5 August 2014

A Preliminary Analysis of the Economic Impact of Future Submarines based on the experience of the Collins Program

Commissioned By:

Defence Materiel Organisation

Table of Contents

Glossary of Terminology and Concepts

ASC	Australian Submarine Corporation
CGE	Computable general equilibrium
DMO	Defence Materiel Organisation
Defence	Department of Defence
ERA	Effective Rate of Assistance
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GSP	Gross State Product
I-O	Input - Output
ISCMMS	Integrated Ships Control Management and Monitoring System
TSC	Technical Subject Code
VUMRF	Victoria University Multi-Regional Forecasting model

Executive Summary

Recently, the issues of whether a new class of submarines should be built in Australia and in what quantities have attracted considerable public attention. While much of the debate has concentrated on aspects of military-strategic planning, the potential economic impact associated with the project has also emerged as a topic of public interest. From an economic impact perspective, one question in particular has dominated: will the new jobs created by building and maintaining a new submarine offset an anticipated decline in employment in the motor vehicle industry in South Australia?

The aim of this report is to explore the potential future economic impacts of a submarine build in Australia, on the basis of what might occur if new submarines are constructed in a similar manner to the Collins class vessels used currently by the Australian Navy. Planning for a Future Submarine Program is still in its formative stages. Consequently, the best that can be achieved at this stage is to deliver indicative impact estimates which may be subject to change as the Program matures.

In addition to the issue of new job opportunities, economic impact modelling can shed light on whether Government may need to take any special or unusual steps to ensure the availability of a suitably skilled domestic submarine workforce.

Very little data currently exists on the potential employment and other economic effects which a future Australian submarine build might have at national, state or regional levels. Very limited economic modelling has been conducted covering the Collins submarines, despite their construction being one of Australia's single largest infrastructure projects. And economic impact data for a range of Navy surface ships does not easily translate into a submarine environment.

With this in mind, the report begins by using historical cost data for building, rectifying and enhancing the Collins submarines to estimate what the economic and employment impacts of building the same vessels might be - in the Australian economy of today as well as the economy of the 2020s, 2030s and beyond when the first phases of new submarine construction are expected to commence.

Then drawing substantially on Collins cost data, the report attempts to estimate the economic impact of alternative scenarios for a Future Submarine Program. Using the Collins experience provides valuable insights into the more general nature of the links between submarine construction and other parts of the economy.

Then the report concludes by considering the issue of fleet size and the economic impacts of sustaining the Future Submarine Program.

The economic model used to assess impacts is the Victoria University Multi-Regional Forecasting (VUMRF) model which has been developed and applied to this project by Victoria University. The model is widely recognised as well suited to the task. The modelling project has been managed by the Defence Materiel Organisation (DMO) in close consultation with the Australian Government departments of Treasury and Industry.

The results from modelling suggest that despite the fact that the Future Submarine Program is likely to be among Australia's largest single public infrastructure investments, its potential economic impacts could be smaller than many expect.

Despite the absolute size of the Program, it is unlikely to have a noticeable or clearly positive impact on the Australian economy as whole, even if the Program was to achieve international competitiveness and extend to include a significantly larger number of vessels than Australia now possesses. If comparable vessels are available from overseas at substantially lower prices, the measurable national economic impact of the Program is likely to be a small negative - as it draws resources from areas of the economy where they could be used more efficiently.

In South Australia, the Program over the next decade is estimated to directly contribute around 1,100 full and part time employees on average. This is much smaller than the State's motor vehicle manufacturing industry where key manufactures employ around 3,100 workers. Program impacts are also likely to be eclipsed by the State's mining, general manufacturing and service sectors over the longer term.

Based on the Collins experience, there are no regions within Australia - including areas of Adelaide - where new submarine construction is likely to make up more than a small fraction of overall regional activity and employment.

Moreover, experience with the Collins submarines suggests that although a Future Submarine will embody a range of highly specialised and advanced technologies and contribute to skilling substantial numbers of people, the so-called spillover effects of a Future build are likely to be negligible.

It seems that most of the advanced technologies associated with Collins submarines had limited application beyond the project by being already well developed in the commercial sphere, technically unique to naval shipbuilding, shared with foreign project partners, restricted in their broader distribution for reasons of national security or never successfully marketed for export when innovation was leading edge. The spillover effects from labour force skilling through participation in the Collins program also appear to have been marginal.

A finding of limited overall spillovers accords with consensus of more general national and international economic studies on the broader impacts of defence expenditure on output and employment.

The overall results from preliminary modelling indicate that if a new class of submarines is to be built in Australia, the value of doing so lies with military strategy rather than economic impact issues. In the absence of methods for ensuring that building the Future Submarines domestically can be achieved much more efficiently than in the past, investing in submarine construction is unlikely to add to the strength of Australia's economy given the alternative uses to which the resources it absorbs might be put.

This suggests that the question of whether to construct submarines in Australia should focus instead on the military-strategic factors likely to influence a decision of where Future Submarines should be built. These include whether foreign shipyards have the capacity to build the types of vessels Australia requires, whether a foreign build can safeguard the submarine technologies Australia considers sensitive, and whether a foreign build is consistent with Australia's subsequent requirement to maintain the vessels in-country.

While all care, skill and consideration has been exercised in the preparation of this report, it should only be used for the purpose it was intended. The purpose of this report is to provide a preliminary analysis of the economic impact of the Future Submarines build based on the experience of the Collins Program for South Australian and national economy.

The findings contained in this report are subject to unavoidable statistical variation. While all care has been taken to ensure that the statistical variation is kept to a minimum, care should be used whenever using this information. This report only takes into account information available to Macroeconomics up to the date of this report and so its findings may be affected by new information and also rely on inputs provided by the DMO.

Modelling Strategy

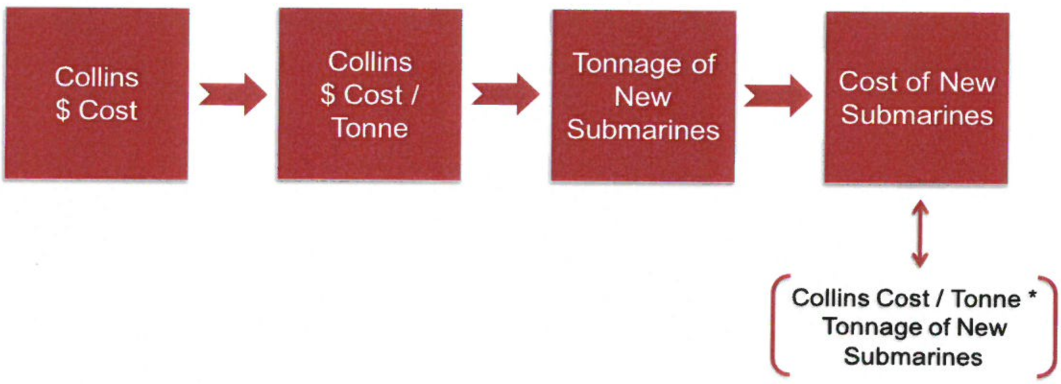
Overall costs

Modelling the economic impacts of a major public infrastructure project likes Future Submarines begins by determining the expected overall or aggregate cost involved. This can be approached by drawing on a combination of past experience - in this case, the cost of the Collins submarines - and any available information on the unique features a Future Submarine might display.

The aggregate costs of the Collins submarines are well defined and on the public record. Although a good deal of care is required to ensure that all aspects of the submarines' manufacture are taken into account - including initial design, the buildings, structures, plant and machinery used in their construction and the effort devoted to bringing the vessels from dockyard completion to operational readiness - sufficient data is available to derive a reliable cost figure.

Estimating the overall cost of a Future Submarine is, at this early stage, substantially more difficult. The best that can be achieved is a rudimentary indicator, calculated in three steps: establishing the cost per tonne of the Collins submarines, applying this figure to engineering estimates of the likely weight of the Future Submarines built-up from an individual component level, and then adjusting the resultant figure - to the extent that available data permits - for whatever special characteristics a Future Submarine might include. Figure 1 below illustrates the process involved.

Figure 1 - Costing a Future Submarine Build Using Historical Collins data



Using this kind of extrapolation, two options for a Future Submarine build in Australia can be explored. The first is an Evolved Design aimed primarily to extending the length - but not the width - of the existing Collins class vessels to accommodate addition capabilities, while leaving the overall structure of the vessels essentially the same. The second is a New Design aimed at creating a submarine from 'first principles', with a structure potentially quite different to that of a Collins approach.

