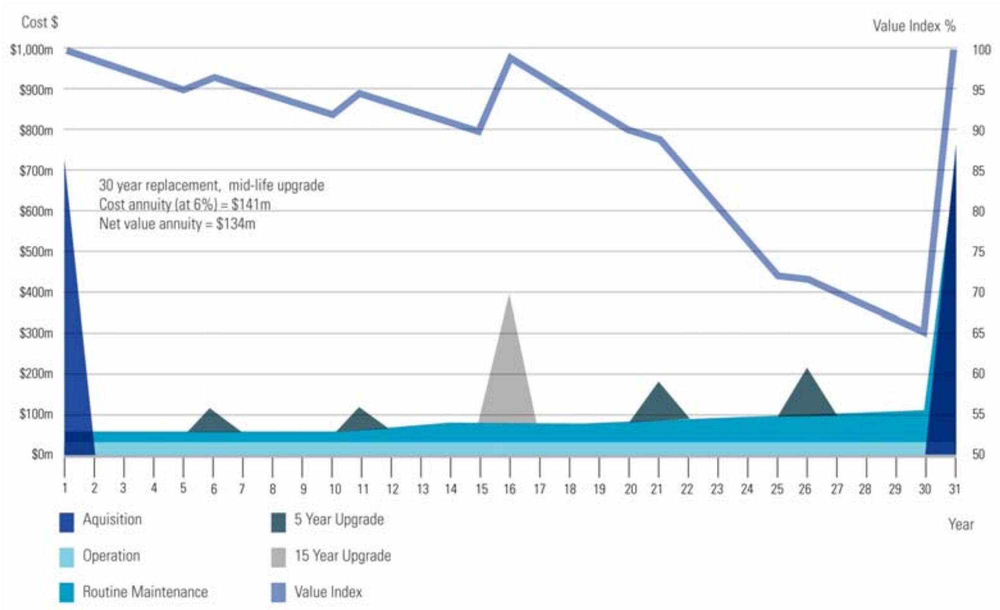


Figure 5: Current pattern of surface warship capability management



On the far left of the figure the acquisition cost is shaded dark blue and heavily concentrated in the first year. In years 5-7 and 10-12 the ship undertakes scheduled maintenance periods (shaded in dark grey). In years 15-17 the ship is taken out of service for a major mid-life upgrade (shaded in light grey) and then the ship has two more maintenance periods prior to being phased out of service and replaced by a new vessel in years 30-31.

At the top of Figure 5, the blue line indicates the varying defence value of the ship according to its condition. This demonstrates that in the period leading up to the vessel's mid-life refit, the ship loses some 10 per cent of its overall capability. The mid-life refit in years 15-17 restores full ship capability, but only temporarily, and at a very high cost. From year 17 onwards, the ship's real operational value declines steeply.

By year 24 the refitted ship only delivers about 75 per cent of relevant ship capability and by year 29 only about 65 per cent of capability. It is clear that this ship becomes much less effective after year 21.

This analysis raises a very interesting question - are ship mid-life refits really worth the effort and expense?

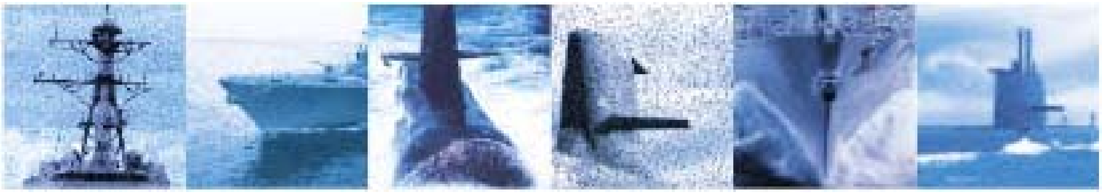


Figure 6: Alternative pattern of surface warship capability management

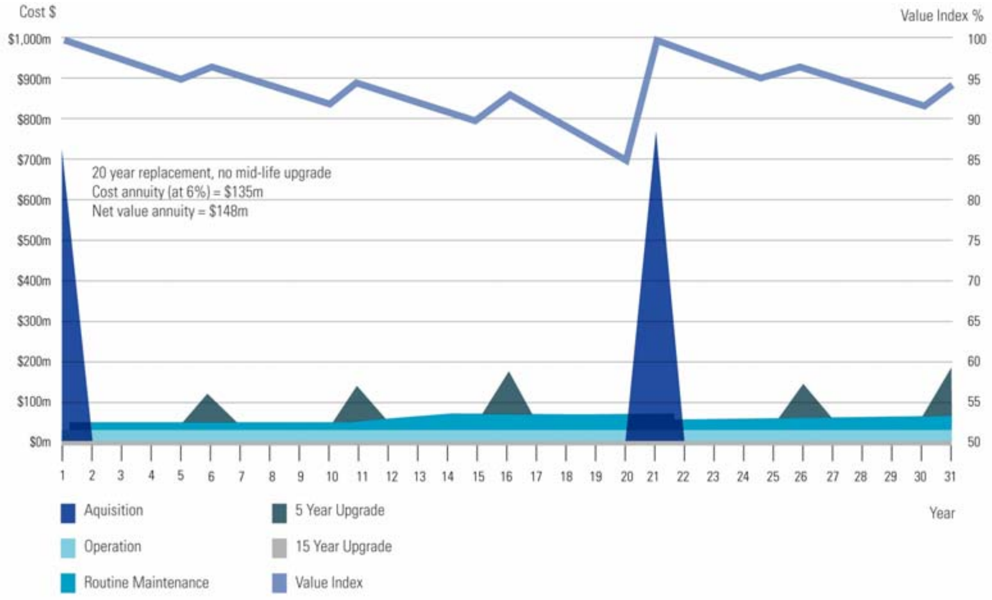


Figure 6 illustrates a possible alternative approach. In this example the major mid-life refit is abandoned and replaced by a further minor maintenance period. By adopting this approach, ship capabilities decline to some 85 per cent of their initial level at year 20, when the ship is phased out of service and replaced by a newly-built vessel.

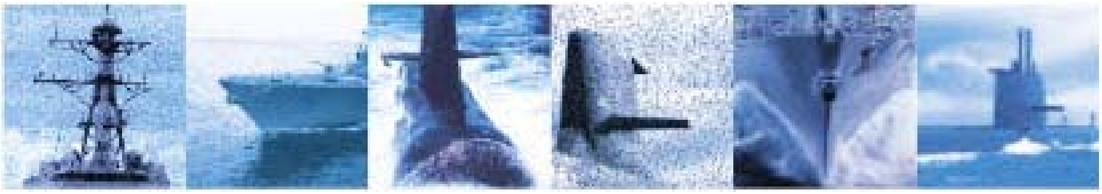
This alternative has several major advantages over the current approach:

- replacing naval vessels in their 20th year not only results in a much younger fleet, but also one which has more advanced capability. Most notably, the steep decline in operational capability that characterises RAN ships during their last 8 years of service is avoided entirely;

- the expensive and only modestly effective half-life refits would generally be abandoned and the relevant funds redirected to new ship construction;

- replacing ships after only 20 years of service would provide the RAN with far greater flexibility to upgrade the key characteristics of vessels to satisfy changing operational and personnel requirements. This approach would, for instance, provide far greater scope for integrating new operational capabilities or upgrading crew habitability to meet the developing social expectations of evolving crew generations;

- replacing naval ships after 20 rather than 31 years would increase the numbers of warships built by some 50 per cent. This approach would allow for extended ship acquisition programs that would routinely produce new vessels in the flatter sections of the learning curve. As a result the unit costs of shipbuilding would be substantially lower;



- significantly lower ship costs will likely make Australian shipbuilders internationally competitive and would result in Australia exporting naval vessels far more frequently, with positive flow-on effects including greater efficiency and Australian economic gain;

- this proposed alternative approach to fleet management could be undertaken at no net cost to the tax-payer, even if the ships that are phased out of service at year 20 are not sold for a profit to another country; and

- the broader consequences for the Australian economy of this alternative approach to naval shipbuilding would be significant. The impact on GDP, consumption and employment would be substantial. Indeed, in some scenarios the positive economic impacts would more than double.

This submission also evaluates the potential consequences of adopting a similar management model for the RAN's fleet of submarines. The primary implications of shifting from current practice are highlighted in Figures 7, 8 and 9.

Figure 7 displays the current pattern of Collins Class submarine management. As shown, there are three major docking and maintenance periods scheduled, separated by approximately 6 year periods of active service. With no major mid-life upgrade, the value of the submarines is expected to decline by year 29 to some 62 percent of their original value. This represents a significant risk if a serious crisis necessitated the operational commitment of the submarines towards the end of their lifecycle.

Figure 7: Current pattern of submarine capability management

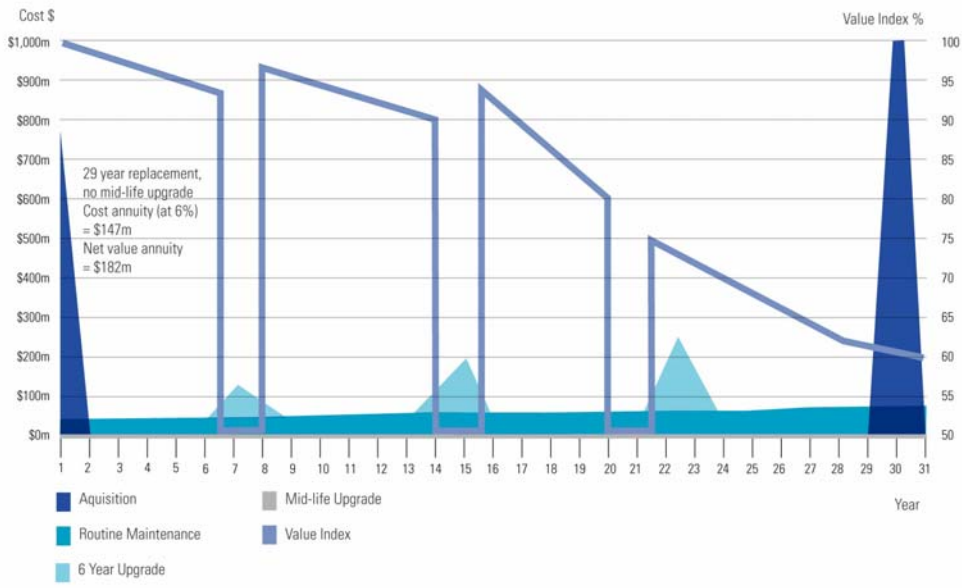
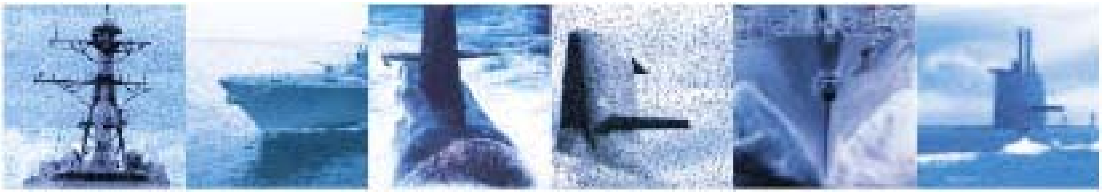
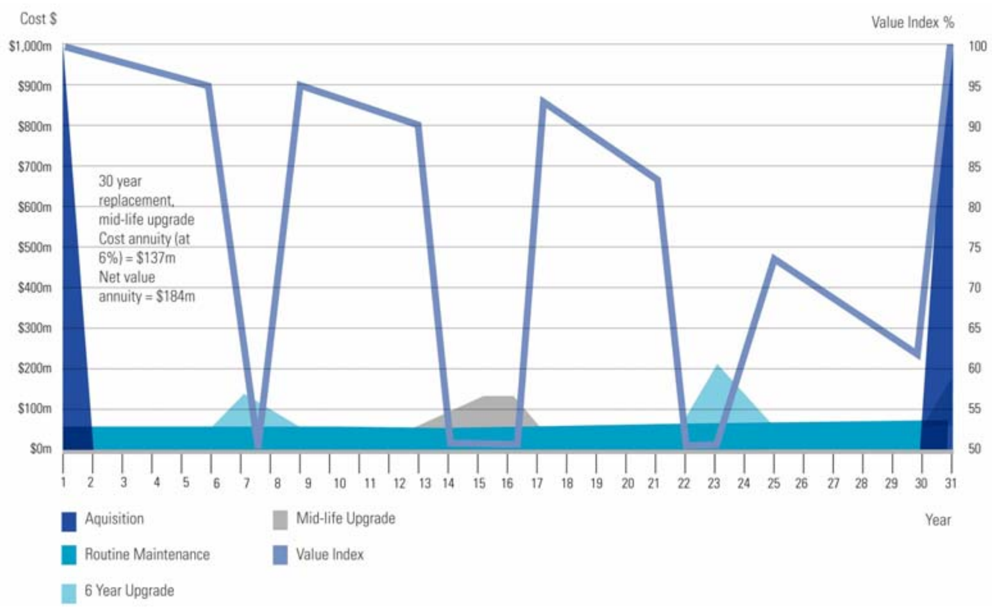


Figure 8 demonstrates the benefit of marginally increasing the work undertaken in the second docking and maintenance period around the 14th year. Extending this maintenance period into a mid-life refit would effectively return full operational value



to the boat and delay the period of rapid capability decline in the last 7 years of the submarine's operational life. Another key benefit of designing and undertaking a complex mid-life refit would be to help sustain Australia's exceptionally valuable submarine high-end design skills. These skills are critical both to the maintenance of the highest engineering standards in the RAN's submarine fleet and also to preserve the core skills that will be required if Australia is to begin designing a new generation of submarines in a few years time.

Figure 8: Submarine 30 year replacement / mid-life upgrade



In the longer term, this modelling suggests that there would be benefits in designing and developing a new class of submarines using an alternative pattern of capability management. This is illustrated in Figure 9.

Within this model, the new class of submarines would be designed for a shorter RAN life of 20-21 years. As the model demonstrates, this approach would require two major dockings and maintenance periods but would avoid the expense of a major mid-life upgrade by commencing vessel replacement in year 20, just when real operational value starts to decline steeply.

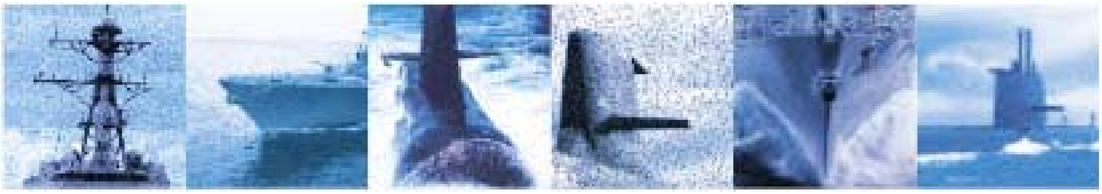
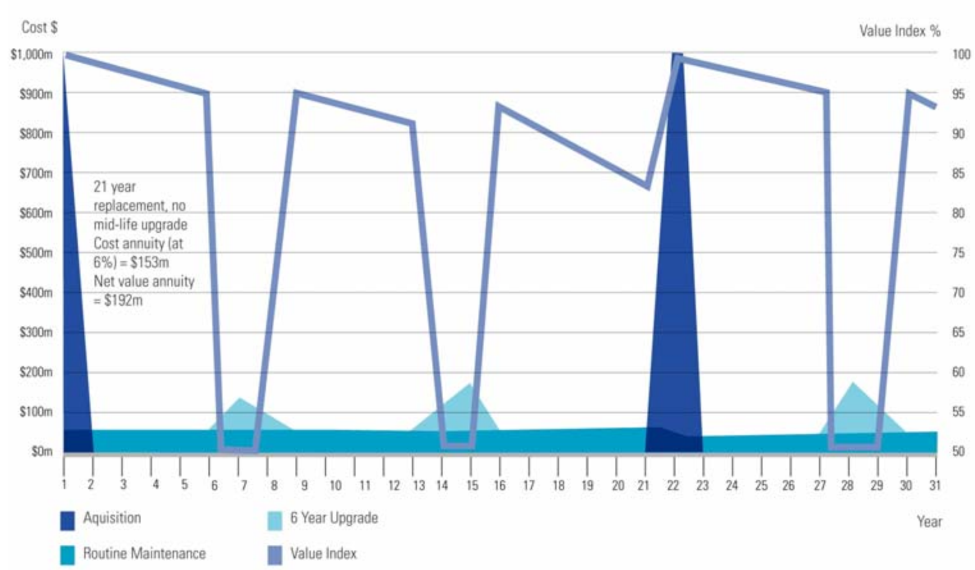
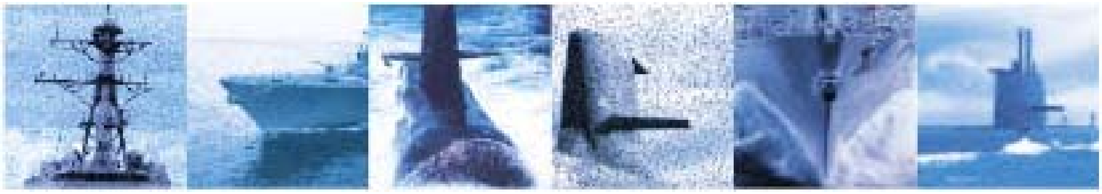


Figure 9: An alternative pattern of submarine capability management – 21 year replacement / no mid-life upgrade





8. From theory to practice – taking the logic of alternative naval vessel management forward

The central thrust of ASC's submission is that there are considerable advantages for Australia in moving, over time, to a different model of naval vessel management. In the medium term it should be possible for the key challenges of the scale and variability of naval vessel demand to be overcome, by changing the way the Defence thinks about the economic life of naval vessels. The detailed modelling ASC has undertaken suggests that, subject to careful validation of the assumptions involved, this can be done at virtually no net cost to the Australian taxpayer.