Because the cost of the Collins submarine program has traditionally been expressed in constant June 1986 dollars, cost estimates for the Future Submarines - which will be built nearly 40 years later - must be adjusted for inflation. The adjustment process produces a slightly lower cost estimate than the $40 billion quoted widely in the popular press during 2013 and 2014, but not substantially so.

Cost breakdowns

The next step in the process of modelling economic impact is to determine how the costs of a submarine are distributed over time, between the different components and systems which make up the vessels, and the geographic locations in which associated work takes place.

Dividing the data

For the Collins submarines, the way costs were distributed was ascertained from extensive financial records held within the Department of Defence. From this, it was possible to map how the costs of the submarines were distributed through different areas and levels of the Australian economy.

These records detailed the value and timing of Departmental expenditure on the Collins submarines to a highly disaggregated level of goods and services. They identified with less precision, but still with reasonable clarity, whether these inputs were drawn from Australian or overseas sources. This was done primarily on the basis of the different currencies in which individual financial transactions were specified - with appropriate adjustments for the fact that, in a small number of cases, the currency used for contract purposes differed from the country in which work on the submarines actually took place.

The records also revealed in some detail where within Australia work occurred, after adjusting for the fact that the location of a company's headquarters receiving payment for its involvement with the Collins submarines may not necessarily have accorded with the location of company production facilities.

The distribution over time of the Collins cost data was influenced by the fact that the contract for construction of the submarines was to a certain degree 'front-loaded'. This applied even after allowing for a practice, common among many large infrastructure projects, for a substantial proportion of material inputs to be purchased early to take advantage of bulk discounts and to avoid the risk of delays during the later stages of production.

Economic impact modelling is based on the levels and timing of 'work effort' rather 'financial flows'. Consequently, the periodic distribution of the Collins cost data was adjusted to reflect the timing of actual effort expended. This was done using two sources of input: independently verified data on the spread of industry employee numbers for the bulk of submarine construction, and a separate assessment of the technical nature and consequent effort associated with each major engineering phase of the construction process.

Critical assumptions

In the absence of detailed cost breakdowns for the Future Submarines, these Colllins data were used to illustrate what might occur if the new vessels were constructed in a similar manner.

This approach rested on a number of highly simplifying but, at this stage, unavoidable assumptions. The most important of these were similarity between the Collins and Future submarines in relation to final platform and combat systems structure, build method, build location, industrial productivity, construction 'learning curve', Australian content and supporting infrastructure. On balance, these assumptions are likely to overstate rather underestimate the economic impacts of any new submarine venture.

Although the Collins experience might be regarded as somewhat unique in terms of the unusually high level of additional effort required to bring the combat system to fruition, no separate downward cost adjustments for this factor were made for the Future Submarine cost figures. The rationale for no adjustment is that any new submarine program is likely to encounter unforeseen challenges - if not with the combat system, then with other program activities. For modelling purposes, a carry-over of full combat system costs from a Collins to a New Submarine environment might therefore be considered a prudent form of cost contingency.

Modelling methods

With the aggregate costs of both the Collins and Future Submarines estimated and the distribution of these costs within Australia identified, modelling then progressed to linking the submarine data to a model of the Australian economy. This occurred in three phases.

Key links

The first phase assigned individual costs to the Input-Output (I-O) product categories or codes on which models of economic impact are structured. The second established the time periods over which modelling would occur and the different scenarios for the production of Future Submarines for which economic impact would be estimated including six vessel and 12 vessel possible build options. The third calibrated the model of the Australian economy to not only reflect the nature of submarine construction and maintenance but the country's longer term economic outlook using the most recent Commonwealth Treasury and Productivity Commission scenarios.

In undertaking these tasks, the construction of the submarines was divided into three phases - design, build and testing - given that each phase had distinct economic features. In addition, construction of the platform was divided from the production of the combat system given that these two aspects of the submarine build also differed markedly in their economic characteristics.

Time frames

In the case of the Collins submarines, the decision was made to evaluate impacts commencing in 2014-15 - rather than 1986-87 when work actually commenced. This was done for a number of reasons: the high costs of 'winding-back' the baseline model of the Australian economy as far back as the 1980s; the fact that the objective of current economic modelling is to illustrate what submarine construction in general might do rather than present an economic history of the Collins program; and, the desirability of comparing the impact of Collins against the impact of a Future Submarine using not only the same economic model but a similar time frame.

To achieve the latter and for purely illustrative purposes, the construction of the Future Submarines was first modeled with a notional starting point of 2014-15.

Model and scenario selection

To derive a set of economic impact figures, a computable general equilibrium (CGE) model of the Australian economy was used in the form of the Victoria Multi-Regional Forecasting (VUMRF) model. In essence, CGE models consider not only the economic impacts investment in a 'project' might have as it 'trickles' from one level of the economy to another but how the project impacts other types of economic activity through its effects on the prices and availability of various inputs to production. A project might not deliver the impacts which one might intuitively associate with its 'trickle down' effects, if it prevents resources - like skilled labour - from moving to other areas of the economy where they might be used more productively.

Also, recognising that the construction of submarines in Australia might not be a wholly discretionary decision, initial modelling was conducted on three different cost bases: including the entire cost of the Program; the price premium Government might pay for preferring a domestic over foreign sources of supply; and, the cost difference between building six Future Submarines and building 12 of these vessels in Australia, keeping in mind that relatively high fixed costs for submarine construction mean that smaller builds are more expensive on a per unit basis. The first of these scenarios provided the focal point for analysis.

Amongst other things, the VUMRF model was selected over competing economic models because it offered both a detailed view of South Australia and a structure best suited to the longer term evolution of the Australian economy against which Future Submarine impacts should ideally be measured. Submarine cost data used as input for the model was provided by the Defence Materiel Organisation (DMO) and the model was applied by Professor Phillip Adams of Victoria University.

Construction vs. maintenance

In the case of the Collins submarines, VUMRF results focus on submarine construction despite this normally accounting for only a small proportion of the total cost of a submarine over its operating life. For the Future Submarines, the economic impacts of both construction and sustainment are considered fully, but separately, to fully differentiate between the two.

The reason for this is that, irrespective of whether Australia's submarines are built in Australia or overseas, the vessels need to be sustained in-country. The size of the sustainment effort will vary with the number of vessels being purchased. That number has already been determined for Collins. But it has not yet been established for Future Submarines. Consequently, the economic impact issue of greatest interest from a sustainment perspective is how many extra jobs will be generated from a 'smaller' purchase - of perhaps six Future Submarines - compared to an expanded strategy covering eight or 12 vessels.

Employment

The economic impacts of submarine programs covered by VUMRF have two main dimensions. One is the effect on the value or size of economic activity measured in dollar terms. The other is the effect on employment. Given that almost all of the attention given publicly to economic issues relating to submarine construction in Australia relate to job opportunities, the employment issue is at the centre of this report.

Employment impact has a number of dimensions: impact over time, impact by occupational group, impact by geographic region and what might be broadly described as impact by position along the industry supply chain. The latter can be measured directly in terms of the number of people employed by companies with contractual links to Defence. It can be gauged indirectly in terms of the jobs created within sub-contractors and component/material/consumables suppliers to these companies as well as the jobs created by employees in all firms along the submarine supply chain through their expenditure on general goods and services.

Indirect effects are measured using employment 'multipliers'. This report presents two different set of multiplier figures: one based on general equilibrium modelling which takes into account both trickle down as well as resource displacement effects, and the other 'partial equilibrium' modelling which takes into account trickle down effects only. A general equilibrium approach tends to yield smaller but conceptually more robust figures and is therefore preferred. But partial equilibrium figures are used widely and are therefore provided in the report for comparative purposes.

Spillovers

The VUMRF model does not directly cover one aspect of potential employment impact which has captured the imaginations of some public commentators but thus far proven unusually difficult to quantify, namely technology and human capital 'spillovers'. Consequently, the report models these impacts indirectly as productivity shocks using sensitivity analysis.

Conceptually, spillovers are economic benefits which a project like submarine construction might generate but for which their owner or originator receives no compensation. In the context of economic impact modelling, they can be regarded as some type of productivity benefit which models based on the measureable value of goods and services - like VUMRF - are able to capture indirectly.

For example, a spillover might have been a new technology developed or paid for by Government to equip the Collins submarines which then became available for use by commercial companies - but for which the Government never received royalties. Alternatively, a spillover might have taken the form of company-sponsored training undertaken by an employee of the builder of these submarines, the added skills from which were then used by that employee after he or she moved to another firm to develop a new product or service or better manage a large defence or commercial project - from which neither the submarine builder nor the original employee were compensated.