In the long term the result would be:

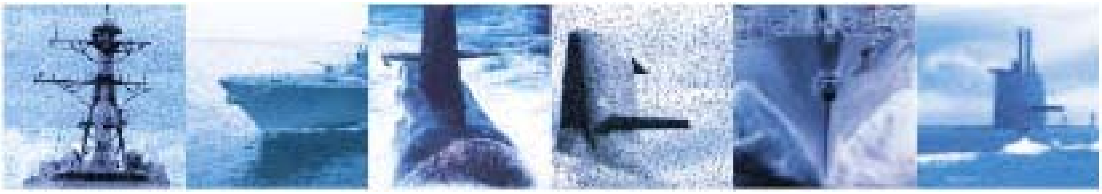
- a more modern and capable RAN fleet;
- a RAN fleet better adapted to current operational, personnel (and any other) requirements;
- a far more capable industrial base that is globally competitive to support the RAN;
- an almost continuous process for the Australian production of frigates/destroyers and submarines that would be globally competitive and capable of winning significant export contracts; and
- a substantial increase in the economic contribution of the naval shipbuilding industry, with marked rises in GDP and consumption, and employment sustained indefinitely.

However, while the logic of these reforms in naval ship management is strong, implementation of this approach would best be undertaken gradually, for a range of very practical reasons.

The RAN's surface fleet, and also its submarine force, are currently structured in a way that would make immediate and complete change to the new model of vessel management unwise.

The main reasons for not immediately implementing this proposal include:

- the remaining guided missile frigates (FFGs) are currently completing their mid-life major upgrade and it would make little sense to change the planning for the rest of their service lives. They are scheduled to be replaced by the air warfare destroyers during the 2014 – 2017 period;
- the ANZAC Frigates have had most unusual lives so far as initially they were built and commissioned into service with a very basic sensor suite, combat data system and weapons fit. However, programs are currently underway to give the

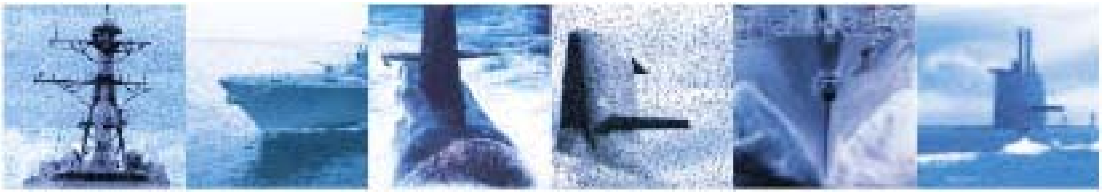


ANZACs a far more capable fit-out and much greater operational capability in nearly every respect. In effect, it could be said that the ANZACs are still being built and, in consequence, it would be sensible to consider these ships' initial operational capability as commencing progressively over the next few years, rather than from the date that they were initially commissioned. At present, the plan is for these ships to be phased out of service during 2023 - 2030, or 20 years after their full system fit-outs have been competed. Operating these vessels with periodic maintenance periods, but no major refits, during this period would appear appropriate.

- for the Collins Class submarines, a program of support and modification is well underway and is being implemented largely via a series of full-cycle dockings. The extreme demands of the underwater environment impose exceptionally tight requirements for maintenance, repair and upgrade activity, and provide little scope for altering both the periods for, and the spacing of, submarine dockings. Moreover, because ASC is the design authority for the Collins Class, the upgrade program for these boats is a vital means of sustaining and exercising the critical submarine design capabilities that will be required to prepare for, and support, the RAN's next generation of submarines. In short, if Australia wants the option of co-designing and building a new class of large sophisticated non-nuclear submarines – and no other country designs and builds conventionally powered submarines as large Australia's – then designing, developing and installing significant upgrades to the Collins Class will help sustain critical skills.

ASC concludes then that for all major RAN vessels currently in service it makes sense to continue the service, maintenance and upgrade schedules as currently structured.

However, for the next generation of major naval vessels, there would be numerous advantages for Australia in planning from the outset to employ a more modern and more flexible vessel management structure and philosophy.



Conclusions and recommendations

ASC has drawn the following conclusions:

- complex surface ships and submarines can be built to a very high standard and in a cost-effective manner in Australia provided that certain key factors for success are present;

- in recent years ASC, and the other major Australian naval shipbuilders, have invested heavily to ensure that, as far as they are able, they possess the key factors for success, such as capacities and capabilities to undertake complex naval vessel design, modern facilities, capability to manage the integration of all ship systems, means of accessing warship intellectual property and strong skills for competitive bidding;

- there is a need for the Australian Government to state clearly the level of maritime systems engineering, the level of naval system integration, the degree of maritime support and maintenance capacity and the extent of in-country research, design, development and integration in key maritime systems and technologies that it requires to be held in Australia; and

- there would be substantial benefits for Australia in adopting a new, more modern, pattern of vessel capability management for all new RAN surface vessels and submarines. This would entail planning new classes of naval vessels from the outset to have shorter service lives, to avoid major mid-life refits, to tender together the construction of all ships of a class and, where feasible, to provide continuous processes of construction of the major categories of surface and sub-surface vessels.

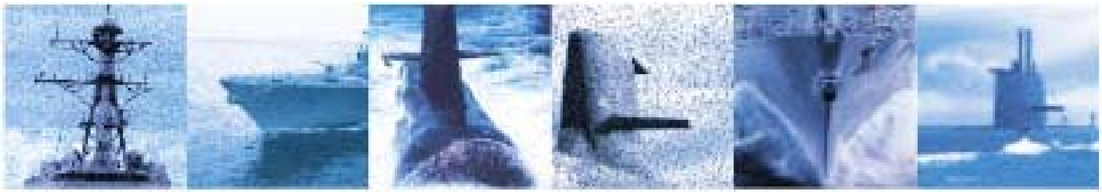
As a consequence of these conclusions, ASC recommends:

- that the Australian Government designate the following strategic capabilities for retention and development within Australia's maritime sector:

    - naval design and systems engineering capabilities adequate for research, planning, building, set-to-work and support complex warships and submarines;

    - the ability to design, develop, test and integrate selected maritime combat systems into warships and submarines; and

    - the ability to trouble-shoot faults, design and undertake repairs, modify a wide range of naval systems and generally support naval vessels within Australia.



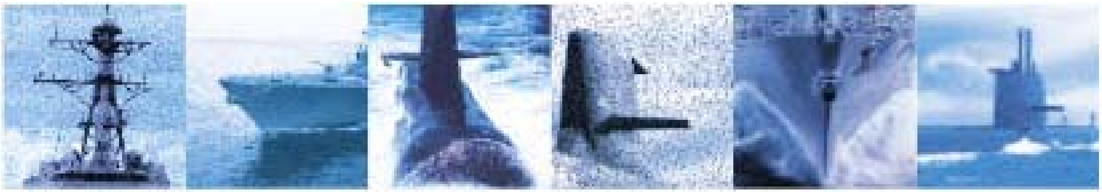
- that all new RAN major surface and submarine combatant programs adopt a modern pattern of vessel capability management comprising the following key features:

    - vessel life in RAN service between 16-20 years;

    - the construction of all series-built naval vessels (frigates/destroyers, littoral combat ships, submarines, mine counter-measure vessels) being tendered for the life of a particular class, and that, where appropriate, series production should be maintained as a continuous, highly efficient process; and

    - abandon the uneconomic practice of mid-life naval vessel refits and redirect the saved funds to new ship construction.

- that in anticipation of production of new classes of combatant, the Australian Government authorise early funded development of key technologies and systems required for the next generation of vessels. In current circumstances, it would be appropriate to authorise early funded development of technologies and systems needed for a new class of submarines to replace the Collins Class.



ATTACHMENT A

NAVAL SHIPBUILDING IN OTHER SELECTED COUNTRIES

Germany: ThyssenKrupp Marine Systems

Germany is the fourth largest producer of ships globally. All German yards are privately owned and generally compete with each other on quality rather than on price. There are no specialised naval yards in Germany but over many decades several companies have cooperated in the design and production of internationally competitive surface and subsurface combatants. The German shipbuilding industry is highly dependent upon exports, with the German Navy only accounting for 25 percent of naval shipbuilding contracts.[7] However, critically it is the German Navy's investment in the non-recurrent engineering for each first of class ship design that enables German industry to export competitively.

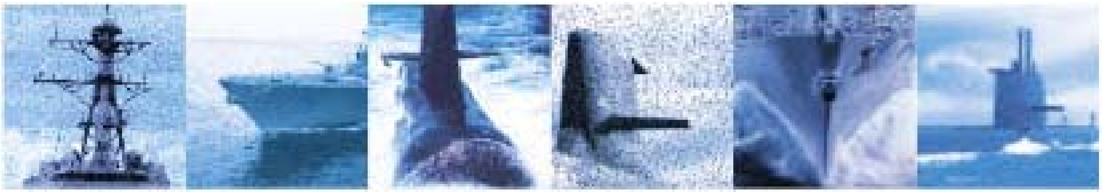
Given the profitability and technological expertise of Germany's naval industry, especially those elements building conventional submarines, the German government, industry and other stakeholders have been reluctant to adopt French proposals for the creation of a 'naval EADS' with the state-owned DCN. After a large merger in 2004, the production of naval ships is now dominated by ThyssenKrupp Marine Systems (TKMS), which unites HDW in Kiel, Blohm & Voss in Hamburg, Nordseewerke in Emden, Kockums in Sweden and Hellenic Shipyards in Greece. The German government strongly supported the creation of this 'national champion' and coaxed BAE Systems into selling its naval electronics company ATLAS to TKMS (75 percent) and EADS (25 percent), despite receiving a higher offer from French Thales.[8] Most of the bidders for the last major naval procurement contract, the F-130 Corvettes, are now united in one company.

The monopoly position of TKMS in the German market for the production of naval combatants is viewed by the government as being necessary to preserve the industry's competence and operational scale, thereby helping to ensure continued success on world export markets. The German Government has, however, been careful not to extend this monopolistic approach to ship repair and modification, where about 20 yards and industry groups compete for naval contracts.[9] The German Navy is, nevertheless, currently studying possible new approaches for managing the future of the F-125 frigates. These ships, which are designed primarily for stabilisation operations, will have endurance in areas of operation of up to two

[7] 'The German Shipbuilding Market,' *STAT-USA Market Research Report*, 29 October 2003, http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/fr/gr110193f.html.

[8] Technology and Aerospace Committee of the Assembly of the WEU, *The future of the European naval defence industry*, Document A/1916, 9 November 2005.

[9] Christian Fischer, 'Die Marine-Schiffbauindustrie in Deutschland,' *Europäische Sicherheit*, vol, 55, no 1 (January 2006), www.europaeische-sicherheit.de.



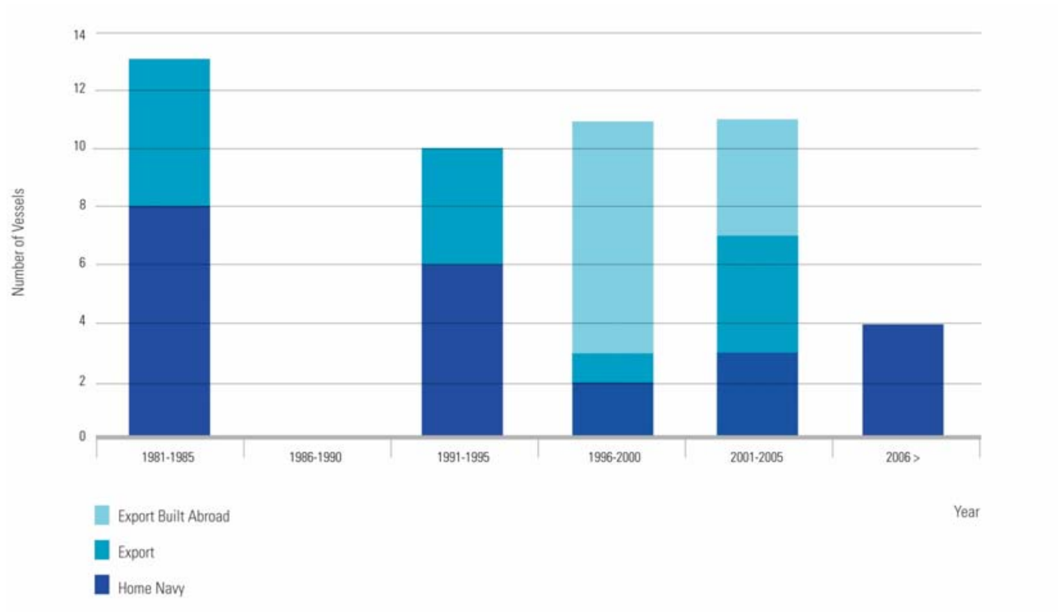
years, with replacement crews being rotated in and out of the area by air. These new ships might be procured with a planned life of only 15 years before being sold.[10]

In the international market for surface combatants, TKMS has been producing ships for both home and export customers based on its MEKO design since the early 1980s. MEKO ships can be scaled to different sizes. Australia's ANZAC frigates and the German Navy's F124, which was a candidate design for the RAN's new air warfare destroyers, are both members of the MEKO family.

The submarine division of TKMS now unites the German submarine producers with Kockums in Sweden. The German yards build the U209 and the new U212/214 with air-independent, fuel-cell driven propulsion systems. Kockums is now focused on small ~1,500 tonne littoral submarines and has apparently significantly diminished in capability since being acquired by TKMS.

Following the withdrawal of the Netherlands from conventional submarine construction, TKMS is now one of only seven suppliers of these systems worldwide. The other suppliers include Russia, France/Spain with the Scorpene, Japan, China, Korea and Australia. As the following graphs demonstrate, TKMS yards have consistently built between one and two submarines per year throughout the 1990s, and delivered numerous components for assembly abroad. In addition, and not shown on the graph, TKMS is active in the refitting and refurbishment of old submarines and in supplying propulsion systems to the Japanese submarine program.[11]

Figure A2: ThyssenKrupp – frigates (3000t to 6000t)



[10]Andreas Jedlicka, 'F 125: Fregatte für Stabilisierungsoperationen,' *Marineforum* no. 7/8 (2004), pp. 7-16.