Rates of Assistance

Nor can VUMRF generate a measure used widely to compare how much Government assistance is received by each sector of the economy relative to others, namely the Effective Rate of Assistance (ERA).

Put simply and in a submarine context, ERA measures the value of the price premium Defence might pay for sourcing submarines from Australia rather than overseas, expressed as a proportion of value of the economic activity it seeks to assist or 'protect'.

To allow price premiums for submarine construction to be compared against premiums for other defence or non-defence projects, the ERA expresses price premiums (if any) for a Future Submarine as a proportion of the submarines' value-added - where value-added equates broadly to the sales price of the submarine, less the price of the material inputs used in their production.

However, the rate of assistance this formula generates is then discounted for the fact that while Government might assist the constructor of a submarine via a price premium, it may simultaneously disadvantage the same company by placing tariffs or other trade imposts on the inputs it sources from overseas. Adjusting for these disadvantages delivers an 'effective' assistance measure.

All ERA calculation rests on the assumption that for every good produced in Australia there is a functionally equivalent good available from overseas. For submarines, this assumption may not hold - or at least not in its strictest sense. It is difficult to deny the possibility that any submarine built overseas may not be able to perform exactly the same way as a submarine built in-country. Consequently, ERA estimates are prepared in this report purely as an ancillary or secondary matter given the complexity of the calculations involved.

Nonetheless, it can be argued that the concept of functional equivalence demands only that Australia be willing to accept an overseas built submarine to meet its (minimum) needs rather than the more stringent requirement that an overseas submarine be able to do everything a domestically produced vessel could. If so, an ERA calculation may still have some value.

The overseas vessel chosen to provide the international price benchmark for ERA estimates in this report is [redacted] which was selected primarily because it is the only overseas build option for which Defence currently has reliable cost data. Unfortunately, dependable costing figures for other overseas supply options - including submarines from [redacted] might be considered closer competitors - are not yet available. As additional data emerges, a broader range of ERA figures can be prepared.

The Costs of Constructing Collins

Building the Collins class submarines commenced in 1987 and finished by 2004 by which time six vessels had been delivered and the Collins Program entered its sustainment phase. The overall build process commenced with initial design work - much of which was conducted overseas - before progressing to the mainly domestic tasks of constructing docks and other support facilities, fabricating hull sections, developing complex combat and sensor equipment, bringing together other major inputs such as the propulsion unit and armaments, integrating the myriad of systems on-board, fitting out the vessels in their final form and then preparing them for operational use through an extensive series of tests and evaluations.

The submarines currently in service are a product of an initial build phase, rectification work to deliver the vessels to their originally required specification and a series of separate investments subsequently made by Government to enhance planned performance and bring the vessels to their current capability levels. These three core tasks have been managed by Defence through five separate procurement projects - some with multiple phases - to make up the Collins submarine program.

From a cost break-down perspective, five features of the Collins program stand out: the costs of the initial build far outweighed the cost of subsequent rectification and enhancement work; two constituent parts to the submarines dominated the vessels' overall costs, namely the hull and the combat system - which absorbed Defence expenditure in roughly equal proportions; constructing the submarines was labour intensive, with the majority of labour costs being associated with 'white collar' rather than 'blue collar' skills; the majority of overall costs, including those relating to white collar labour, were fixed rather than variable - meaning that most were incurred irrespective of how many submarines were ultimately built; and, it was not until the 3rd vessel was completed that the unit costs of the submarines were minimised.

Reflecting these points, the submarines had a high level of Australian content. While certain critical inputs - such as design expertise, propulsion units, weapons and eventually most of the combat system - were imported, the majority of remaining labour and material inputs were sourced from or through Australian-based providers. A high labour content was driven in part by submarine construction not lending itself to the kinds of automated approaches to production characteristic of consumer goods manufacture. Indeed, even in an industry as specialised as defence capital equipment and even naval ships, submarines stood out as a bespoke product.

However, despite a high domestic content and the fact that construction of the submarines drew on an extended in-country supply chain consisting of hundreds of individual firms, much of the work conducted on the vessels within Australia was concentrated in just a few companies and conducted at a small number of geographic locations.

Fully half of the work undertaken on the submarines in Australia is estimated to have been retained by the prime-contractor, the Australian Submarine Corporation (ASC). And the largest 10 Australian-based suppliers to the Collins program absorbed, and were seemingly able to retain, nearly 90 percent of all domestic program expenditure. South Australia and New South Wales attracted nearly 90 percent of all in-country industry activity.

Tables 1-5 and Chart 1 below profile the Collins program cost structure.

Table 1 Collins Program Costs – By Major Procurement Project
(1986 Prices)

Element 1986 Prices and Exchange Rates	$m	$m	Years
SEA 1114 - ASC Build Contract	$3,526		1987 – 2003+
- DMO Infrastructure & Facilities	$331		1987 – 2003
Sub total		$3,857	
SEA 1420 Ph 1 - SATCOM	$23		1997 – 2009+
SEA 1429 Ph 1 - Heavyweight Torpedo Studies	$3		1998 – 2005
SEA 1429 Ph 2 - New Heavyweight Torpedo	$284		2003 – 2017
SEA 1439 Ph 1A - Enhancement Studies	$ <1		1999 – 2004
SEA 1446 Ph 1 - Intermediate Operating Capability	$127		2000 – 2015
SEA 1439 Ph 2A - Combat System Augmentation	$4		2001 – 2005
SEA 1439 Ph 3 - Reliability and Sustainment	$198		2001 – 2020
SEA 1439 Ph 4A - Replacement Combat System	$258		2003 – 2016
SEA 1439 Ph 4B - Weapons and Sensor Enhancements	$24		2003 – 2010
Sub total		$921	
Combat System Additional Effort (Cost to Rockwell / CSA)		$131	1987 – 1995
Total Program Outlays		**$4,908**	

Table 2 Collins Program Costs - Fixed & Variable Cost by Major Inputs to Build
(1986 Prices)

TSC	Total Cost $m	Non-Recurring Cost $m	% of Total	Recurring Cost $m	% of Total
Hull	$1,128	$1,042	30	$86	2
Propulsion	$218	$27	1	$191	5
Electrical	$61	$24	1	$37	1
Command & Control	$1,115	$895	25	$220	6
Auxiliary Systems	$268	$130	4	$138	4
Outfitting & Furnishing	$317	$3	0	$314	9
Armament	$174	$44	1	$130	4
Integration / Engineering	$245	$235	7	$10	0
Grand Total	**$3,526**	**$2,400**	**68**	**$1,126**	**32**

Note: * Project overheads allocated across TSC Codes.

Table 3 Collins Program Costs - Build and Combat System
(1986 Prices)

Supplier Category	$m	$m	% of Total
Ship Builder – White Collar	$906		26
Ship Builder – Blue Collar	$430		12
Sub-contractors	$963		27
Ship Build – Total		**$2,299**	65
Combat System – Software	$738		21
Combat System – Hardware	$293		8
Combat System – Total		**$1,031**	29
Platform Designer (Kockums)		**$196**	6
Grand Total		**$3,526**	100

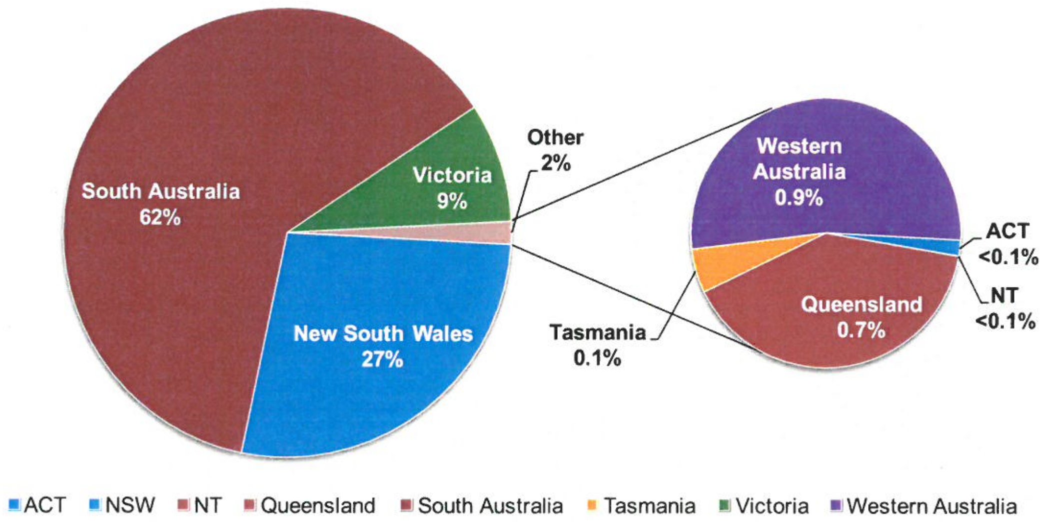
Table 4 Collins Program Costs - Australian Industry Content (AIC) by Project Element
(1986 Prices)