[11]*Breakthrough in Japan for Stirling AIP,* 11 July 2005, www.kockums.se/news/050711japan.html

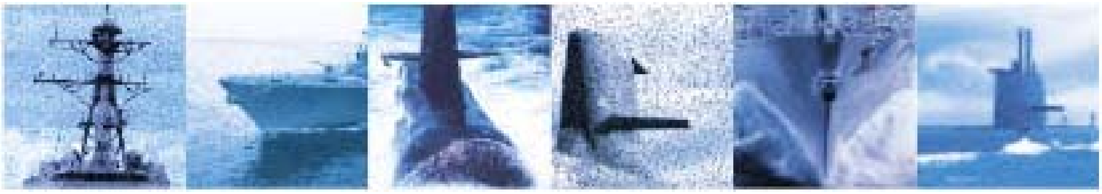


Figure A3: ThyssenKrupp – submarines (<2000t)

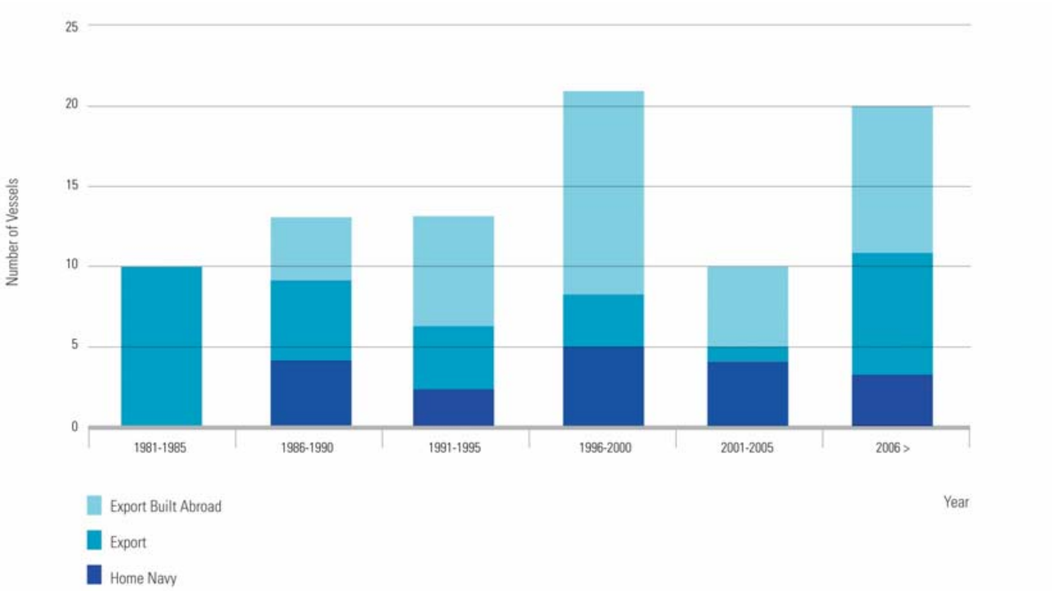
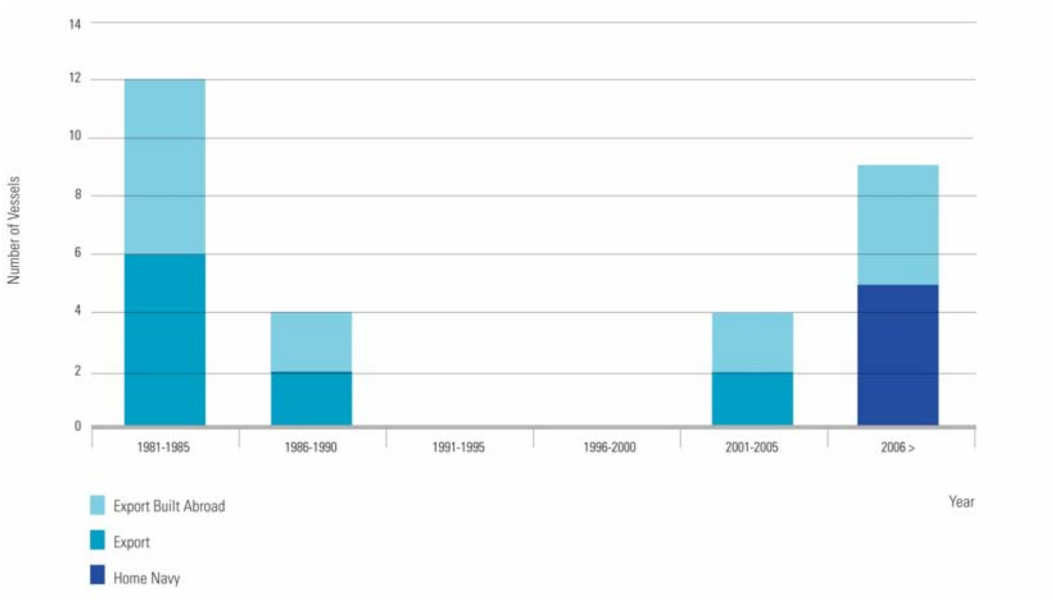
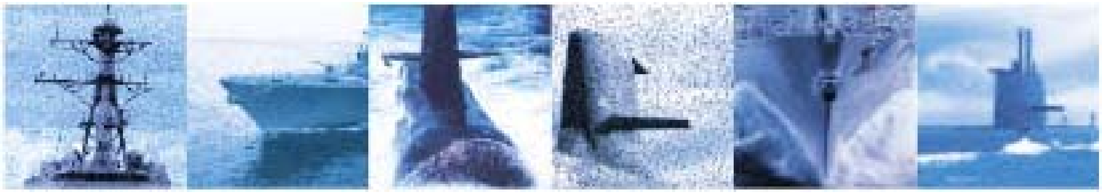


Figure A1: ThyssenKrupp – corvettes and light frigates (1000t to 3000t)



Sources: Howaldtswerke-Duetsche Werft GmbH; Blohm + Voss, Nordseewerke GmbH; Center for Nonproliferation Studies, *Strategic Submarine Proliferation*, http://cns.miis.edu/research/submarines.



United Kingdom: an industry in flux

In contrast to Germany's naval shipbuilding industry, the United Kingdom's (UK) naval shipbuilding industry is focussed almost exclusively on the UK market. This largely reflects the high-end complexity of the Royal Navy's current requirements and the limited incentives for the UK industry to produce modestly-priced readily-exportable frigates.

Since the end of the Cold War, the size of the Royal Navy fleet has declined significantly: by 2000 it was about 60 percent of its 1970 size.[12] This reduction in fleet size resulted in a commensurate reduction in new orders. In the 1970s, the number of ships delivered per year ranged from four to seven but by the late 1990s the number of ships delivered each year dropped to between zero and four.

During the 1980s, in parallel with these developments on the demand side of the British naval shipbuilding market, the British Government decided to re-privatise the nationalised British shipbuilding industry (although it still holds a 'golden share' in BAE Systems Naval Ships). The resulting pressure for consolidation and insolvencies was exacerbated by the Ministry of Defence (MoD) policy of competing all shipbuilding work.

Today only three major firms are involved in building ships for the MoD, all of which are dedicated naval shipbuilders: BAE Systems Naval Ships, Swan Hunter and Vosper Thorneycroft Shipbuilding. BAE Systems Naval Ships, which is the prime contractor for most naval ships, is different from most other European prime integrators as it is an electronics systems firm that has adopted a vertically integrated business model by acquiring naval yards.[13] Babcock Engineering Services, Devonport Management Limited and Fleet Support Limited are primarily involved in the repair of warships (surface and submarines).

A key issue in Britain is the capacity of this residual industry to supply and support the government's ambitious program to upgrade the Royal Navy fleet over the next 15-20 years. According to the British Government's Defence Industrial Strategy (DIS) released in December 2005, key features of this effort include:

- the Astute Class attack submarine program (three boats on order with options for acquisition of a further five boats);
- a future amphibious capability comprising of two landing platform docks, one landing platform helicopter and four landing ship dock auxiliaries;

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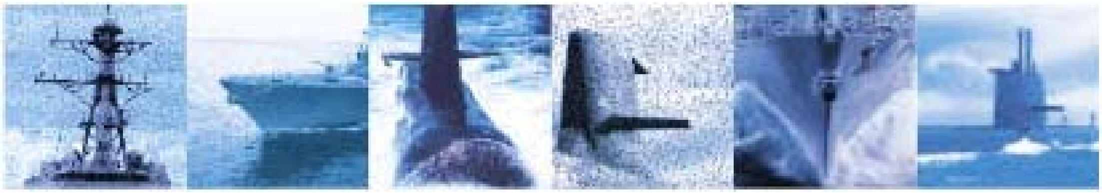
[12] M.V. Arena, H. Pung, C. Cook, J. Marquis, J. Riposo and G. Lee, *The United Kingdom's Naval Shipbuilding Industrial Base: The Next Fifteen Years* (Santa Monica: RAND, 2005).

[13] Technology and Aerospace Committee of the Assembly of the WEU, *The future of the European naval defence industry*, Document A/1916, 9 November 2005.



- Type 45 multi-role destroyers (six on order with up to 8 planned to enter service over the next decade);

- future aircraft carrier (unapproved but possibly two ships);

- future surface combatant (unapproved, possibly 14 ships in two classes);

- joint casualty treatment ship (one ship, unapproved); and

- afloat support ships (possibly ten ships, unapproved).

The DIS provides the policy framework within which the British Government plans to pursue the above naval shipbuilding programs. In publishing the DIS the British Government's overarching objective has been:

> " ….to tell industry very clearly where, to maintain our national security and to keep the sovereign ability to use our Armed Forces in the way we choose, we need particular industrial capabilities in the UK (which does not preclude them being owned or established by foreign-owned companies)." [14]

To this end, the British Government has designated the following strategic capabilities for retention in the UK maritime sector:

- **maritime systems engineering**
  it is a high priority to retain the suite of capabilities required to design complex ships and submarines, from concept to point of build, and the complementary skills for managing the build, integration, assurance, test, acceptance, support and the upgrade of maritime platforms through-life;

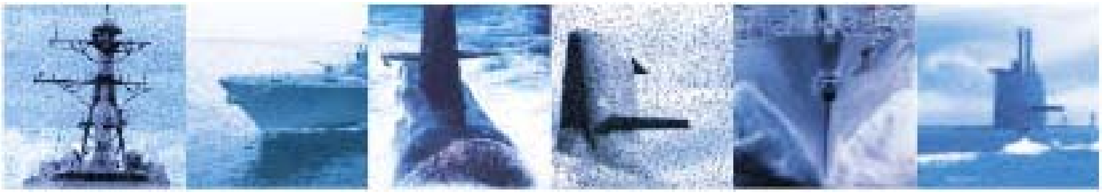
- **shipbuilding and integration**
  there is no requirement to build all warships and Royal Fleet auxiliary vessels in-country, but a minimum ability to build and integrate complex ships in the UK must be retained;

- **submarines**
  for the foreseeable future the UK will retain all of those capabilities unique to submarines and their Nuclear Steam Raising Plant (NSRP), to enable their design, development, build, support, operation and commissioning;

- **maritime combat systems**
  the ability to develop complex maritime combat systems and integrate them into warships and submarines is an essential in-country capability;

- **maritime support**
  the UK shall retain the ability to maintain and support the effectiveness of the Fleet, including through incremental acquisition, generating force elements to be held at readiness and meeting urgent operational requirements; and

[14] The Secretary of State for Defence, *Defence Industrial Strategy* (London: Ministry of Defence, 2005), p. 7.



- **maritime systems and technologies**
  it is a high priority to retain in-country research, development and integration of specific key maritime systems and technologies.[15]

In order to implement the above objectives, the MoD is working with British industry to develop a maritime industrial strategy that:

- abandons the previous policy of constructing all warship hulls in-country;

- recognises the British industry may not have the fabrication capacity to deliver the full Royal Navy build program at its peak;

- defines the UK shipbuilding industry's future in terms of high value design, system and sub-system assembly and integration, specialist and novel hull construction capability; and

- calls for further industry consolidation and restructuring, particularly in the submarine domain. This consolidation to be industry-led but MoD customer-focused.[16]

It is understood that the MoD will not order the next batch of Astute nuclear submarines until industry has consolidated into a single submarine business able to address all build and through-life support requirements.

The DIS highlights the following features of the MoD business model that underpin the emerging maritime industrial strategy:

- a more selective approach to competition, which will be retained for embedded electronics and marine equipment but modified where alternative approaches stand to yield better value for money (eg an industry alliance along the lines of those used in the oil and gas industries has been formed to undertake the future aircraft carrier project);

- specification of the core workload necessary to sustain key in-country capabilities on a commercially viable basis and allowing industry to scale its capacity accordingly;

- viewing the forward capital equipment procurement and support program as a set of projects that can be phased so as to balance required military capability, affordability and industrial sustainability – hence, for example, the surface ship supply chain will be scaled for delivery of one new platform every one-to-two years; and

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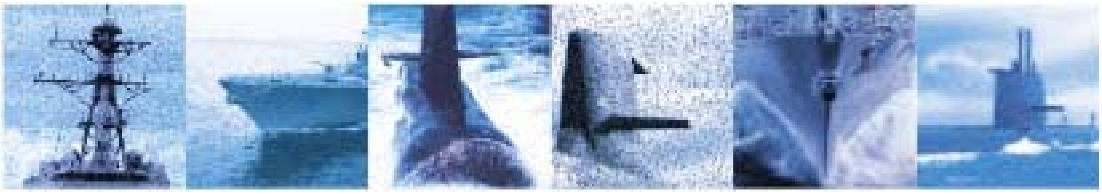
[15] The Secretary of State for Defence, *Defence Industrial Strategy* (London: Ministry of Defence, 2005), p. 70.

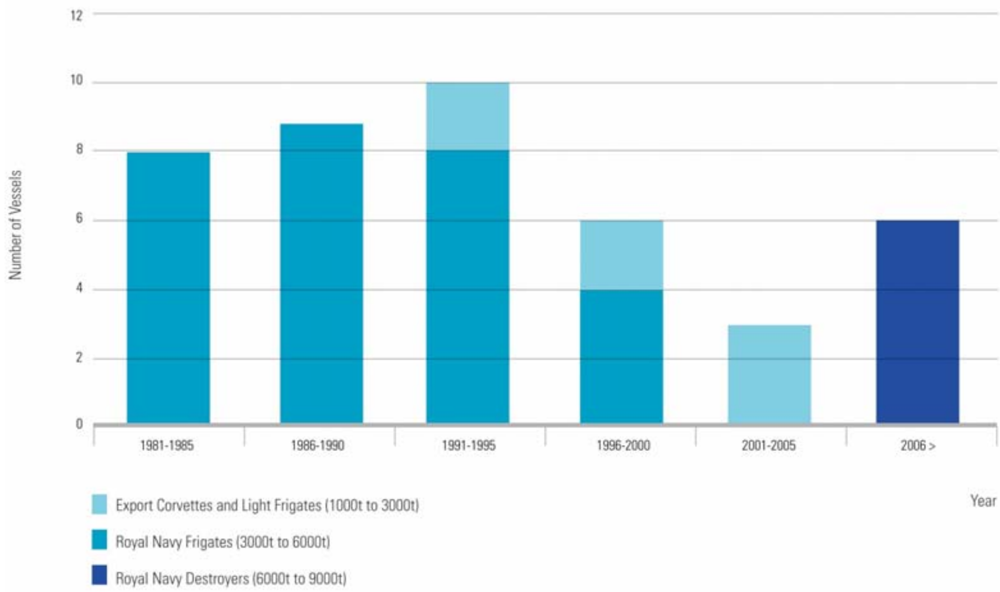
[16] The Secretary of State for Defence, *Defence Industrial Strategy* (London: Ministry of Defence, 2005), p. 74.



- avoiding a ‘boom and bust’ cycle driven by the overlap of future aircraft carrier and the Type 45 programs by allowing foreign provision of less complex elements of the future aircraft carriers if the UK’s steady-state capacity is exceeded and better value for money can be obtained abroad.[17]

Historically, the MoD has tended to maintain a younger fleet than, for example, Australia[18]. The Type 21 Tribal Class frigates commissioned during the 1960s were retained in service for some 24 years. The UK built 26 Leander Class frigates in three batches from 1963-1970. Of these batches, the ships in the first were retained for some 23 years, those in the second batch were retained for an average 27 years while those in the third batch were retained for 22 years on average. The Leander Class frigates were replaced by the Type 22 frigates built in three batches during the 1980s/early 1990s. Britain sold the first batch of four Type 22 frigates to Brazil after they had been in service for only 16 years. Britain decommissioned most of the second batch of Type 22 frigates (comprising six ships built in the mid-1980s) after 14 years of service. The four Type 22 ships comprising the third batch (built in the late 1980s/early 1990s) are still in service with the Royal Navy.

Figure A4: United Kingdom – corvettes, frigates and destroyers



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[17] The Secretary of State for Defence, *Defence Industrial Strategy* (London: Ministry of Defence, 2005), pp. 74-76.

[18] British data obtained from http://web.ukonline.co.uk/aj.cashmore/britain accessed 6 February 2006

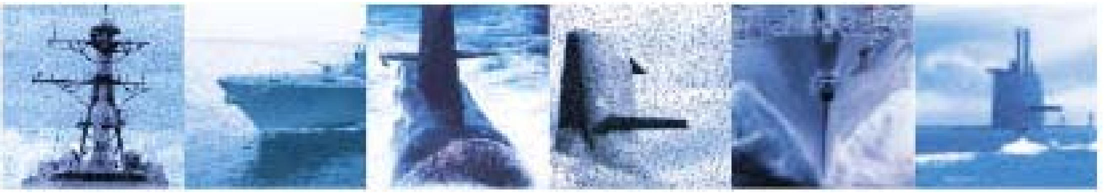
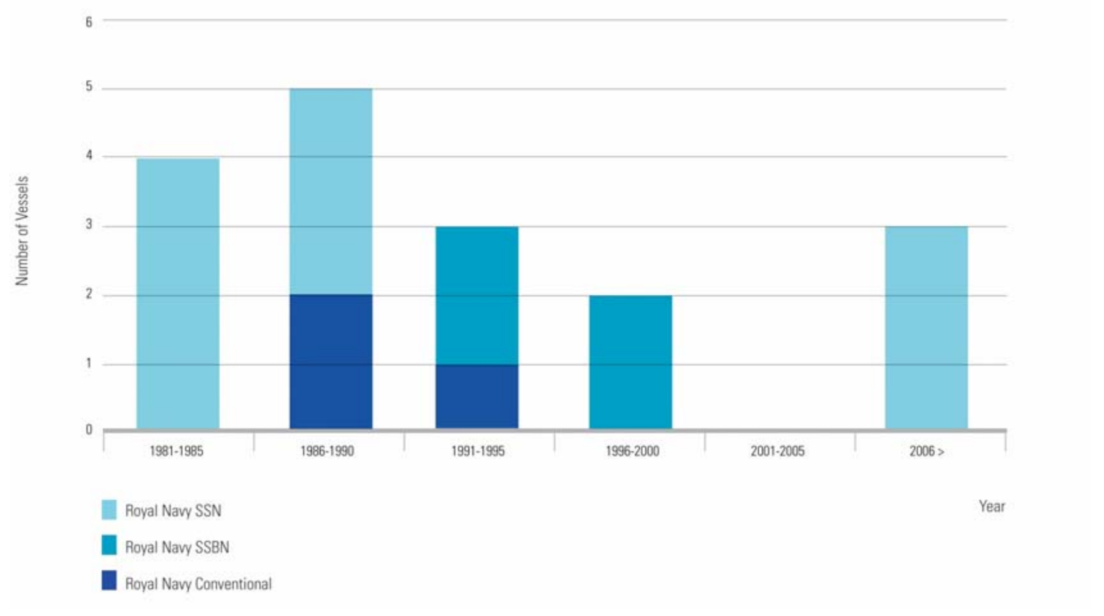
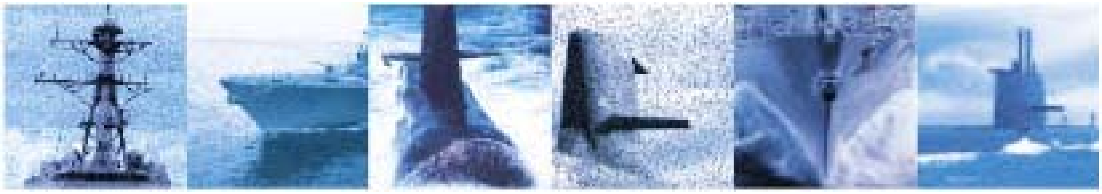


Figure A5: United Kingdom – submarines



Sources: www.naval-technology.com; www.globalsecurity.org; http://web.ukonline.co.uk/aj.cashmore/britain.



France, Spain and Italy: surviving state monopolies?

The naval industries in France, Spain and Italy cooperate closely. Their naval shipbuilding industries are either fully or mostly state owned and they all depend heavily on domestic naval orders. All three countries are engaged in the construction of conventional submarines, surface combatants and aircraft carriers, while Spain and France also build amphibious ships.

France's naval industry is by far the largest of the three and dominated by the state-owned DCN with yards in Cherbourg (conventional and nuclear submarines), Lorient (frigates and destroyers) and Brest and Toulon (operational maintenance). DCN cooperates with Thales Naval, in which the government holds about 30 percent of shares and which is also active in development and project management. Together they have formed the joint marketing company, Amaris. Large ships are also produced by the Alstom/Chantiers de l'Atlantique yard in Saint-Nazaire.

While France builds and operates nuclear submarines, it does not itself operate conventional ones. As a consequence, it has joined its export activities in that field with the Spanish company, Navantia.

Following domestic production of the stealthy La Fayette class of frigates in the 1990s, France is now also jointly developing all its new major surface combatants with the Italian, also state-owned, industry. Two Horizon air defence destroyers for each country are under construction and the joint development of FREMM frigates is underway. DCN's profitability in the coming years, and thereby also its standing compared with other European naval companies, will be determined by the latter program, the new Barracuda SSN and the new French aircraft carrier.[19] It is notable that Britain withdrew from the Horizon project due to its 'unfocussed management'[20] and that the production costs of the UK's domestic ship will be about 8 percent lower than those of the collaborative Horizon project.[21]

In spite of a severe restructuring program and large state subsidies during the 1990s, the Spanish shipbuilding industry still lost €850 million in 1998 alone. Subsequently, the Spanish Government decided to merge its state-owned naval yards (BAZAN) with the previously privately-owned civilian yards (AESA) to form the fully state-owned IZAR. However, the European Commission later forced IZAR to repay several hundred million euros in state-subsidies that had accompanied this merger and in 2004 the Spanish Government again separated the civilian from the military yards in order to ensure the latter's survival. The new, still fully state-owned, company has been renamed 'Navantia' and is allowed to produce civilian ships up to 20 percent of turnover.

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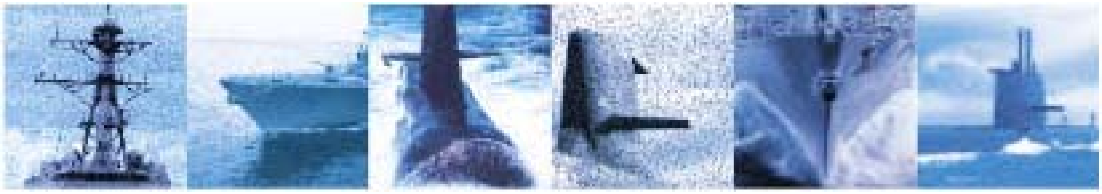
[19] Technology and Aerospace Committee of the Assembly of the WEU, *The future of the European naval defence industry*, Document A/1916, 9 November 2005.

[20] House of Commons, *The Common New Generation Frigate Programme*, Defence Committee, 1999.

[21] Keith Hartley, *Naval Shipbuilding in the UK and Europe: A Case for Industrial Consolidation?*, Centre for Defence Economics, University of York.



Navantia closely cooperates with the Netherlands in the production of amphibious vessels and with the French DCN in the production of Scorpene export submarines. Its S-80 submarine program for the Spanish Navy is derived from the Scorpene, but is produced fully in-country.

Navantia's main surface vessel program, the F-100 frigate, is using the AEGIS radar and combat system because the broadly comparable systems developed by the Netherlands and Germany were deemed to be too expensive. Spain subsequently won an order for five AEGIS frigates from the Royal Norwegian Navy.[22]

The production of major naval vessels and submarines in Italy is concentrated in the Fincantieri naval yards in Genoa. Fincantieri also has a large civilian business in passenger and transport ships and it is owned by a government holding company. There are, in addition, three yards specialising in the maintenance and repair of naval vessels that are also owned by the Italian Government.

Italy no longer has domestic frigate or destroyer programs. As a consequence, Fincantieri and the electronics company Finmeccania have teamed to cooperate with DCN in the Horizon and FREMM programs. Similarly, Italy is not building further domestically-developed submarines, but it does licence-produce ThyssenKrupp's U212 for the Italian Navy. Although there are plans for an eventual privatisation and separation of naval and civilian yards, Fincantieri has been profitable in recent years and the Italian Government does not seem to be in any hurry to change the structure of the industry.[23]

In general, there is no clear pattern of how long any of these countries keep their ship classes (Spain still has most of its domestically-produced large combatants in service as it still commissioned ex-United States Navy ships until the 1970s).

Until the commissioning of the new Horizon destroyers in the near future, France and Italy will have kept at least some of their air warfare destroyers for up 40 years in service. During the Cold War, France retired both its destroyers and frigates after 25 and 30 years in service.

Italy kept its frigates for a similar time (28 to 30 years) although those currently in service will probably remain so for a total of more than 30 years until they are replaced by the FREMM.

Both Italy and France have kept their conventional submarines in service for 30 years or longer.

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[22] Technology and Aerospace Committee of the Assembly of the WEU, *The future of the European naval defence industry*, Document A/1916, 9 November 2005; www.daegel.com.

[23] Technology and Aerospace Committee of the Assembly of the WEU, *The future of the European naval defence industry*, Document A/1916, 9 November 2005.

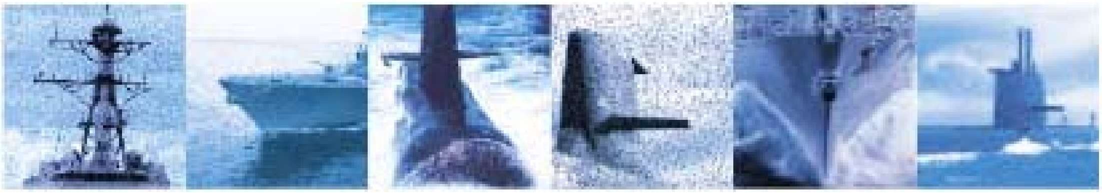


Figure A6: France – corvettes and light frigates (1000t to 3000t)

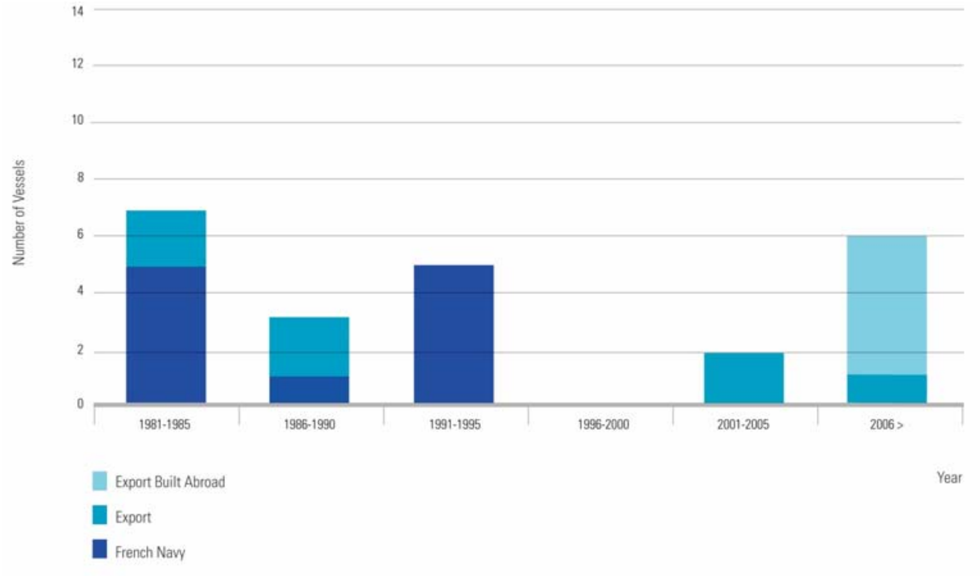
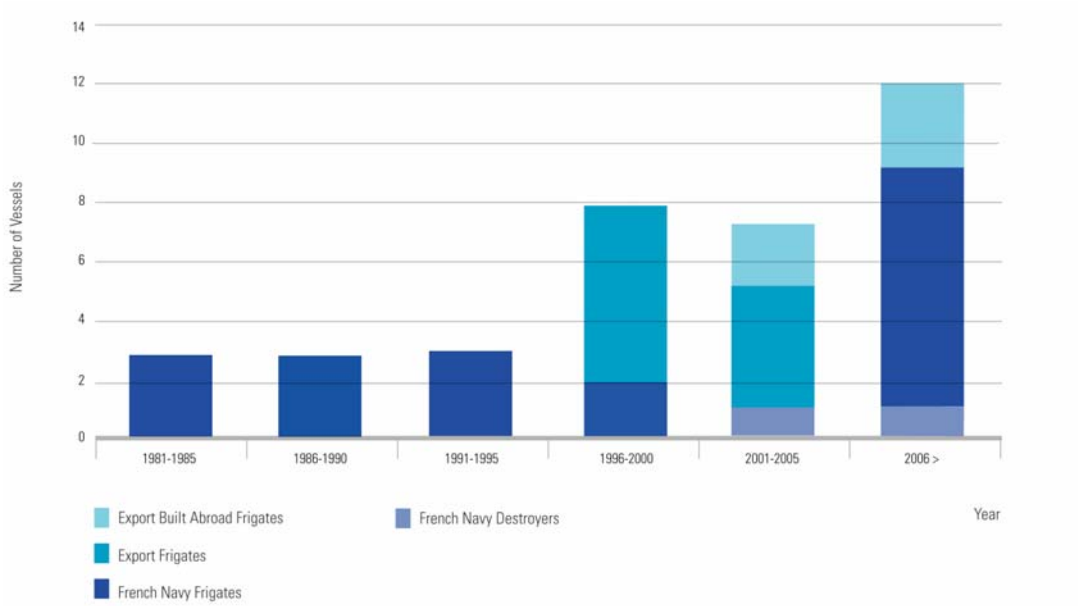


Figure A7: France – frigates (3000t to 6000t) and destroyers (6000t to 9000t)



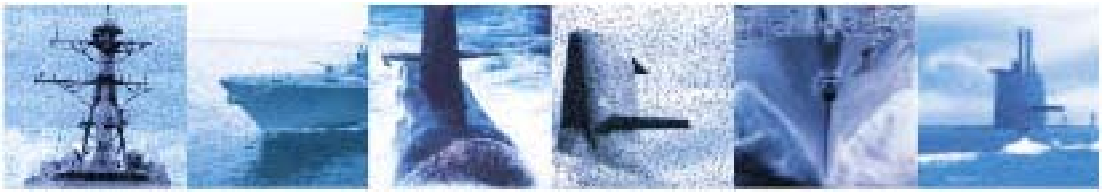
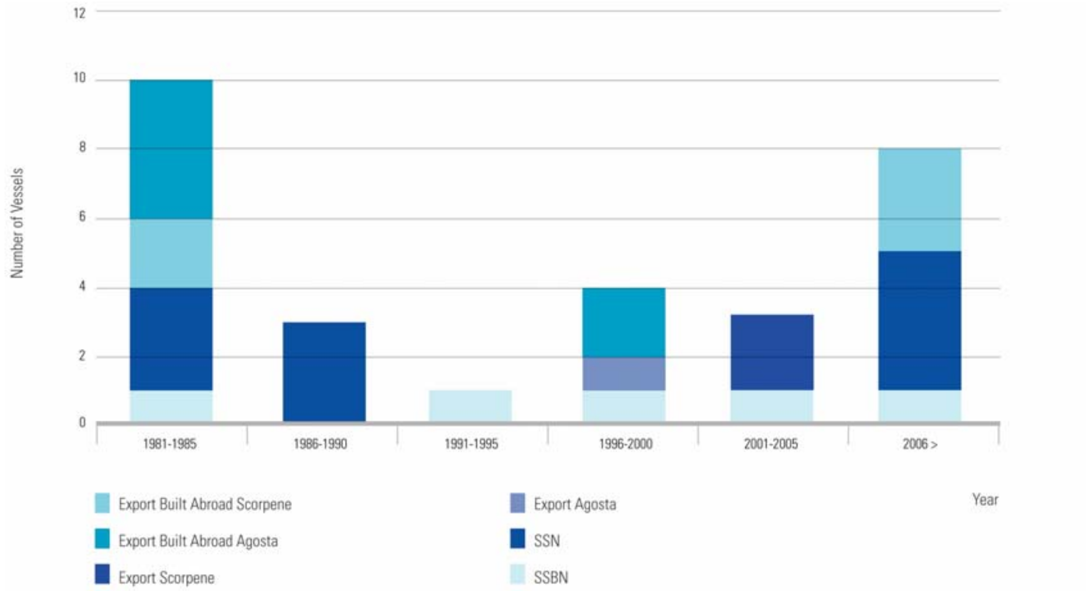
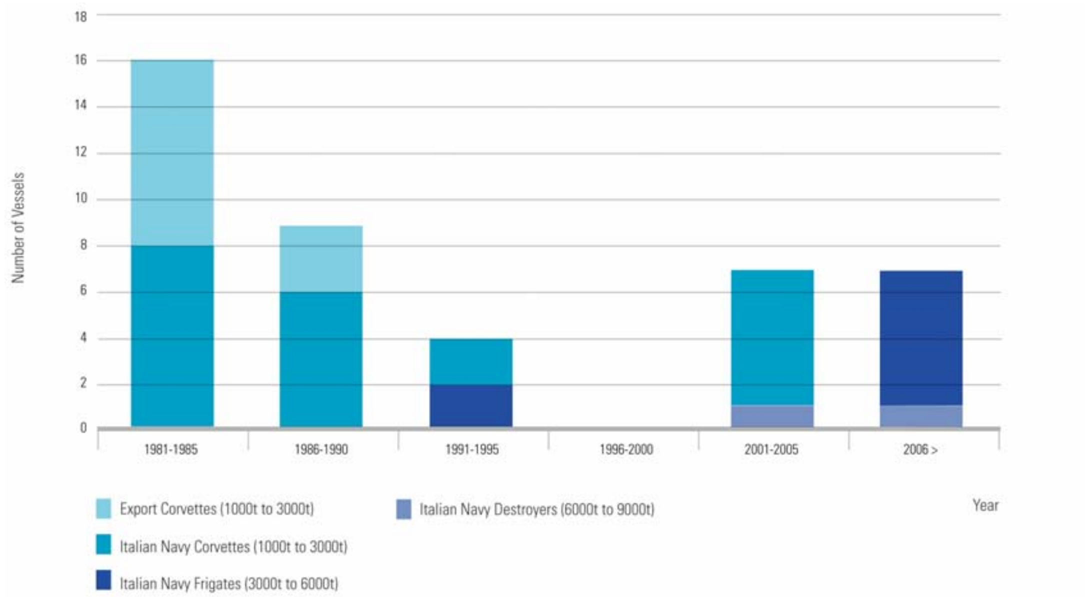


Figure A8: France – submarines



Sources: Christian Gantes Young, 'Scorpenes for the Chilean Navy', *Naval Forces,* vol. 23, no. 6 (2002), pp. 67-71; Center for Nonproliferation Studies, *Strategic Submarine Proliferation*, http://cns.miis.edu/research/submarines; DCN; www.netmarine.net; www.deagel.com; www.hazegray.org; Massima Annati, 'FREMM-France and Italy Join Forces for an Ambitious Programme', *Naval Forces,* vol.26, no. 2 (2005), pp. 84-91.