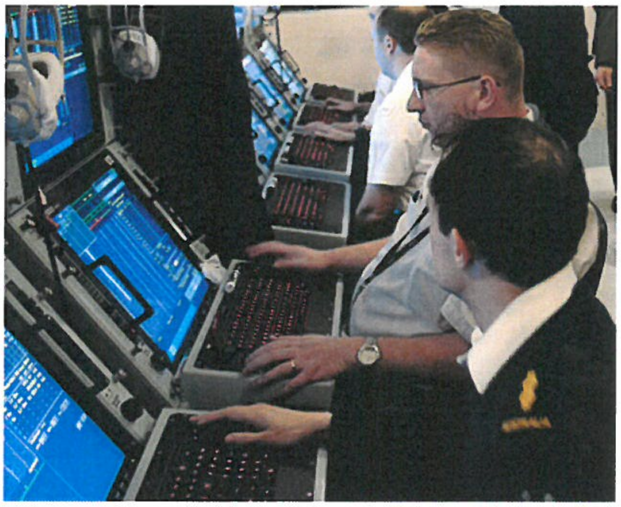
Element	Total	AIC	AIC
	$m	$m	%
Build Contract	$3,526	$2,384	68%
Rectification and Enhancement Projects	$920	$574	62%
DMO Infrastructure & Facilities	$331	$189	57%
Combat System Additional Effort	$131	$131	100%
Total Program Outlay	**$4,908**	**$3,278**	**68%**

Table 5 Collins Program Costs - Top 10 Australian-Based Suppliers
(1986 Prices)

Supplier Group	AIC $m	AIC %	Accumulated %	Location
ASC	$1,273	53	53	SA / NSW / VIC
Rockwell	$324	14	67	NSW / VIC
Wormald	$162	7	74	NSW / SA
ADI	$99	4	78	NSW / VIC / SA
Computer Sciences of Australia	$58	2	80	NSW
Kockums	$48	2	82	NSW / SA
AWA Defence Industries	$45	2	84	SA
Westinghouse Electric Australasia	$43	2	86	NSW
Scientific Management Associates	$36	2	88	VIC
British Aerospace Australia	$34	1	89	NSW / SA / VIC
Other	$262	11	100	Various
Total	**$2,384**	**100**	**100**	

Figure 2 Collins Program Costs – By State and Territory
(1986 Prices)





The Costs of the Future Submarines

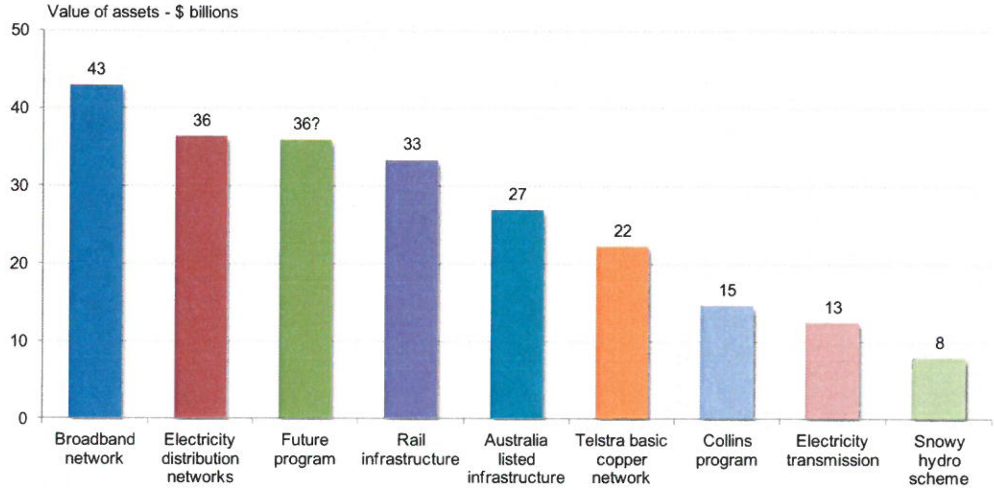
Available engineering data suggests that the (submerged) weight of the Evolved Collins will be approximately 3,500 tonnes, and 4,000 tonnes for the New Design. From this, both options under the Future Submarines program will be heavier than the 3,350 tonne Collins vessels. Applying a cost per tonne figure for the Collins submarines to the tonnage figures for the Future Submarines indicates that an Evolved Collins built in Australia will be 15 percent more expensive than the cost of building the original Collins submarines. The corresponding figure for the New Design is 30 percent - keeping in mind that although they may come at a higher cost, the Future Submarines should provide a superior military capability. Table 6 below sets out the relevant data.

Table 6 Comparative Cost Per Submarine - Excluding Enhancements (2013 prices)

	Collins	Evolved Collins	New Design
	$m	$m	$m
Build	$1,827	$1,911	$2,179
Defence Funded Activities	$212	$222	$253
Rectification	$204	$417	$475
Total Program Outlay	**$2,243**	**$2,550**	**$2,908**

At a total cost of approximately $35 billion in its more expansive form, the build aspect of the Future Submarine program ranks as one of Australia's largest infrastructure developments. Figure 4 below compares the build against recent or expected public infrastructure investment projects in the areas of telecommunications, power and transport as well as the build element of the Collins program - based on the original six submarine strategy.

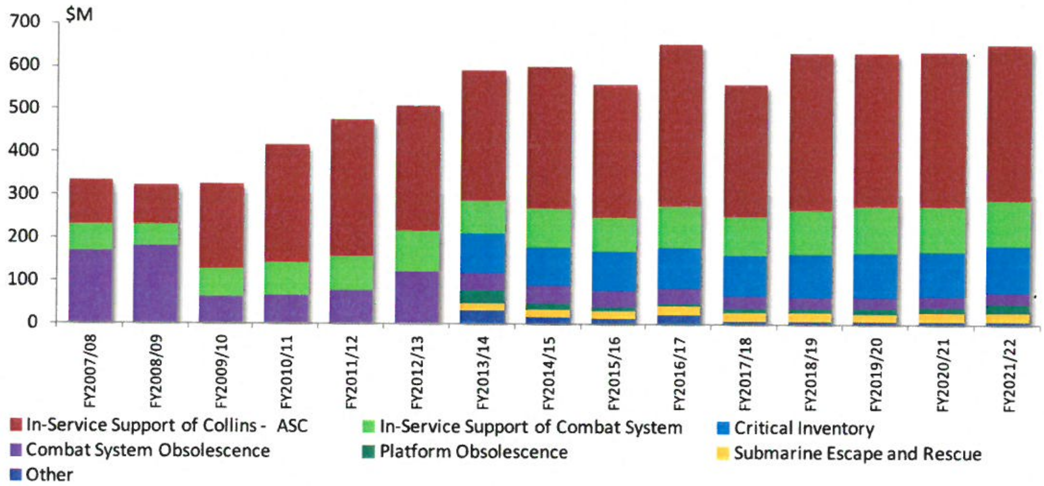
Figure 3 Cost Comparison of National Infrastructure Projects - Build Costs for 6 Collins and 12 Future Submarines (2013 prices)



Source: SMART Infrastructure Centre 2012 & **Macroeconomics**.
Note: National Broadband Network figures relate the original plan for the network.

Relative to the original build costs, the costs of sustaining a Future Submarine are expected to be similar to those for the Collins program in its mature form. Taking into account platform obsolescence and the availability of critical inventory, the Collins experience suggests that the costs of sustaining a Future Submarine over its entire life may be twice that of a submarine build. That is, of the overall cost of the submarines, one third is likely to pertain to their acquisition and the remaining two thirds to sustainment. The relevant Collins sustainment figures are set out in Figure 4 below.

Figure 4 Collins Submarines - Sustainment Outlays Actual* and Estimates (2013 prices)



Note: *Some sustainment funding was reallocated to projects in the mid 2000s and so this chart likely understates the initial maintenance budget.

Each Collins submarine took an average of 6.2 million man hours to construct, after the material and component inputs for the vessels had been supplied. The corresponding figures for the Evolved Collins are 6.5 million man hours and for a New Design 7.4 million man hours. The majority of labour inputs - and therefore total submarine costs - are expected to remain fixed or non-recurring due to the heavy white collar element associated with planning by the shipbuilder and the effort required to design software for the submarine combat system. Table 7 below details the breakdown in labour effort associated with the Collins build, from which man hour figures were derived for the Future Submarines.