Figure A9: Italy – corvettes, frigates and destroyers



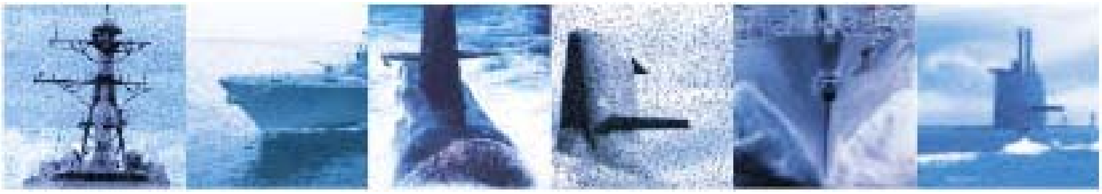
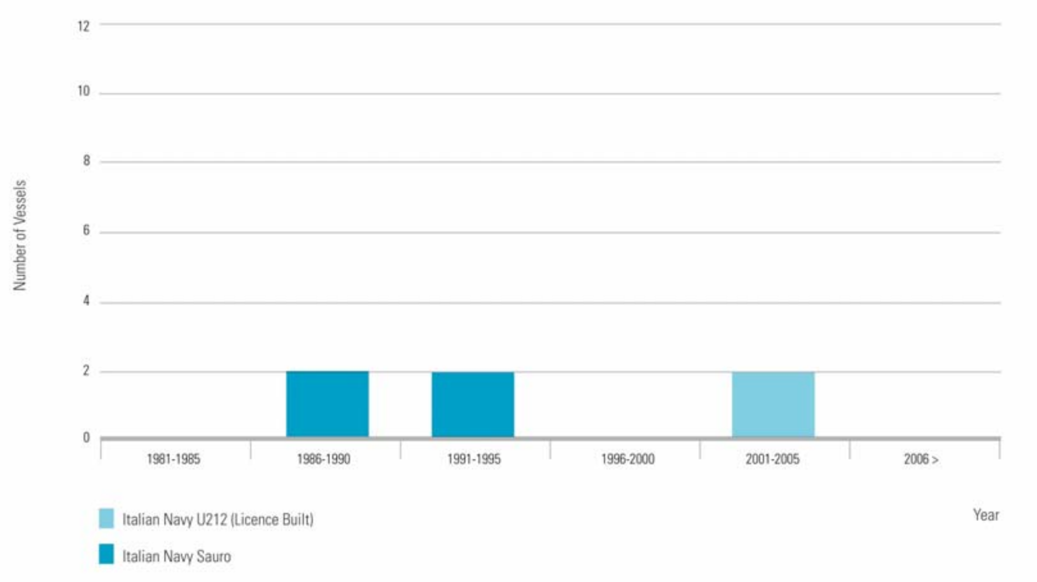
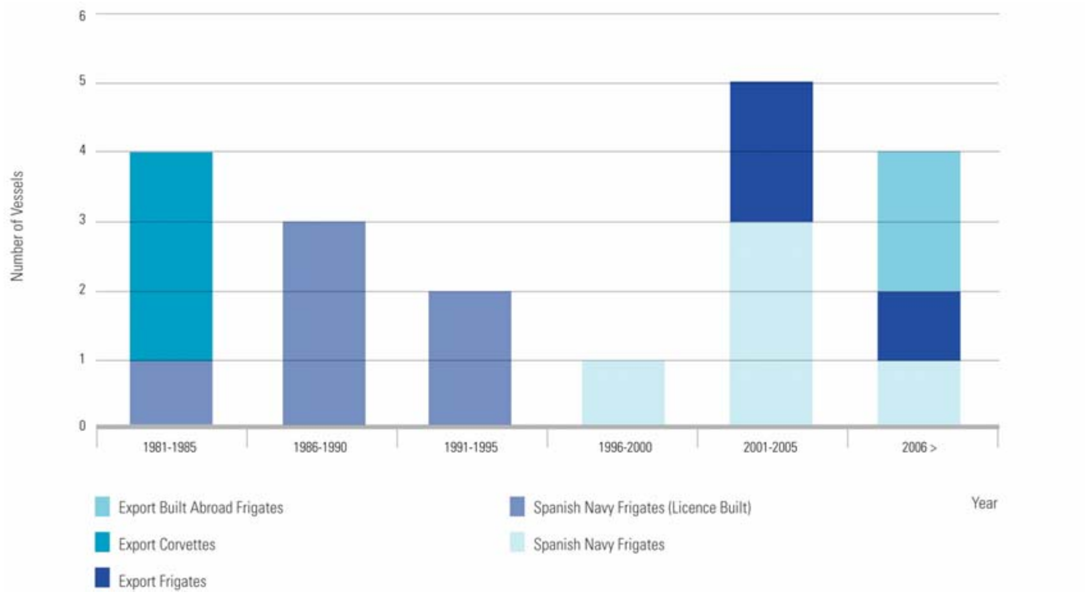


Figure A10: Italy – submarines



Sources: Center for Nonproliferation Studies, *Strategic Submarine Proliferation*, http://cns.miis.edu/research/submarines; www.naval-technology.com; www.hazegray.org; www.deagel.com; http://web.ukonline.co.uk/aj/cashmore/italy/frigates/;Massima Annati, 'FREMM-France and Italy Join Forces for an Ambitious Programme', *Naval Forces*, vol. 26, no. 2 (2005), pp. 84-91; Luca Bonsignore, 'Launching of First Italian 212A Class Submarine', *Naval Forces*, vol. 24, no. 6 (2003), p. 136.

Figure A11: Spain – corvettes (1000t to 3000t) and frigates (3000t to 6000t)



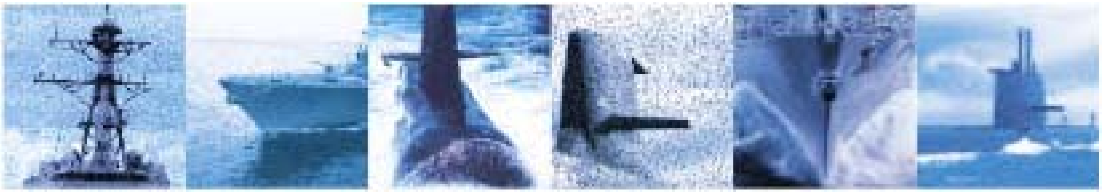
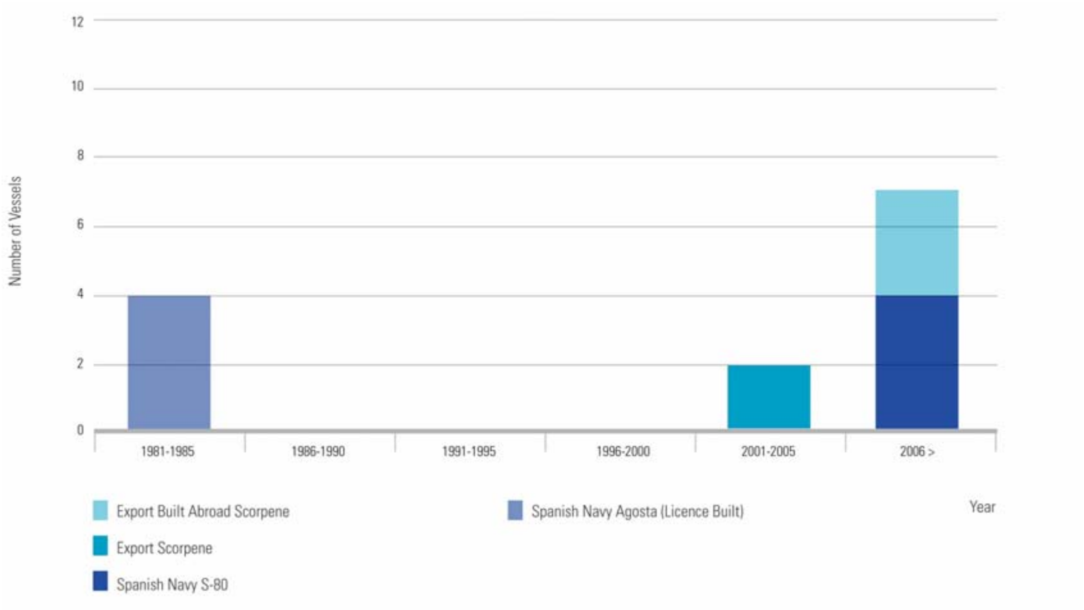
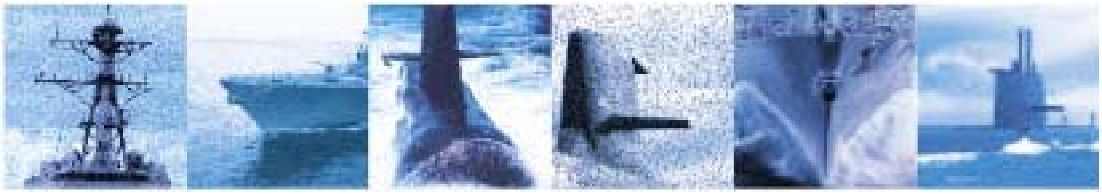


Figure A12: Spain – submarines



Sources: Christian Gantes Young, ‘Scorpenes for the Chilean Navy’, *Naval Forces,* vol. 23, no. 6 (2002), pp. 67-71; Center for Nonproliferation Studies, *Strategic Submarine Proliferation*, http://cns.miis.edu/research/submarines; www.naval-technology.com; www.deagel.com; ‘A New Generation of Frigates’, *Naval Forces,* Special Issue (2001), pp. 23-27; ‘Submarines: A New World Leader’, *Naval Forces,* Special Issue (2001), pp. 28-32, Antiono Terol Garcia, ‘Keel Laying of First f-310 for Norway at IZAR’, *Naval Forces*, vol. 24, no. 3 (2003), pp. 124-125.



Japan: a defence industry symbiosis

The post-war Japanese defence industry is privately owned and heavily concentrated. Five large corporations account for nearly 60 percent of Japanese defence contracts: Mitsubishi Heavy Industries, Toshiba Corporation, Mitsubishi Electric Corporation, Kawasaki Heavy Industries and Ishikawajima-Harima Heavy Industries Corporation.[24] Other prominent Japanese defence manufacturers include NEC, Komatsu, Fuji Heavy Industries and Itochu[25].

The dominant Japanese naval shipbuilders are Mitsubishi Heavy Industries, Kawasaki Heavy Industries and Ishikawajima-Harima Heavy Industries.

All these Japanese defence suppliers play roles in much larger Japanese 'keiretsu', as Japanese business conglomerates are known. Hence, defence-related sales account for a small percentage of their production. For example, in 1994 a member of the Keidanren's Defence Production Committee[26] noted that defence-related sales accounted for about 17 percent of total sales of Mitsubishi Heavy Industries, one of the highest ratios of the major Japanese defence manufacturers.[27] We judge that this proportion is unlikely to have changed significantly in recent years.

Several analysts[28] have commented on the Japanese Government's post-war policies of fostering Japan's defence industry. These policies moved progressively from licensed production of overseas (mainly US designs) through local adaptation to indigenous design, development and production.

Chinworth argues that Japanese production of overseas licensed systems peaked in the late 1980s. Japanese naval shipbuilding programs are now characterised by very high levels of Japanese content in design, development, production and support.

The attached figures suggest that the Japanese surface fleet bore the brunt of Maritime Self Defence Force (MSDF) reductions in response to the end of the Cold War, with deliveries of corvettes, frigates and destroyers since 1991 falling to half

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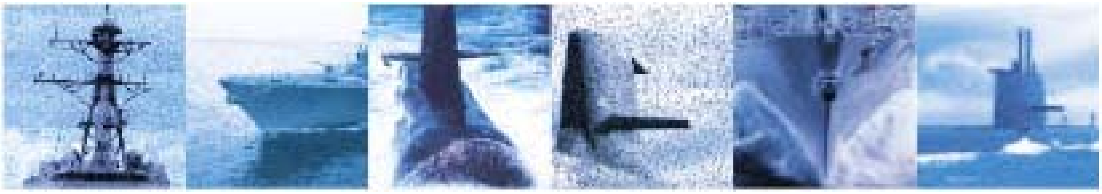
[24]www.globalsecurity.org/military/world/japan/industry, accessed 30/01/2006.

[25]NIHON KEIZAI, 10/5/04, p. 3, US Embassy translation 10/5/04 at www,jiaponline.org, accessed 1/30/06.

[26]The Keindanren is the dominant Japanese business federation that claims over 1300 companies as members.

[27]Yutaka Hineno, 'Challenges for the Japanese Defense Industry' at http://www.keidanren.or.jp/english/policy, accessed 1/30/06.

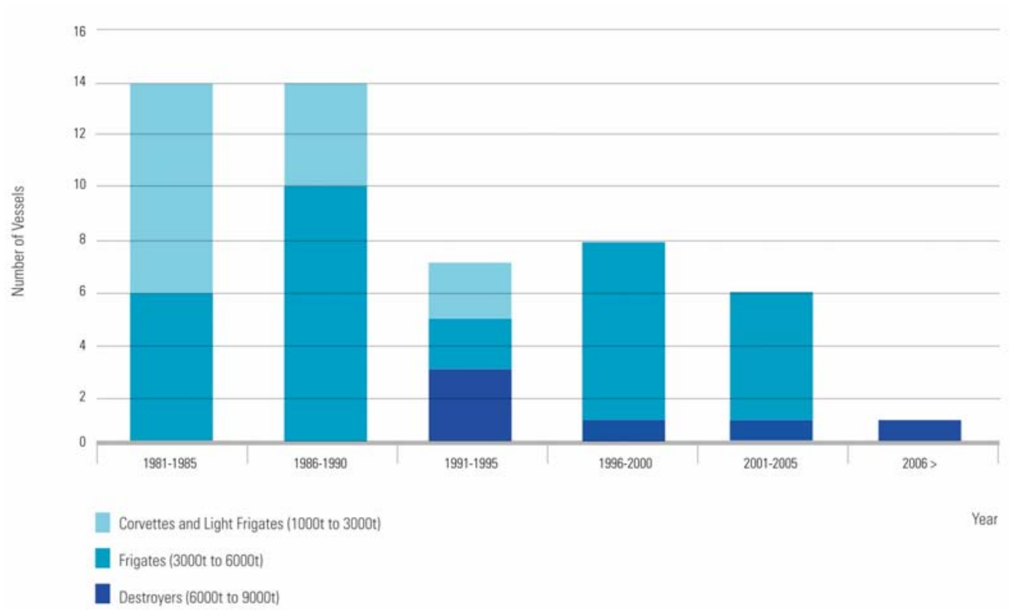
[28]See, for example, Richard J. Samuels, *Rich Nation Strong Army: National Security and the Technological Transformation of Japan* (Ithaca, NY: Cornell University Press, 1996), pp. 154-197, Michael W. Chinworth, 'Defense-Economic Linkages in US-Japan Relations: An Overview of Policy Positions and Objectives' at http://www.gwu.edu/-nsarchiv/japan/chinworth, accessed 1/30/06.



those achieved in previous decades[29]. In contrast, the Japanese maintained submarine numbers at 15-16 boats, with Mitsubishi and Kawasaki taking it in turns to deliver one submarine each year. The MSDF maintains steady state production by keeping submarines in service for some 19 years, with submarines typically spending the last 2-3 years of their service life being operated as training vessels.

The data suggests that the MSDF turned their smaller ships over more quickly than the larger ships. In the 1970s three Japanese yards (Mitsui, Ishi-hari and Hitachi) built a total of 11 Chikugo Class destroyer escorts, each of which was retained in service for some 26 years. On the other hand, the MSDF kept four Takatsugi Class anti-aircraft destroyers built by Ishi-hari and Mitsubishi during the late 1960s/early 1970s in service for some 32 years. This is a slightly longer service life than the three Minegumo Class anti-submarine warfare destroyers built in the late 1960s/early 1970s (in service for some 30 years) and the three Tachikaze Class guided missile destroyers (built by Mitsubishi in the late 1970s/early 1980s) which will have been in service for some 31 years.

Figure A13: Japan – corvettes, frigates and destroyers



[29] Data compiled from www.globalsecurity.org/military/world/japan/jmsdf.htm accessed 6 Feb 2006

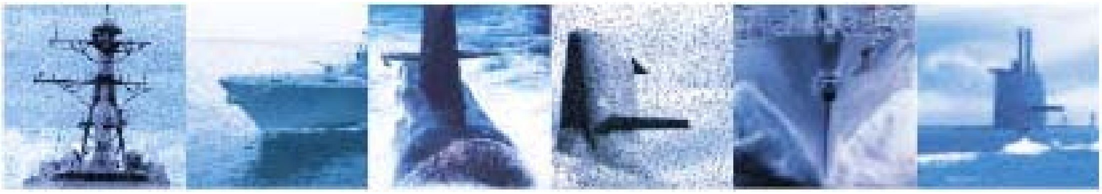
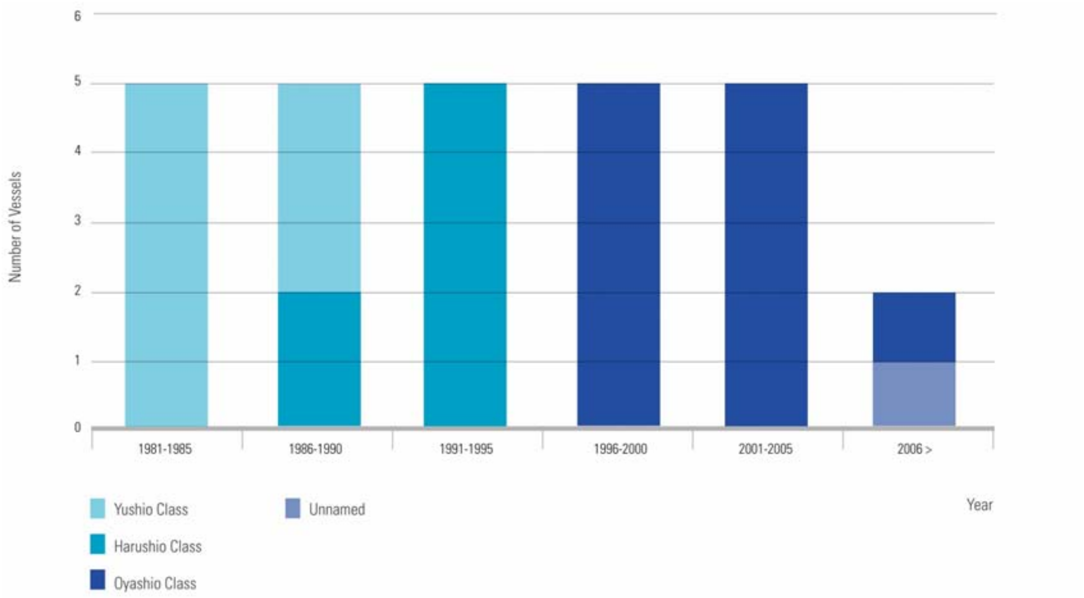
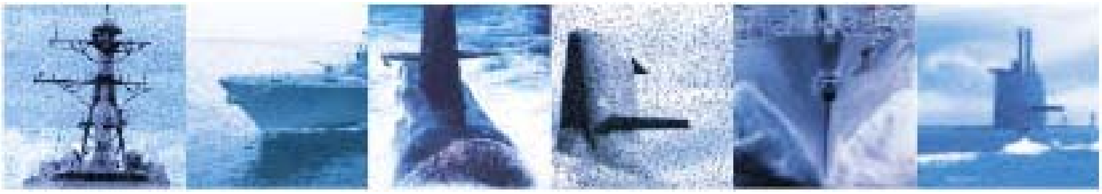


Figure A14: Japan – submarines



Source: www.globalsecurity.org



United States: an ambivalent duopoly

The United States' (US) response to the end of the Cold War included a major reduction in the size of the US Navy (USN) and the rate at which ships were built for it. According to the Congressional Research Service[30] the total number of battle force ships[31] in the USN peaked at 568 in 1987 and declined thereafter, to 288 in 2005. This steep decline was reflected in the number of combat ships the US Congress authorised each year when the numbers fell from some 17-19 annually in the late 1980s to 5-7 annually in the early 2000s.

The decline in USN ship numbers was exacerbated by a shift in USN force structure policy caused initially by the collapse of the Soviet Union, the re-emergence of regional security challenges to US security interests and US preoccupation with global terrorism after September 11 2001[32]. Prior to the Soviet Union's collapse, the USN had been structured to counter Soviet naval forces at sea during a multi-theatre NATO-Warsaw Pact conflict. By 2005, USN force structure policy had shifted to the requirements of influencing events ashore through countering both the land and sea-based forces of a number of countries other than Russia and also a number of non-state terrorist organisations.

This shift in USN force structure planning is reflected in the profusion of precision-guided, air-delivered weapons in the USN inventory; in increased numbers of Tomahawk-capable ships in its fleet and in the increased sophistication of USN systems for command, control, communication, computers, intelligence, surveillance and reconnaissance (C4ISR). It also accounts for USN experiments with ships specialised for littoral combat.

More generally, however, while the US policy community generally recognises that historical figures for the total number of ships in the USN fleet are a poor guide in assessing the adequacy of today's USN or plans for future USN development, a consensus on the appropriate size or composition of the future fleet has yet to emerge.

The US naval shipbuilding industry has responded to the collapse in USN demand and the shift in USN force structure policy by a dramatic consolidation. The upshot of this consolidation process is that between them General Dynamics and Northrop Grumman own all of the 'big six' US naval shipyards[33]. This industry consolidation on the supply side of the US naval shipbuilding market, and smaller scale changing

[30] Ronald O'Rourke, 'Potential Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress,' *Congressional Research Service* (Washington D.C. June 2005), Appendix B.

[31] "Battle force" ships are combatants and combatant support ships; the term excludes, for example, sealift and pre-positioning ships operated by the Military Sealift Command and oceanographic ships operated by the National Oceanic and Atmospheric Administration.

[32] This analysis draws heavily on pages 15-22 of O'Rourke's analysis.

[33] http://www.hazegray.org/shipbuilding accessed 7 January 2006

requirements on the demand side of the market, have confronted the US naval shipbuilding community with policy issues of overcapacity, competition, legacy fleets and an enhanced need for innovative solutions. In addition, the United States industry is lagging behind the European and Asian industries in terms of overall productivity.[34] In grappling with these issues the US companies have evolved distinct solutions for submarines and surface ships.

United States submarine construction

The attached chart of the annual rate of commissioning of US nuclear submarines illustrates the impact of the post Cold War reduction in demand. The chart demonstrates that, after a hiatus following the cancellation in 1992 of the Seawolf nuclear submarine program (being built by General Dynamics Electric Boat) the US submarine industry subsisted on the construction of the Virginia Class attack submarines, delivering them at the rate of one per year.

The resulting commercial pressures forced the industry to propose in December 1996 that General Dynamics Electric Boat and Northrop Grumman's Newport News build the Virginia Class submarines as a team rather than as competitors[35]. Under this arrangement, which was subsequently accepted by Congress and the US Department of Defense, each yard constructs about one half of each boat and generally specialises in building the same sections for each boat. The constructed sections from each shipyard are then barged to their counterpart and the shipyard designated as the 'delivery yard' for that boat completes the construction.

While the above arrangement mirrors those between Spain's Navantia and the French DCN in the production of the Scorpene submarine, it constitutes a departure from traditional US naval shipbuilding practice. Traditionally, labour, materials and equipment flowed through the yard to focus on the boat under construction on an inclined launch way.

Under the new teaming construction arrangements, submarines are broken down into some 24 hull sections and modules, each of which constitutes a key sub-assembly of the submarine's hull or equipment. Modules are extensively outfitted and tested 'off-hull' before the individual pieces are loaded into the open ends of hull sections and then joined to form the submarine.

United States surface combatant construction

The DDG-51 Arleigh Burke class of guided missile destroyers is now the mainstay of the USN destroyer force. The USN planned to buy a 57 of these ships, delivery of which began with the commissioning of the lead ship in 1991[36]. Deliveries were initially planned at the rate of five per year but, as the attached chart illustrates, this rate subsequently stabilised at around three per year after the mid-1990s. These

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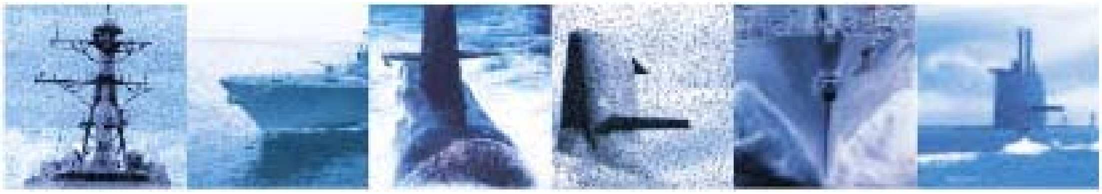
[34]First Marine International, *Findings for the Global Shipbuilding Industrial Base Benchmarking Study* (Washington D.C.: Under Secretary for Acquisition, Technology and Logistics – Industrial Policy, 2006).

[35]http://www.globalsecurity.org/military/systems/ships/ssn-774-con.htm accessed 7 January 2006.

[36]http://www.globalsecurity.org/military/systems.ship/ddg-51-unit.htm accessed 7 January 2006.



ships are constructed in flights (ie batches) to enable the program to take advantage of the technological development of systems. The nominal service life of these ships is 35 years, so that, under present plans, the lead ship is not due to be decommissioned until 2026.

Construction of the Arleigh Burke Class destroyers is shared between the lead yard General Dynamics Bath Iron Works and Northrop Grumman's Ingalls shipyard. Unlike the Virginia Class submarine program, each yard still builds an entire ship in parallel.

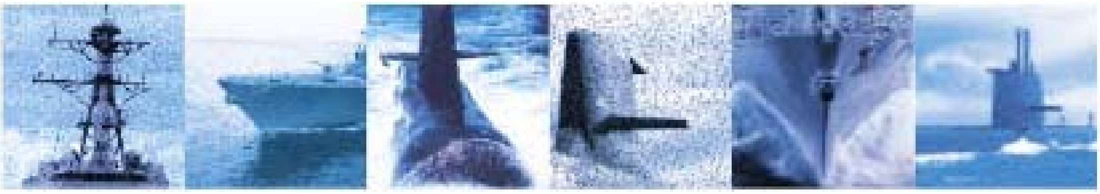
However in 2002, the USN, General Dynamics and Northrup Grumman agreed to adjust arrangements for parallel construction of the Arleigh Burke Class by rationalising the distribution of workload for that class and the San Antonio Class (LPD-17) amphibious transports being built concurrently. Within the Memorandum of Understanding Concerning the Reallocation of LPD-17 And DDG-51 Ship Construction Workload signed by all three parties in June 2000, construction of future DDG-51 destroyers was to be concentrated at Bath Iron Works, thereby freeing up Northrop Grumman Ship Systems yards for construction of the four LPD-17 amphibious transport ships. According to the Congressional Research Service, a key factor driving this arrangement was the need to avoid the extra costs incurred by 'splitting the learning curve' through construction of the LPD-17 in separate establishments.[37]

Clearly economies of scale have had a great impact on the consolidation of US naval shipyards. However, economy of scope has also had a significant impact on those companies undertaking naval design in the US.

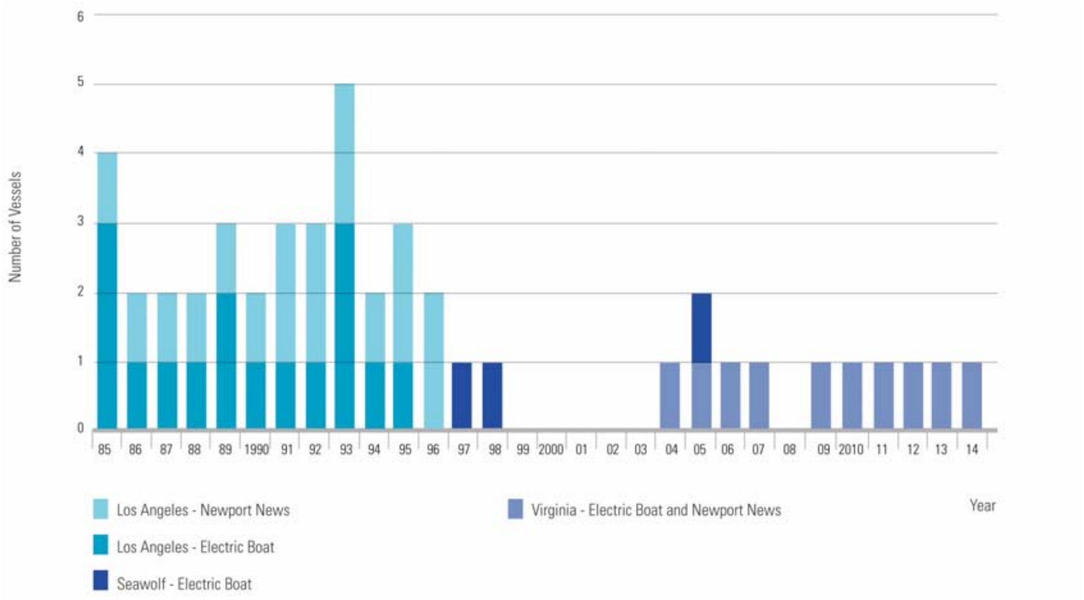
More than a decade ago, with several independent shipyards in existence, design consultants, naval architects, such as Gibbs & Cox played an important role. They acted as a neutral repository of knowledge, working with any shipyard to complete ship design and ensuring that knowledge was available when it was required.

However, during the last ten or more years, the US Navy has concluded that due to economies of scope, and coupled with economies of scale, it is better to consolidate design expertise within its two primary shipbuilders, General Dynamics (Electric Boat and Bath Iron Works) and Northrop Grumman.

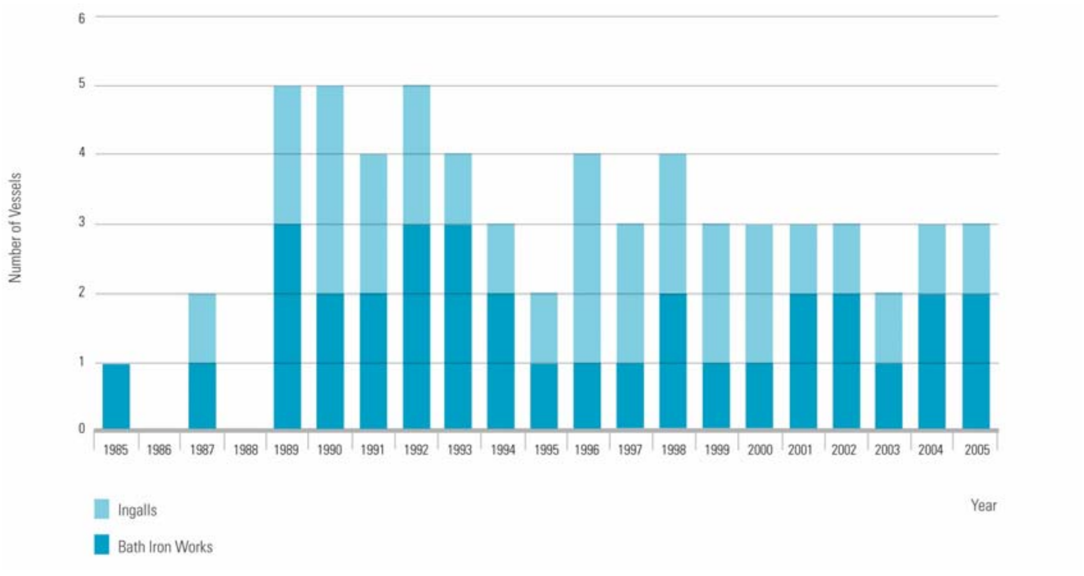
[37]Ronald O'Rourke, 'Potential Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress,' *Congressional Research Service* (Washington D.C. June 2005).