Table 7 Estimated Labour Effort by Key Input - Collins Submarines

Supplier Group	Non-recurring	Recurring	Total	Recurring per Sub
ASC - White	9.6	0.0	9.6	0.0
ASC - Blue	1.2	6.7	8.0	1.1
CS - Hardware	0.9	0.9	1.1	0.2
CS - Software	6.1	0.1	3.0	0.0
Platform Designer	1.0	0.0	1.0	0.0
Sub - contractor	3.6	7.2	15.1	1.2
Totals (million hours)	**22.2**	**15.0**	**37.2**	**2.5**

Economic Impacts

What follows is an assessment *primarily* of the economic impacts of the Collins build program modelling scenario assuming a 2014-15 start date. It reveals that:

- a build program should achieve respectable (if not significant) output and employment gains for a small number of regional centres, especially in Adelaide, but also in Sydney and scattered across Victoria, but that the overall national economic gains will most likely be smaller due to crowding-out effects;
- a build program should achieve downstream 'multiplier' impacts within South Australia that are comparable to other large construction projects and these impacts are also likely to be higher than those associated with equivalent dollars spent on social services;
- a build program is unlikely to experience significant labour skills shortages, except perhaps in a small number of occupations;
- a build program is unlikely to attract significant positive technology spillover impacts;
- a local build program is likely to represent a small overall burden to the domestic economy relative to the cost of building overseas;
- alternate domestic build options are likely to achieve roughly the same employment outcomes in total and across industries based on the same initial spend; and
- sustainment costs are more driven by fleet size then design selection.

Macroeconomic Impacts

The key state and national macroeconomic impacts of the Collins build program scenario are provided in Table 8, assuming a 2014-15 commencement and completion within 16 years.[1] At the national level, the Collins build program, despite being a large infrastructure project, has a relatively modest impact. On average, each year, spending on submarine construction is $943 million, with direct employment of 1023 Full Time Equivalent (FTE) jobs. From this, annually only $65 million is added to real Gross Domestic Product (GDP) and 733 FTE jobs are added to national employment. These estimates are less than one hundredth of one percent of annual GDP and national employment.

[1] The effects of the submarine construction are calculated as the differences between two projections for the economy. One projection is the base case, in which there is no submarine construction. The second projection deviates from the base case in response to a Collins-build. For credibility purposes, included in the base case is everything that is known about Australia's economic future, including announced changes in government policies and confirmed investments in large projects. Also included are the effects of industry closures, including the shutdown of motor vehicle manufacturing in South Australia and Victoria.

Table 8: Key Indicators of Collins 6 Ship Impact (impacts in an average year)

	South Australia		National	
	$mil#	% of base case*	$mil#	% of base case*
Real GSP/GDP	368	0.42	65	0.01
	FTE	% of base case*	FTE	% of base case*
Employment (FTE)	1,794	0.18	733	0.01

Source: VUMRF modelling.
Note: # $ million in constant prices of 2013. * % deviations away from values in the base case in an average year of the build.

The national economic impact of building the submarines is small because the expansion in activity associated with the submarine construction *crowds out* activity elsewhere in the economy. There are two main mechanisms via which crowding out occurs.

1. The cost of the vessels must ultimately be paid for by Government through increased taxes or reductions in its own expenditure in relation to other priorities like education or health spending. Both these actions reduce economic activity.
2. The project is likely to increase the demand for certain types of labour employed in building submarines, placing upward pressure on wages - not only in the naval construction industry but other industries in which similar skills are required. Wage pressures eventually erode the competitiveness of Australian industry more broadly, in both domestic and export markets.

At the state level, for South Australia, on average, each year, spending on construction is $369 million and direct employment is 733 FTE jobs. This injection of activity ultimately raises real Gross State Product (GSP) by $368 million each year (around 0.4 per cent, or close to one half of one per cent, of the state's GSP), and increases total state employment by 1,794 FTE persons each year (around 0.18 per cent, or almost one fifth of one percent, of the state's employment). Note that the average percentage change in employment is around half that of real GSP, indicating that more than half of the GSP gain comes from factors other than employment. One factor is increased capital directly associated with ship building. Much of this capital currently exists, but in the future would be idle if it were not for a new program of submarine construction. The other factor is productivity improvement. Submarine construction stimulates the production of business and financial services and equipment industries with high expected productivity growth.[2]

Given that about half of total spending associated with the Collins build scenario occurs in South Australia, it is not surprising that South Australia stands to gain most from the submarine

[2] In the base case projection these industries experience rates of technological progress that exceed the economy-wide average. Shifting the composition of the economy towards industries with relatively fast productivity growth, all else unchanged, increases the average productivity performance of the economy as a whole.

program. However, this comes at the cost of overall reductions in output and employment in the rest of Australia.

Direct & Indirect Employment Impacts

To obtain some idea of the relative size of the total upstream and downstream impacts of direct program spending on regional economies we need to calculate 'multipliers'. For example, the total employment multiplier (2A) compares the total of all jobs created under the program to the jobs directly created in the shipbuilding industry for the Collins build program for given region [3]. The multiplier calculation is presented in Table 9 for the Collins build in South Australia. It shows that on average for every 763 jobs created directly, a further 1,031 jobs are generated indirectly - to give a total of 1,794 jobs. This implies an average employment multiplier of 2.4 (=1,794/763). In other words, for every direct job created via the Collins build program in South Australia, almost another 1 $^{1}/_{2}$ jobs will be created somewhere else in the state, on average.

Spending on submarine construction is also likely to be uneven over time in terms of its composition (materials, wages, subcontractors etc.) and so employment multipliers may vary throughout the build cycle. Table 9 illustrates that in the peak year, total direct employment is 2,061 jobs, with a similar level of indirect employment, implying a multiplier of 2.0. In the low activity year, total direct employment is 114 jobs, while indirect employment is 373 jobs which implies a relatively high multiplier of 3.3.

Table 9 also provides an estimate for South Australia of the employment multiplier associated with a comparable industry, namely motor vehicle manufacturing. In a typical year, car manufacturing is estimated to have a multiplier of around 2.5, comparable with that estimated for submarine construction. Therefore, the Collins build appears to have a similar employment multiplier to the car manufacturing industry in South Australia.

---

[3] The ratio of total employment creation compared to the direct employment created in the shipbuilding industry for the Collins build program scenario for a given region yields a 'CGE version' of the Total Employment Multiplier (2A) calculated in input-output (I-O) studies. Theoretically this ratio should be lower than a comparable I-O estimate as the VUMRF submarine model accounts for the full range of economic behaviour – notably the crowding out effects noted above. An alternative multiplier measure 2B deducts the direct impact from the total impact and so lowers the multiplier' ratio. Experts in I-O analysis believe this artificially reduces the headline figure and so adds nothing to the calculation.

Table 9: Direct and Indirect Employment in South Australia Including implied CGE Multipliers for South Australia and Nationally (impacts in average, peak and low years, FTE)

South Australia	Average	Peak	Low
ASC	694	1,076	79
Other	39	985	35
Total Direct	733	2,061	114
Indirect	1,031	2,063	260
Total	**1,794**	**4,124**	**373**
Implied CGE Total Multiplier (2A)	2.4	2.0	3.3
Implied CGE Multiplier – Motor Vehicle Manufacturing#	2.5	Not applicable	Not applicable

Source: VUMRF modelling. **Note:** # Generated from a VUMRF simulation in which (hypothetically) final demand for Motor vehicle production in South Australia is increased by one per cent.

Alternative estimates of the total employment ratio (2A) are reported in Table 10 based on the standard I-O techniques applied to the VUMRF database for the South Australian and national regions, for submarine construction and sustainment, and a range of other industries included for purposes of comparison.

- The I-O multipliers associated with the Collins build are higher at 3.1 than the CGE estimate of 2.4 for South Australia, and the national I-O estimate for the Collins build program is 2.9. One publicly available study on naval shipbuilding from ACIL Allen Consulting (2013) estimates a 2A employment multiplier across all regions of Australia at 2.0. This does suggest that submarines may have a higher multiplier than surface vessels. However, comparison between models is not recommended.
- For the motor vehicle manufacturing industry, the comparable I-O multiplier is 2.9 for South Australia, which suggests slightly lower multipliers from car manufacturing compared to submarine construction. The national I-O multipliers for car manufacturing is 2.6 .
- The I-O multipliers associated with the Collins build are higher than for most of the 'comparable' industries included in Table 10, except for Steel production. They are certainly much higher than those associated with social services like spending on education and health.