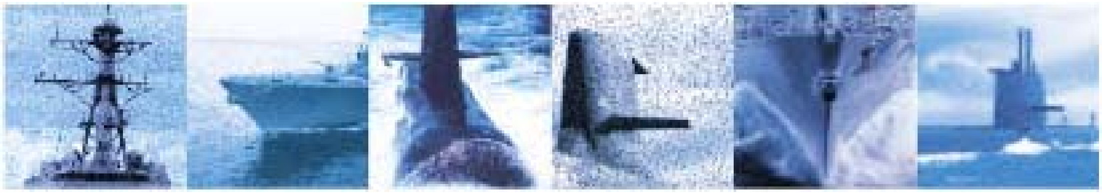
A16: US Navy SSN (years of commissioning)



A15: US Navy Arleigh Burke Class destroyers (years of order)



Source: www.globalsecurity.org



ATTACHMENT B

MODELLING OF CONSTRUCTION / UPGRADE STRATEGIES

Introduction

In the context of the Department of Defence's proposed Australian Naval Shipbuilding and Repair Sector Strategic Plan[38], that ultimately was not endorsed by Government, ACIL Tasman examined the issues associated with the economic life of major naval ships. They explored how optimal economic life (ie one that maximises the capability outcome that government is seeking at an acceptable cost) might influence the way in which Defence procures its future major surface ships. Throughout that work, ACIL Tasman introduced the concept of 'value' of the ship and fleet capabilities to economic modelling of alternative ship and fleet support and replacement management strategies.

This attachment summarises the ACIL Tasman material already presented to Government for surface ships and extends that modelling concept to submarines.

Basis of modelling

In accordance with economic principles, ACIL Tasman defined the 'economic life' of a vessel in terms of the net value a given vessel adds to defence capability, rather than just the vessel's costs. The value of capability takes into account the likelihood of needing the capability and the consequences of not having it. The ship value therefore varies in accordance with, for example, the age and design age of the fleet and the nature of external threats – an approach consistent with Defence policy principles.

The modelling promotes the concept of maximizing fleet value within a budget constraint as an alternative to simply minimising through-life costs within a constraint on minimum capability.

There is, of course, a high level of subjectivity in any notion of vessel, fleet or capability value, but it remains true that some notion of 'value' must underlie any sensible interpretation of 'economic life' and the very rationale for maintaining a fleet. Without at a least an implicit sense of value, cost minimisation principles would rapidly lead to a contraction in fleet capability, if not a cessation of operations.

With some concept of value, it is useful to ask whether the costs of expanding the capability can be justified in terms of additional value or, conversely, whether a marginal contraction in capability would deliver cost savings greater than any implied loss of value.

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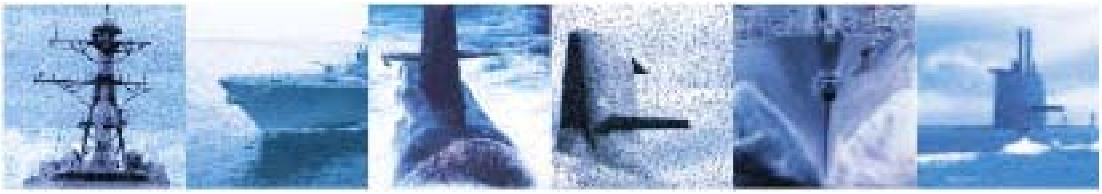
[38] *Australian Naval Shipbuilding and Repair Sector Strategic Plan* (Department of Defence, Canberra, 2002). See especially Chapter 14: *Future Demand Management,* pp.169-178.



The modelling undertaken on the basis of this definition incorporates the concept of long term annuities used in the accounting for other rolling replacement infrastructure investment programs (such as major utilities). Use of the annuities concept enables sound comparisons of different vessel management strategies. The same concept was then extended to ensure that the modelling could also allow sound comparisons of the costs of alternative strategies.

A feature of this approach is that it does not rely only on the through-life costs of a particular vessel, but rather looks at the rolling cost of maintaining the capability a vessel brings to the fleet, including costs and benefits of future replacement. This then allows a more balanced comparison of alternative fleet management strategies involving different vessel lives.

This approach provided a parametric model of the through-life costs and value of services delivered by a single vessel. ACIL Tasman also developed a parametric model of the through-life costs and value of services of a fleet of vessels and this is available for future modelling of varying strategies and concepts.

Critically, the modelling recognises that, even with significant upgrades, the value of a vessel, in terms of the 'additional capability it affords the fleet' can be depreciated rapidly in older vessels as a result of constraints imposed by the old platform design relative to newly designed vessels. This value concept is currently captured in a value index that may be calibrated relative to the opportunity cost of vessel replacement.

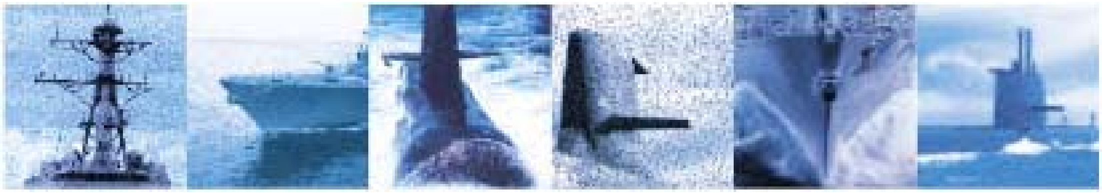
The methodology is intrinsically conservative as it does not take into account beneficial outcomes that are likely to flow from opportunities to provide industry with more predictability of demand. It also deems the residual value of vessels at the end of their lives to be negligible, whereas vessels replaced earlier in their lives have a commensurately higher residual value.

The data presented is stylised for simplicity. For surface combatants, minor upgrades are represented as five yearly activities providing moderate value enhancement. Major upgrades are depicted as mid-life refits. For submarines, only the full-cycle dockings at 72 months and a possible mid-life upgrade – superimposed on the second full-cycle docking - at around 15 years are represented. Intermediate dockings and mid-cycle dockings are simplified under basic annual maintenance costs. Acquisition costs include a share of all project-related costs, as well as vessel-specific costs, under the current project-by-project model. Notwithstanding the stylised data, the graphs are indicative of trends in the modelled system's behaviour with respect to alternative replacement strategies.

Modelling outcomes – surface combatant

For surface combatants, the modelling indicated that the effective cost (cost annuity) of retaining a ship in the fleet is fairly stable across the range of replacement ages from 15 years through to around 25 – 30 years.

This highlights that precise estimates of costs in this range, which are relatively difficult to achieve, are probably of limited value. More importantly, it indicates that



annualised costs of capability ownership are relatively insensitive to variation in vessel life in this range.

Effectively, the higher acquisition costs of earlier replacement closely match the rising maintenance costs avoided as a result of earlier replacement, coupled with a trend towards operating cost efficiencies in replacement vessels, so 'average' net cost impacts are small over time.

This significant finding has enabled a number of conclusions to be drawn about the so-called 'economic life' of naval vessels. The most significant conclusion is that future replacement strategies can be optimised against objectives, such as industry implications, fleet value (a function of capability) and onshore maintenance, without a significant cost downside.

The relationship between replacement strategy and annualised cost is made clear in the following graphs, sourced from the Australian Naval Shipbuilding and Repair Sector Strategic Plan.

Figure B1: 30 year replacement, mid-life upgrade

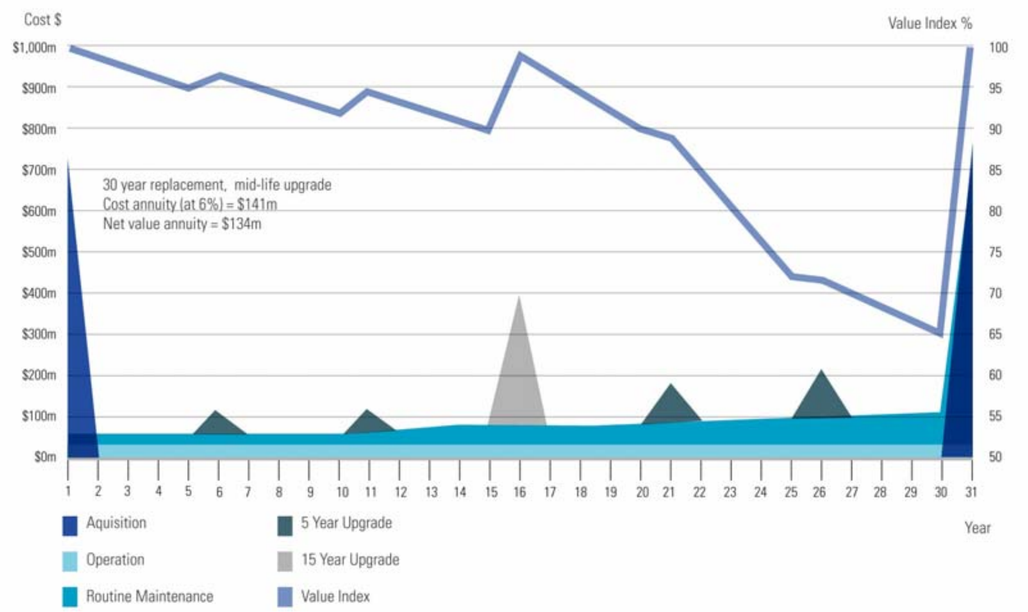


Figure B1 can be viewed as the current replacement strategy. It is characterised by gradual decline, periodically partially offset by 5 year servicing periods, in value index (a function of capability) out to a major upgrade at the mid-life. This upgrade largely restores the capability but, as a consequence of the physical constraints imposed by underlying aged equipment and design, the vessel's capability then falls significantly more rapidly in the second half of its life, out to the end of the ship's life. A significant period of compromised capability exists in the final 10 years or so of the vessel's life. This may be significant if a heightened threat environment occurs during this period.

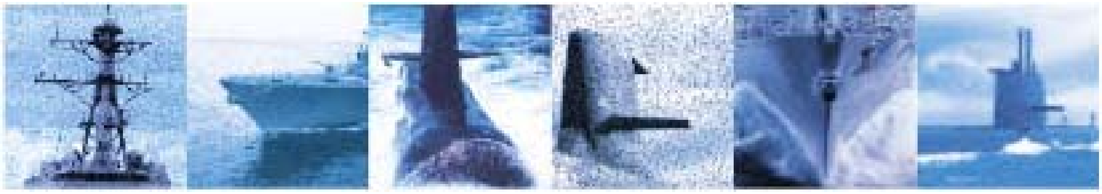


Figure B2: 25 year replacement, no mid-life upgrade

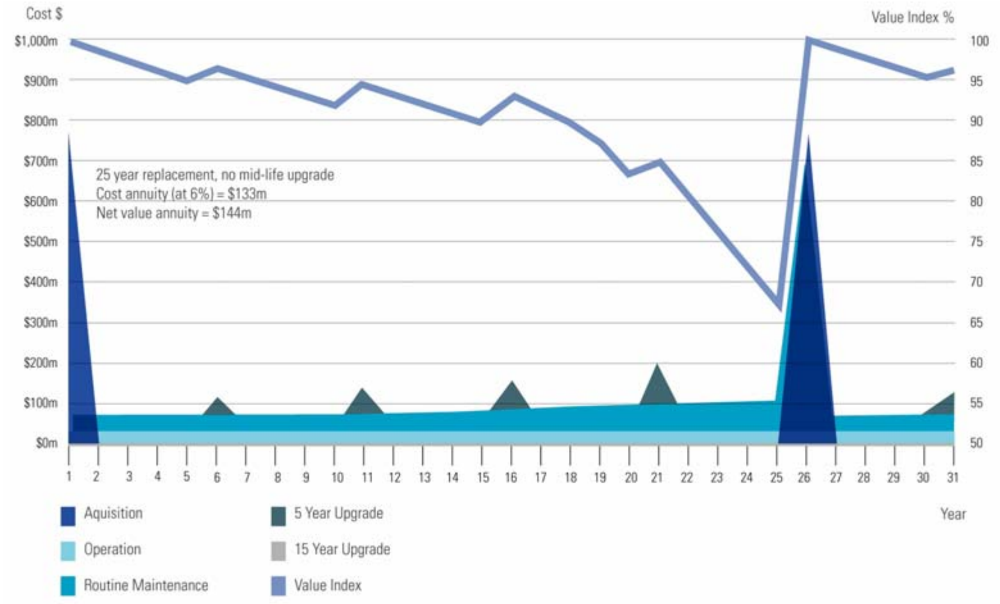


Figure B2 presents an alternative strategy based around vessel replacement after 25 years, but without a major mid-life upgrade. The modelling suggests that this approach is likely to involve the least cost but, as was noted earlier, the difference in cost compared to any of the other strategies presented here is small. Despite its lower cost, comparison of the patterns shown by the value indexes suggest that it may well involve no loss of value relative to the longer life 30 year replacement upgraded vessel strategy set out in Figure B1. While removing the half-life upgrade has a detrimental impact, this is partially balanced by the much greater value delivered between years 25 and 30. This type of trade-off consideration, taken over the indefinite life of the fleet, is central to the modelling approach.

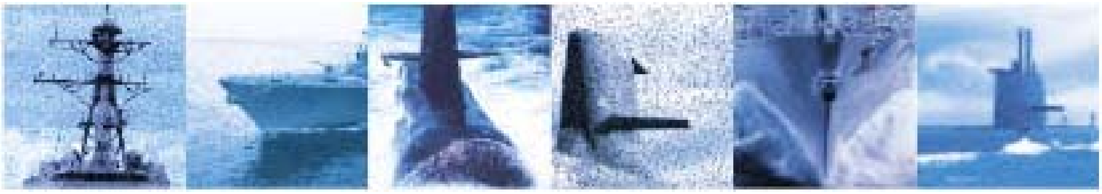


Figure B3: 20 year replacement, no mid-life upgrade

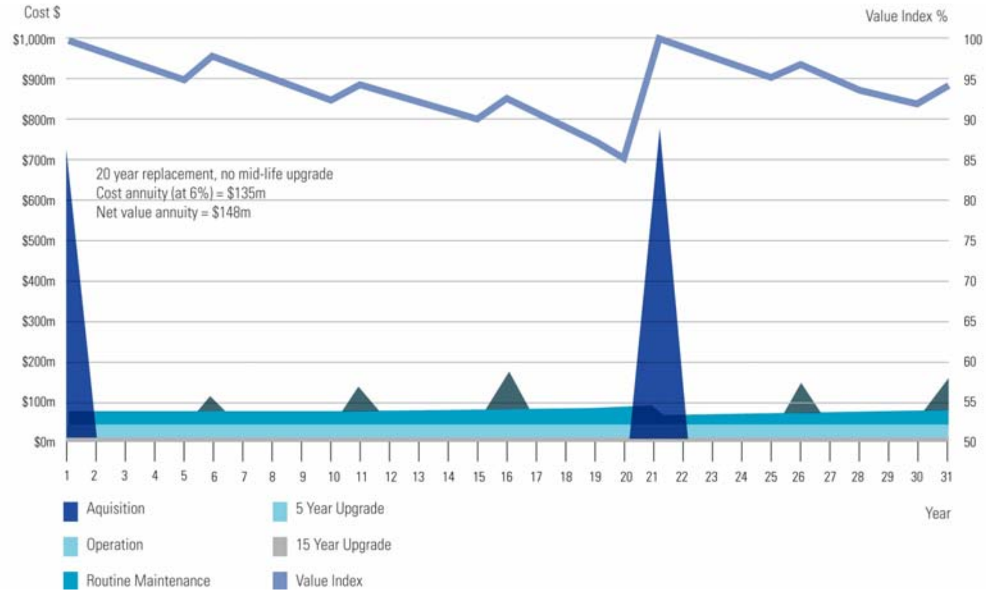


Figure B3 demonstrates the consequences of further advancing a vessel's replacement age to 20 years. This approach raises costs very slightly, but has an unambiguous offsetting impact on value. This strategy can be viewed as one which maximises the net value delivered, based around the value assumptions made. In return for a small rise in average annual costs, it largely eliminates the otherwise significant decline in value between years 20 and 25.

Figure B4: 18 year replacement, no mid-life upgrade

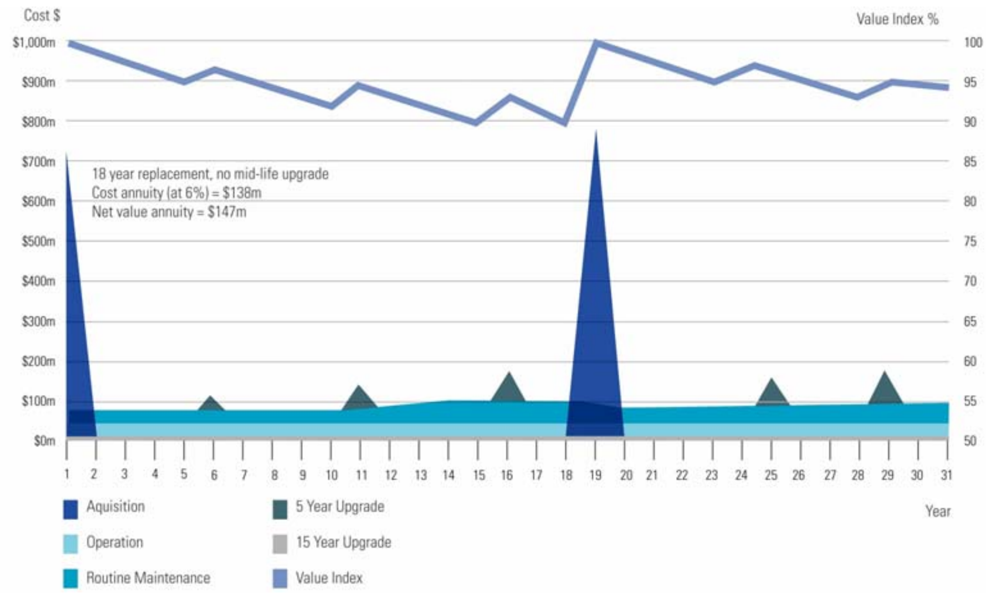
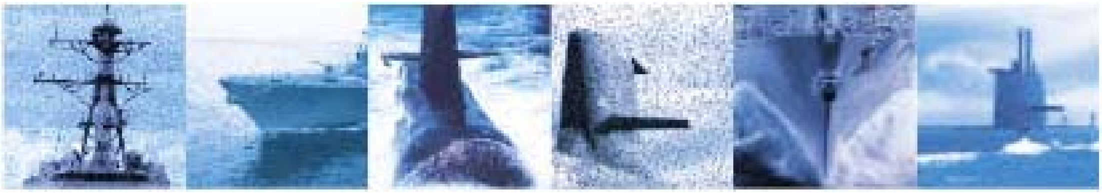


Figure B4 shows the effect of replacing ships even earlier than the optimal 'indicative net value' strategy. The slightly higher annualised costs, accompanied by a rise in the value annuity, involve, on the face of it, a less satisfactory strategy. However, the



cost trade-off is small; demonstrating the proposition that optimisation on other objectives can be accommodated. This strategy could well prove justifiable if it were to facilitate strategic changes to the build program that delivered a reduction in acquisition costs, or if it delivered a substantially higher fleet value over time.

Given that technology is progressing exponentially, it may be highly beneficial to accelerate the replacement cycle and thereby ensure that all the benefits of rapidly evolving technology are captured.

In summary, the model demonstrates the feasibility of replacement strategies considered, with the current strategy delivering the worst annualised value. The long life of a vessel virtually demands a major upgrade at some point, but progressive platform design obsolescence and aging, even of upgraded systems, imply a substantial loss of capability late in vessel life. The strategy that is optimised for cost shares this capability weakness for a significant portion of its life. The analysis in this case suggests that the optimum value annuity is achieved with a ship life closer to twenty years, but replacement earlier than this can be justified on wider fleet capability management or industry grounds.

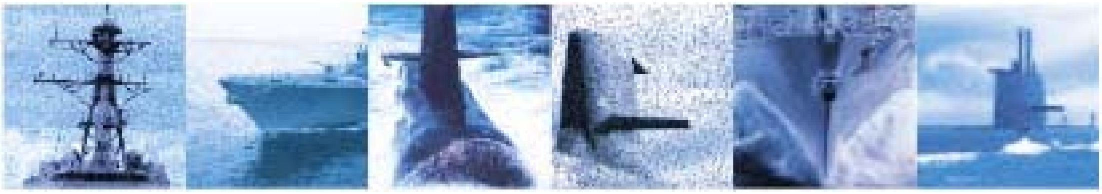
The most significant result of this modelling process has been that, even under a conservative methodology that effectively ignores residual values, the strategy of early replacement of ships can provide significant capability (ie value index) benefits without incurring excessive costs.

If there was a significant market for ‘middle aged’ vessels, this would strengthen the case for early replacement and would advance the optimal replacement timing on both cost (avoided loss of sale value) and value (advanced access to a more capable and newer vessel) grounds. With rapid decline in the residual value across the middle years, this effect can be quite substantial.

The subjectivity of the value assessment does, of course, introduce additional uncertainty. In general, increasing the value attributed to surface vessel capability (for example, as perceptions of threat rise, or likely future tasking requirements evolve in ways likely to favour this capability) then this will tend to favour earlier replacement. Similarly, more rapid technology advances, or advances by opponent forces that may pose a potential threat, would favour earlier replacement by increasing the value of such replacement.

This result also highlights the flexibility by which replacement scheduling can be tailored to deliver other benefits such as smoother demand profile, possibly lower acquisition costs, more reliable retention of necessary skills and infrastructure and flexibility for the RAN in implementing changes to vessel design to influence crew policies and personnel retention.

These possibilities were identified in this context in the Australian Naval Shipbuilding and Repair Sector Strategic Plan, 2002. An important point is that, if shipbuilding efficiencies can be achieved through these methods, the effect becomes self-reinforcing. If acquisition costs can be lowered without compromising vessel capability, and on-going support costs do not fall by as much, then again earlier replacement will make sense because the cost benefits of replacement relative to



ongoing support are improved. The scope for adopting a more strategic approach to fleet support and replacement, while offering greater fleet and on-shore capability and capability value, and possibly lower costs, is highlighted by these analyses.

Modelling outcomes - submarines

For submarines, the modelling shows that the effective cost (cost annuity) of retaining a vessel in the fleet is still declining, though slowly, out to 30 years, driven mainly by the high capital cost and the assumption of zero residual cost. This means that the current replacement strategy of retaining the submarines in service out to 27 - 30 years is the low cost approach, but it also delivers the lowest minimum value of the vessel. Replacement at 21 years, without upgrade, provides maximum value over the life of the vessel.

These minimum values are built into the value annuity calculations, but do serve to highlight the way in which earlier replacement reduces the periodic decline in value away from current 'competitive capability'. This aspect needs to be interpreted in the context of whole-of-fleet capability. It is worth noting that these minimum values do not include low values that arise during dockings, where the effect of the extended mid-life docking can be considerable. The value index during routine maintenance periods is represented with a value of zero, this reflects the longer, more intensive, maintenance periods in which submarines are out of service.

Figure B5: 29 year replacement, no mid-life upgrade

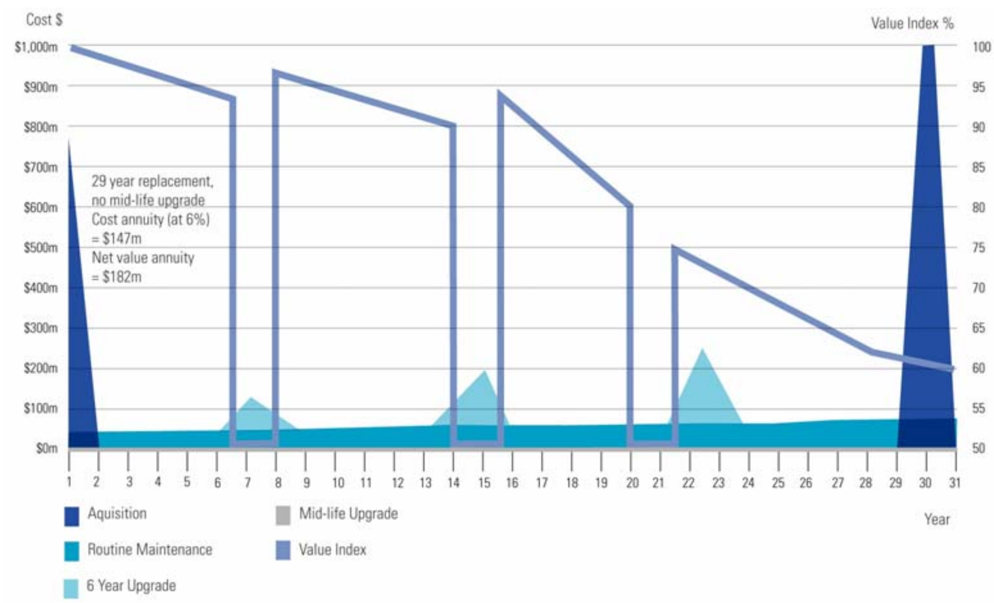
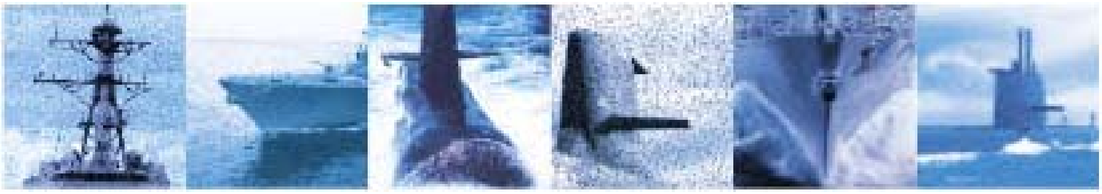


Figure B5 represents the current replacement strategy. It is characterised by a gradual decline in value index (a function of capability) out to around the 18 year mark where the decline in value becomes much steeper as a consequence of the age of equipment and physical design. A significant period of compromised capability exists in the final ten years or so of the vessel's life; this is perhaps even



more critical for a submarine and might be critical if a heightened threat environment should arise during this period.

Figure B6: 21 year replacement, no mid-life upgrade

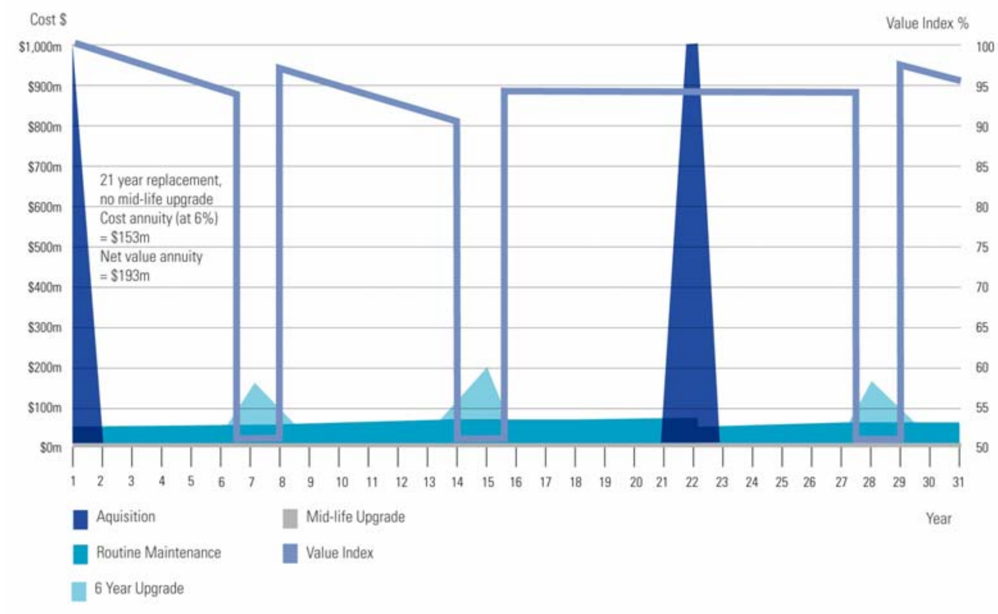
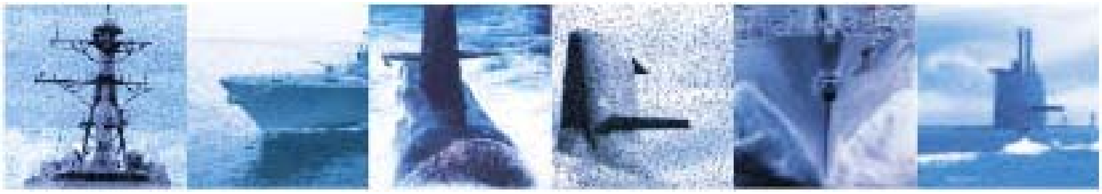
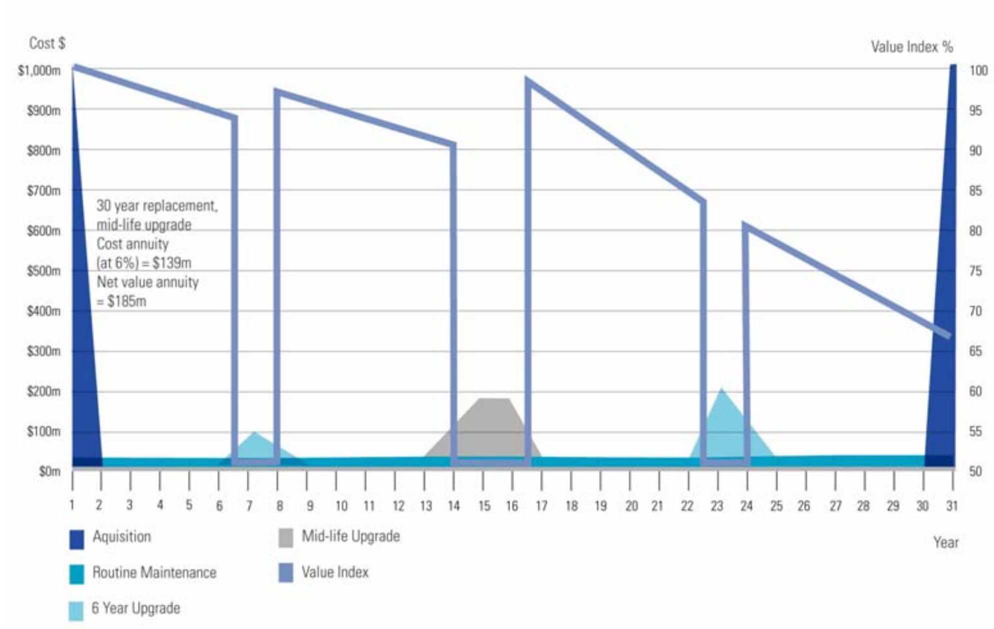


Figure B6 represents an alternative strategy, based on submarine replacement after 21 years, also without a major mid-life upgrade. The modelling indicates that this approach does not involve the least cost but, as was noted earlier, the difference in cost is not large compared with the current replacement strategy. However, a comparison of the patterns shown by the value index indicates an increase in value relative to the longer-life replacement strategy.



B7: 30 year replacement, mid-life upgrade

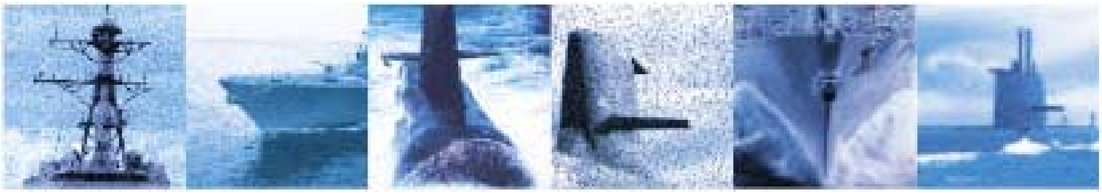


Noting that it is already too late to consider implementing an early replacement strategy for the current fleet of submarines, Figure B7 represents the effect of undertaking a mid-life upgrade of the current fleet. This strategy assumes that the gradually declining value effects of annual maintenance activities and six yearly upgrades are partially offset by the replacement of submarine systems and sub-systems during the mid-life upgrade. On this basis, the modelling indicates a decrease in cost annuity over the no-upgrade strategy in Figure B5 but a worthwhile increase in value annuity.

In summary, the model demonstrates that the current strategy delivers the worst annualised value. Even though it is not currently part of the submarine fleet strategy, a long vessel life virtually demands a major upgrade at some point, but progressive platform design obsolescence and aging even of upgraded systems imply a substantial loss of real capability late in the vessel's life. The analysis suggests that the optimum value annuity is achieved with a vessel life of 21 years. This could be further refined if alternative options for required docking activities, including docking durations, were considered.

The most significant result of the modelling process has been that, even under a conservative methodology that, for instance, effectively ignores residual values, the strategy of early replacement of submarines at the 21 year mark can provide significant capability (ie value index) benefits without incurring excessive costs. If Australia were able to access a market for 'middle-aged' submarines, this would strengthen the case for early replacement and would reduce or eliminate any increase in cost annuity. A reduction in the cost of acquisition of new vessels would have a similar effect.

These results are again heavily dependent on the assumptions made regarding the nature of the value function – the value of a new vessel in the fleet and the nature of



the subsequent decline in this value relative to a then current design replacement. This is quite different from the decline in physical capability. An aging vessel may, as a result of system upgrades, be substantially more capable than it was when new. The comparison here is with a current design vessel, which incorporates trends and new technological systems developed since the original design, without the constraints imposed by the primary systems design of the original vessel.

The results of this modelling indicate that the Australian government and the RAN have an opportunity to replace submarines at an early stage, thereby winning potential benefits that include options to change to vessel designs to both substantially improve operational performance and, though improving crew habitability, influence crew policies and personnel retention. Such options would also allow industry to retain and increase its maturity and effectiveness by being exercised almost continuously, with resultant lower acquisition and support costs.

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