Table 10: Alternative I-O Estimates of the Total Employment Multipliers (2A) for South Australia and Nationally

Current Study	Region	I-O Multiplier
Collins build	South Australia	3.1
	National	2.9
Collins sustainment	South Australia	3.1
	National	2.7
Motor vehicle manufacturing	South Australia	2.9
	National	2.6
Sheep cattle	South Australia	2.9
	National	2.5
Iron ore	South Australia	3.0
	National	2.6
Textiles Clothing and Footwear	South Australia	2.6
	National	2.5
Steel	South Australia	4.4
	National	2.8
Road freight	South Australia	2.7
	National	2.7
Education	South Australia	1.8
	National	2.3
Health	South Australia	1.8
	National	2.2
Other Studies		
ACIL Allen Consulting 2013	National	2.0

State and Regional Employment Impacts

In terms of sub-state employment impacts, the location of most additional activity in South Australia is Adelaide, which is broken down by key local government areas in Table 11. Most submarine related employment, or around 1,463 FTE, each year, on average, is likely to be located at Port Adelaide Enfield, an area which extends from Dry Creek in the north to Devon Park in the south and from Windsor Gardens in the east to Semaphore in the west.

Similarly for the key build state, New South Wales, most of the additional activity occurs near or around Sydney (within 25km) at either Ryde (113 FTE, per year, on average), or Warringah (114 FTE). The exception to this is in Victoria where the additional employment is shared equally between Greater Bendigo (141 FTE, per year, on average), which is 150km from Melbourne, and the Yarra Ranges (79 FTE) (especially Lilydale and Chirnside Park), which is an outer eastern suburb, around 40km from Melbourne.

Table 11 shows clearly the impacts of crowding out on the regional economies. South Australia gains employment, and those gains are shared across most regions in that state. However, the other key states (New South Wales and Victoria) in general lose employment because they are under-represented in industries that experience production and employment gains, and over - represented in industries whose production and employment are crowded out. As a result, Adelaide gains around 1,568 FTE jobs on average each year, but Sydney and Melbourne each lose over 600 FTE jobs.

Table 11: Key State and Regional Employment Outcomes (annual average)

States and Regions	FTE	Share of Region Employment
South Australia Total	**1,794**	**0.2**
Key Local Government Areas Adelaide		
Playford	74	0.3
Port Adelaide Enfield	1,463	2.6
Salisbury	31	0.1
Rest of South Australia	227	0.0
New South Wales Total	**-590**	**-0.0**
Key Local Government Areas of Sydney		
Ryde	113	0.2
Warringah	113	0.2
Sydney	-641	-0.2
Rest of New South Wales	-176	-0.0
Victoria Total	**-781**	**-0.0**
Key Local Government Areas of Victoria		
Greater Bendigo	141	0.4
Yarra Ranges	76	0.2
Rest of Victoria	-998	-0.0
Rest of Australia	**310**	**0.0**

Source: VUMRF modelling and Australian Bureau of Statistics special request.

Table 12 compares total employment created under the Collins build scenario in South Australia, on average, in the key Adelaide sub regions identified previously, to existing employment levels in those regions across key benchmark industries, based on Census 2011 data. Those benchmark industries include shipbuilding (both defence and non-defence), motor vehicle manufacturing, total manufacturing, mining and total employment.[4] Based on these data no single region is reliant on employment from submarine construction in terms of total employment share. For example, the most submarine build 'dependent' region is Port Adelaide Enfield where the submarine program represents less than 3 per cent of total employment. Nor will submarine building replace all the jobs being lost in declining industries due to structural change. For example, in the Playford region, the Collins scenario predicts there will be 74 jobs created, on average. Currently there are 777 FTE jobs in the car manufacturing industry in this region.

[4] The shipbuilding industry is defined as constructing vessels of 50 tonnes or more. The car manufacturing industry includes only vehicle manufacturers, not car part manufacturers nor suppliers, nor firms undertaking any ancillary activities such as repairs.

Table 12: South Australia Employment Outcomes (annual average) compared to industry benchmarks by Key Region

States and Regions	Submarines	Regional Employ. Share	Ship* build	Motor#	Total Manuf.	Mining	Total
	FTE	%	No.	No.	No.	No.	No.
South Australia Total	**1,794**	***0.2***	**1,652**	**3,119**	**73,119**	**9,647**	**719,224**
Key Local Government Areas Adelaide							
Playford	74	*0.3*	87	777	4,369	187	21,645
Port Adelaide Enfield	1,463	*2.6*	369	219	5,773	307	55,932
Salisbury	31	*0.1*	177	813	8,000	298	40,396
Rest of South Australia	227	*0.0*	1,019	1,310	54,977	8,855	601,251

Source: VUMRF modelling and Australian Bureau of Statistics special request.

Note: *The ship building industry includes all employment (defence and non-defence) in construction of vessels greater than 50 tonnes in South Australia at Census 2011. #Motor vehicle total includes only car manufacturing and not car parts manufacturing and/or other related employment.

Occupational Impacts

One key issue regarding the Future submarine build is whether there will be enough skilled labour available to underpin each of the design, construction and testing phase. Table 13 seeks to establish whether the Collins build would encounter occupational bottlenecks if it commenced in 2014-15. Table 13 attempts to provide a way to gauge potential skill shortages by looking across the different skills categories involved in submarine construction using three broad indicators: what proportion of the total skills available for shipbuilding as a whole would be absorbed by building a Collins submarine (**Column 4**), if the submarine was to be built now; what proportion of the national skills base (for all industries) would be absorbed by building a Collins submarine (**Column 7**), if the submarine was to be built now; and, whether the skills a submarine build is likely to rely on may be in high demand at a national level up to 2020-21 (**Column 9**). Based on this, skills shortages relevant to submarines are more likely when submarines are likely to absorb a high proportion of the overall shipbuilding and broader skills currently available. Shortages would also be more likely if the future demand for the skills for building a submarine were likely to be high.

Certain White Collar skills (Senior Managers, Naval Architects and Combat System Integrators) and certain Blue Collar skills (especially Sheet Metal Works, Mechanical Fitters and Painters and perhaps Hull Welders and Electricians) are expected to be in short supply when peak demand is reached for each of these occupations. This is true if only the existing labour market in the national shipbuilding sector (including defence and non-defence elements) is considered as a pool for recruitment (see Column 4, Table 13). This may be an accurate depiction of the situation of many While Collar skills where shipbuilding skills and experience may provide the closest match to the skills required for submarine building and hence a source of potential supply. This is definitely true for White Collar technical subject experts, but not necessarily true for generalist roles required to support any Future submarine build. For example, it is commonplace for high quality senior managers in the private sector to transfer between industries whilst still maintaining a level of performance that is heavily remunerated.

Table 13: Occupational Peak Demand Forecast For Six Ship Collins Build Scenario Compared to the Stock of Employed Persons in Shipbuilding and National Employment

	1.	2.	National Ships		5.	National Total		8.	9.
	Occupation	Collins 6 Ships (Peak)	3. AUS	4. %	Indicator	6.AUS	7. %	Indicator	Projected growth %
White Collar Mix	Senior Management	74	88	84	Red	35,799	0.2	Green	1.6
White Collar Mix	Management	197	424	46	Green	347,348	0.1	Green	1.8
White Collar Mix	Engineers	124	496	25	Green	62,780	0.2	Green	0.7
White Collar Mix	Technicians	50	198	25	Green	39,572	0.1	Green	1.0
White Collar Mix	Draftsman	450	1,728	26	Green	271,991	0.2	Green	1.1
White Collar Mix	Naval Architect	101	110	92	Red	4,504	2.2	Green	0.9
White Collar Mix	Administration	256	499	51	Yellow	641,734	0.0	Green	1.9
White Collar Mix	Combat System Integration	175	181	97	Red	72,153	0.2	Green	0.4
White Collar Mix	Logistics, Facilities, Tests	35	370	9	Green	374,051	0.0	Green	1.0
White Collar Mix	**White Collar Total**		**4,094**			**1,849,932**			
Blue Collar Mix	Electricians	207	263	79	Yellow	111,502	0.2	Green	2.1
Blue Collar Mix	Boiler Makers	111	599	19	Green	41,306	0.3	Green	2.3
Blue Collar Mix	Mechanical Fitters	70	32	219	Red	4,965	1.4	Green	2.3
Blue Collar Mix	Pipe Fitters	131	320	41	Green	76,761	0.2	Green	2.0
Blue Collar Mix	Painters	123	89	138	Red	15,493	0.8	Green	1.6
Blue Collar Mix	Sheet Metal Workers	335	32	1047	Red	6,509	5.1	Green	1.9
Blue Collar Mix	Hull Welders	194	247	79	Yellow	22,975	0.8	Green	0.9
Blue Collar Mix	Ship Wright	26	207	13	Green	852	3.1	Green	0.7
Blue Collar Mix	Construction	39	256	15	Green	182,087	0.0	Green	1.4
Blue Collar Mix	Other	0	128	0	Green	2,692	0.0	Green	1.0
Blue Collar Mix	**Blue Collar Total**		**2,173**			**465,142**	**Average**		**1.4**
	Total		**6,267**			**2,315,074**			

Source: VUMRF modelling and Australian Bureau of Statistics special request.
Note: Collins employment figures are on an FTE basis. Other employment figures are as at 2011 Census.

There would be no anticipated skill shortages for the submarine build if employees with the required skills could be drawn from outside of shipbuilding and across the national labour force (see Column 7, Table 13). This measure is probably most applicable to Blue Collar skills. It can be argued that these skills are more readily transferable from non-submarine or non-ship activities to submarine activities. In all of the potential skill shortage areas identified at the industry level for Blue Collar trades, there is a significant national (non-shipbuilding) skills that could offset any future labour market bottleneck. This is also true for certain White Collar skills. An interesting case is Combat System Integration, where the overwhelming size of the national pool of information technology programming and hardware expertise is encouraging.

The final column of Table 13 gives projected average annual growth rates (%) in Australia-wide demand for the occupations identified in the first column. These numbers are consistent with the latest projections of occupational demand prepared by the Centre of Policy Studies, and span the eight years, 2013-14 to 2020-21.[5] The projections have been adjusted to include employment associated with a future program of submarine construction. Overall, average annual growth in employment demand between 2013-14 and 2020-21 is 1.4 per cent. When considered in combination with the industry level traffic light indicators in **Column 5** and **Column 8**, very few occupations important to a submarine build (Senior Managers, Mechanical Fitters, Painters and Sheet Metal Workers) are likely to experience excess demand over the forecast period).

Table 14 compares the current pool of ship building (defence and non-defence) employment in South Australia at Census 2011 by detailed occupations and in total, to other key benchmark industries (including motor vehicle manufacturing, manufacturing (total), mining and the total labour force). The table illustrates there is a significant pool of skilled workers in South Australia in related sectors that could be available in future to support a submarine build based on the critical assumption that people from naval and even commercial surface ship construction can readily transfer across to submarine construction. It also provides some perspective on the size of the shipbuilding industry compared to the car manufacturing. The prospect of a Future submarine build which we estimate may directly employee 1700 FTE, cannot fill the breach in other declining sectors.

---

[5] In the projections it is assumed that employment is demand determined, with supply of each occupation adjusting to match demand at the going real wage rate. This is a medium to long-run assumption, made in nearly all economic forecasts of the labour market.

Table 14: Skills Profile in Key Occupations for South Australian Shipbuilding Compared to Other Key Sectors based on Census 2011

Occupation (ANZSCO 2006)	Ships	Motor	Manufacturing	Mining	Total
Management	**169**	**174**	**5,466**	**343**	**23,899**
Production Manager (Manufacturing)	34	94	2,217	22	2,712
Engineering Manager	31	13	392	39	1,156
Quality Assurance Manager	27	35	439	5	982
Other	77	32	2418	277	19049
Engineers	**206**	**112**	**1,185**	**92**	**4,245**
Engineering Professionals	43	13	313	23	1,214
Mechanical Engineer	40	42	355	33	742
Other	123	57	517	36	2289
Naval Architect	53	0	56	0	83
Logistics, Facilities, Tests etc	**126**	**471**	**2,457**	**523**	**27,174**
Program or Project Administrator	31	12	360	63	5,058
Contract Administrator	28	6	120	49	1,211
Store person	37	100	1,731	60	7,459
Other	30	353	246	351	13446
Electricians	97	83	1,126	194	7,740
Pipe Fitters	78	65	1,398	545	3,720
Painter	31	25	95	3	877
Sheet Metal Workers	129	35	2,238	119	3,129
Hull Welders	58	50	1,320	19	1,892
Ship Wright	35	0	62	3	81
Other	903	2,545	65,669	8,472	701,305
Total	1,655	3,118	77,891	9,649	739,361

Source: Australian Bureau of Statistics special request.

Spillover Impacts

Investment in defence shipbuilding typically has very small ongoing financial returns to Australian taxpayers during peacetime and so typically only makes a marginal contribution to 'measured' economic activity. Defence ships do not 'pay their own way' compared to commercial ships employed in transporting goods and people which earn streams of financial returns. Hence significant ongoing financial contributions from the public sector are necessary to ensure private sector involvement in this sector. As a result, analyses of such assets will most likely find that they have little or no effect on real GDP over time.

A possible exception to this rule would be if there were significant spillover productivity improvements from the construction sectors or for other parts of the economy from building defence ships. Such improvements lower unit production costs. In general, spillover effects are unambiguously positive for real GDP: for every $ saved an equal amount is added to real GDP. However, their impact on employment are not at all clear. Spillover effects that lead to increased efficiency in the use of labour may actually reduce the number of persons required to undertake various tasks.

The relevant economic literature only supports negligible or ambiguous impacts at best. It finds that if spillovers do exist they are highly targeted to specific industries, and so are not broadly available (Saul 2001, Cowan & Fry 1995 and Alexander 1990). Following Saul (2001), it would be possible to envisage a small increase in the rate of total factor productivity in the submarine building industry due to government procurement in technology.[6] For the sake of illustration, using VUMRF we assessed the impact of a small increase in productivity which increased the efficiency in the use of primary factors in submarine construction by 2.0 per cent. We find that with the improved productivity fewer workers are required to work on submarine construction. This reduces annual employment in South Australia by around 36 jobs, while leading to a small increase in annual real GSP of around $8 million. The increase in real GSP reflects directly the cost reduction associated with the productivity improvement. Sensitivity analysis for productivity improvements of -2.0 per cent, 2.0 per cent and 5.0 per cent are reported in Table 15. Across this spread of outcomes there were relatively little changes in the employment and Real GSP outcomes for South Australia. Spillovers offer little justification for significant public investment.

Table 15: Impact of Spillovers on Collins Six Ship Total Employment in South Australia (impacts in an average year)

Spillover Magnitude	FTE Employment	Real GSP ($m, 2013 prices)
-2.0	1,839	359
0	1,794	368
2.0	1,758	376
5.0	1,704	387

Source: VUMRF modelling

Consultations with Collins stakeholders both within and outside Defence failed to identify technological changes from the original Collins build project that led to measurable impacts. Stakeholders identified a list of technological developments that were associated with the project (Table 16). But in each case they seem to have had very limited application beyond the project for a variety of reasons including:

- already an established technology in the commercial sphere (pump technologies, carbon fibre and glass reinforced plastic);
- technically unique to naval shipbuilding (welding skills);
- already shared with foreign project partners (steel recipe);
- not successfully marketed for export when innovation was leading edge (ISCMMS, block build and batteries); or

---

[6] Saul (2001) measures the rate of total factor productivity as the efficiency in use of all primary factors of production – capital and labour. A one per cent increase in efficiency in use means that to produce the same level of output, one per cent fewer physical inputs of labour and capital are required.

- restricted distribution for reasons of national security (anechoic coatings and adhesives).

Table 16: Collins Submarine Build Technological Developments and Potential Spillovers

Item	Spillover Potential
ISCMMS (Integrated Ship Control Management and Monitoring System).	Collins delivered the innovative ISCMMS system but as the product was not marketed for export foreign competitors had time to develop their own improved versions of the concept.
Material science, especially the Steel	Both steel recipe and welding techniques were shared with Swedish and United States who have already exploited the scientific breakthroughs.
Welding techniques and skills.	A former DSTO expert stated that welding technique are so defence specific (related to shock resistance) that they have no broader application.
Anechoic coatings and adhesives.	These are 'crown jewels' technology and they haven't been shared outside DSTO and original contractor licence.
Block build and section management.	The principle which first applied to Collins is now in general use.
Quality assurance.	The process of certifying subcontractors tended to raise standards across the sector.
Use of carbon fibre and fibre reinforced plastic structures.	Company says technologies were developed prior to Collins project.
Development of pump technologies.	Company says technologies were developed prior to Collins project.
Pacific Marine Batteries.	Defence subject experts say that technology has not been commercialised for other clients.

Source: Defence staff and Collins contractors.

In terms of human capital spillovers, a survey study by Swedish defence technology/innovation analyst, Professor Gunnar Eliasson (2013) based on a limited sample (less than 10) of former Collins production staff found that none felt they acquired project specific skills as lasting impacts of working on the project. The conclusion to be drawn is that (technology and human capital) spillover effect may have been far smaller than many expect and negligible in absolute terms.

Summing up, the Collins experience suggests there is indeed scope for positive spillovers in a Future submarine build if the technological elements are identified and explicitly managed with a view to maximising productivity returns that are available. However, these should not be expected to generate significant employment opportunities. In theory *learning by doing* should generate a positive productivity impact through the naval shipbuilding supply chain. It should also be long lived if people are retained by companies or at least within the industry. Perhaps one of the reasons we have not detected this impact is that the core workforce was not retained for long enough, so human capital was not built, to freely transfer to other sectors.

Overseas versus Local Build Option Impacts

The key state and national macroeconomic impacts of a local (Collins) versus overseas [redacted] build program are provided in Table 17, assuming a 2014-15 project commencement and completion within 16 years.

Table 17: Key Indicators of Collins versus [redacted] Build (impacts in an average year)

	South Australia		National	
Future Collins (Local option)	$mil#	% of base case*	$mil#	% of base case*
Real GSP/GDP	368	0.42	65	0.01
	FTE	% of base case*	FTE	% of base case*
Employment (FTE)	1,794	0.18	733	0.01
[redacted] **(Foreign option)**	$mil#	% of base case*	$mil#	% of base case*
Real GSP/GDP	[redacted]	[redacted]	[redacted]	[redacted]
	FTE	% of base case*	FTE	% of base case*
Employment (FTE)	447	0.05	101	0.00

Source: VUMRF modelling.
Note: # $ million in constant prices of 2013. * % deviations away from values in the base case in an average year of the build.

Not surprisingly, the foreign option stimulates activity at the national and state levels by much less than the local build option. At the national level, the effects on real GDP and employment of [redacted] option are negligible. For South Australia, the effects are slightly positive, because the foreign build requires some additional manufacturing and assembly within Australia, and nearly all of that activity is undertaken by industries within that state.

The ERA for the Collins build is calculated in Table 18 compared to the [redacted] based on a costing model provided by the DMO and not VUMRF estimates. The purpose of the calculation is to identify the price difference between an overseas submarine build and a domestically built submarine (adjusted for weight differences) expressed as a proportion of the total value added of a domestically built submarine (the Collins). This is estimated by taking the gross value of assistance provided to the local shipbuilder (here $194 million) and adjusting that value for the protection applying to other inputs that the submarine build might attract (estimated at a nominal rate of 0.8 per cent of the value of materials expenses or $46 million).[7] The ERA for the Collins build is then calculated as the value of the net subsidy of $148 million divided by the unassisted value added in Australia from the project ($148 / $6,307) or 2.3 per cent. However, this estimate is very low based on estimates for other Defence projects provided by the DMO and industry benchmarks published by the Productivity Commission.

---

7 Based on the latest Productivity Commission estimate (2014)of assistance applying to the Other Transport Vehicles Manufacturing sector which includes shipbuilding.

Table 18: Effective Rate of Assistance on Collins Six Ship Build Compared to Other Defence Projects and Industries

			Options	
Notes	**Evolved Collins ERA Calculation**		**Collins**	[redacted]
From DMO	Total cost estimated in 2013 dollars	$m	12,184	[redacted]
From DMO	Tonnage	Tonne.	2,590	[redacted]
	Total cost estimated in 2013 dollars adjusted for tonnage	$m	12,184	[redacted]
	Assistance: difference between least cost option	$m	194	
From DMO	Australian industry content	%	68	
Total cost * AIC	Gross value local content	$m	8,285	
From DMO	Material to output ratio (material share of local production)	%	22	
From DMO	Value of all materials (Australian & imported)	$m	5,729	
Equals wages and profit	Value added in Australia	$m	6,455	
	Effective Rate of Assistance			
From above	Assistance (Gross subsidy equivalent)	$m	194	
From PC 2014	Nominal rate of assistance (NRA) on materials	%	0.8	
$ material. * NRA	Additional material costs due to assistance to other industries	$m	46	
	Unassisted value of materials	$m	5,683	
	Net subsidy equivalent (NSE)	$m	148	
Value added less NSE	Unassisted value added	$m	6,307	
NRE compared to unassisted value added	Effective rate of assistance	%	2.3	
	DMO Provided ERA Estimates		**ERA**	
	Selected DMO Projects			
	Land 121 Phase 4 - MSA (Light armoured mobility vehicles)			
	- Thales	%	69	
	- GDLSA	%	112	
	- FPE	%	104	
	Land 121 Phase 3 - (medium weight vehicles)	%	36	
	Air Warfare Destroyer	%	33	
	Landing Helicopter Docking Ship	%	190	
	Productivity Commission ERA Estimates		**ERA**	
	Australian Manufacturing Sector	%	4.2	
	- motor vehicles	%	8.9	
	- textiles, clothing and footwear	%	8.1	
	Australian Mining Sector	%	0.2	
	Australian Agricultural Sector	%	2.6	

Source: The DMO and Productivity Commission 2014.

Comparing Local Build Option Impacts

Key indicators of the economic impact of two alternative domestic build designs (Evolved Collins and New Design) scenarios for South Australia and nationally are presented in Table 19 in terms of direct and indirect impacts for both 6 ship and 12 ship options. Results presented are of a similar order to that for the Collins build program scenario examined previously. Summarising the employment outcomes shown in Tables 19 leads to the following conclusions:

changes in employment are approximately proportional to the size of program spending associated with each options and the length of the build period. If spending and build phasing under each scenario are approximately the same, then the employment outcomes would be roughly the same in total and across industries.[8]

Table 19: Comparison of Alternative Local Build Options (impacts in an average year expressed in $m, 2013 prices and FTE)

	Collins	Evolved Collins		New Design	
	6	6	12	6	12
National Real GDP	65	62	92	72	68
South Australia Real GSP*	368	381	454	435	490
South Australia Direct Employment	763	736	916	840	1,010
South Australia Indirect Employment	1,031	1,030	1,441	1,172	1,492

Source: VUMRF modelling. **Note**: * Percentage contribution to state GDP for each option is as follows: Collins 6 Ship 0.42 per cent; Evolved Collins 6 Ship 0.44 per cent; Evolved Collins 12 Ship 0.52 per cent; New Design 6 Ship 0.50 per cent and New Design 12 Ship 0.56 per cent.

Sustainment Impacts

The costs of sustainment are more driven by fleet size then design selection. Table 20 reveals some key indicators of the economic impact of sustainment on the South Australian and national economy over time for the Evolved Collins scenario. It suggests that sustainment of six submarines will generate around 322 FTE jobs in total, whereas 12 submarines will generate around 580 jobs in South Australia, in total, on average. South Australia once again fairs better in terms of output gains relative to the national total implying that other regions are somewhat worse off. It also suggests the total employment multipliers (2A) associated with submarine sustainment are comparable to that associated with a build.

Table 20: Sustainment of Evolved Collins Six Ship versus Twelve Ship (impacts in an average year expressed in $m, 2013 prices and FTE)

	6 Ship	12 Ship
National Real GDP	76	122
South Australia Real GSP	119	207
South Australia Total Employment	322	580
South Australia Direct Employment	142	249
South Australia Indirect Employment	180	331
Implied CGE Total Multiplier (2A)	2.3	2.4

Source: VUMRF modelling

[8] This applies to regions and occupations as well.

References

ACIL Allen Consulting, 'Naval shipbuilding and through life support: economic value to Australia', Report to Australian Industry Group. December 2013.

Alexander, J.D., 'Manufacturing productivity and military depletion in the post-war industrial economy', in Bischak, G.A., Towards a Peace Economy in the United States: Essays on Military Industry, Disarmament and Conversion, St Martin's Press, New York, 1990.

Cowan, R., and Foray, D., 'Quandaries in the economic of dual technologies and spillovers from military to civilian research and development', Research Policy, 1995, 24 , pp. 851-68.

Eliasson, G., 'The advanced firm as a technical university – A pilot study human capital creation on the Collins Submarine project in Australia 1986 – 2004', Swedish Entrepreneurship Forum Conference, May 2013.

Saal, D.S, 'The impact of procurement-driven technological change on U.S. manufacturing productivity growth', Defence and Peace Economics, 2001, Vol.12 (6), pp.537-568.