Forecasting Australian Shipbuilding Skill Demand

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INTRODUCTION

KPMG works with a number of clients, including members of the National Shipbuilding College, to understand the challenges associated with the National Shipbuilding Program (NSP) and the implications for the planned construction program. This paper draws on examples of this work, including scenario analyses conducted using KPMG's Shipbuilding Enterprise Workforce Model[1]. Insights into workplace relations considerations are also used, which influence the leavers the Commonwealth may use to help achieve the workforce required.

The Naval Shipbuilding Strategic Workforce Discussion Paper (NSWDP) (National Naval Shipbuilding Office, 2019) acknowledges a number of the risks associated with the workforce supply for the NSP, and the Commonwealth's role in addressing some of these by identifying levers to address shortages of supply. However it did not address the Commonwealth's role in creating or smoothing the demand side of the equation. Key drivers for this demand are:

- size and structure of the overall fleet
- the planned in-service life of different vessel classes including upgrade paths and capability assurance programs (CAPs)
- plan for sequential vessel development and delivery (see Figure 1)

These elements represents considerable levers within the Government's control to achieve a sustainable sovereign shipbuilding industry. The modelling presented in this paper identifies the boom and bust cycle will likely continue without further changes to the NSP program and the longer term plans for the force structure (Birkler & Et al., 2015).

The remainder of this paper will explore the context of the challenge, provide updated estimates for the scale of the workforce demand and how this compares with the 2015 RAND analysis and 2019 NSWDP, and offers a high level overview of the key levers available to balance supply and demand and further smooth the predicted boom and bust cycle.

[1]Analysis conducted in June 2018 prior to the announcement of BAE Systems Type 26 as the winner of the SEA5000 competitive evaluation process.

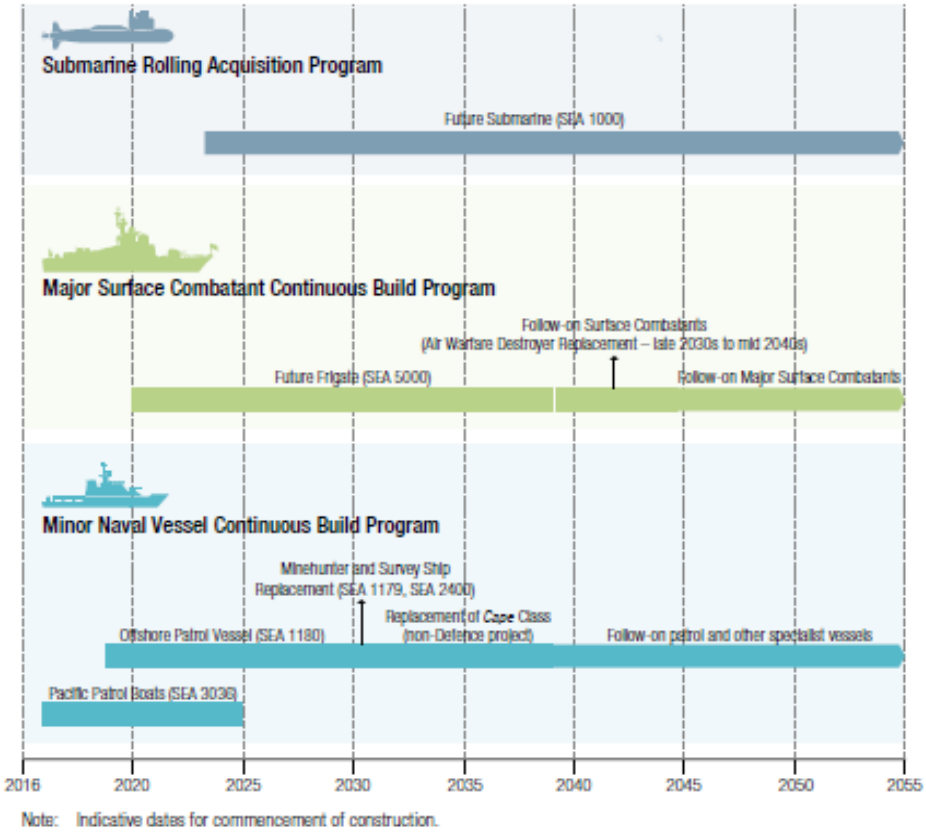

Figure 1: Naval Shipbuilding Continuous Build Programs (Commonwealth of Australia, 2017)

CONTEXT OF THE CHALLENGE AND DRIVERS WHICH HAVE RESULTED IN THE CURRENT STATE

There are a number of factors that have contributed to the current state and challenges faced by Australia in implementing the NSP.

The length of service of Royal Australian Navy (RAN) vessels has been increasing since Federation, but has remained relatively constant since the 1970s with a median in-service duration of 34 years for major surface combatants (Figure 2 and Figure 3). Lengthening service life for ships is a consistent global trend, but for a relatively small naval fleet such as Australia's, this makes continuous demand for Naval Shipbuilding difficult.

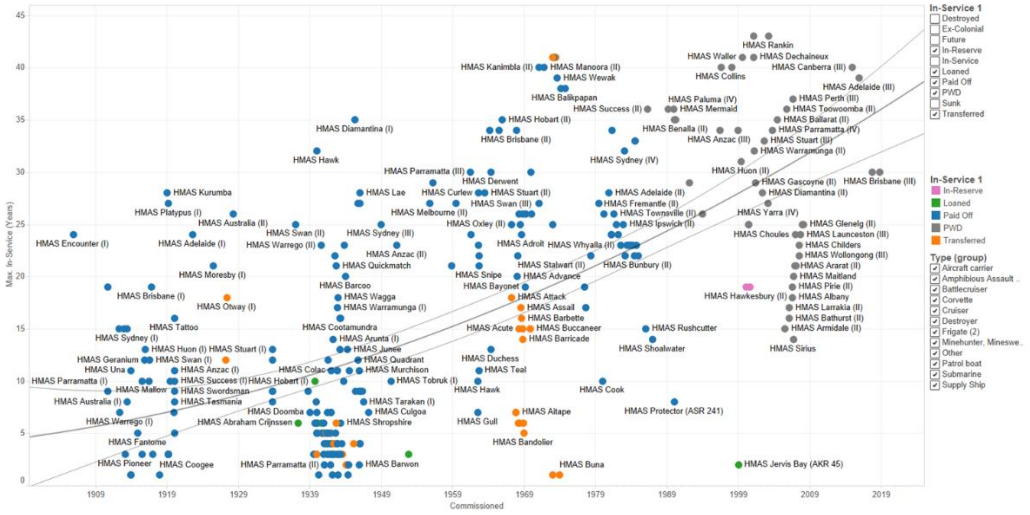

Figure 2: In-Service Duration of Australian Warships Scatter plot against commissioning date[2]

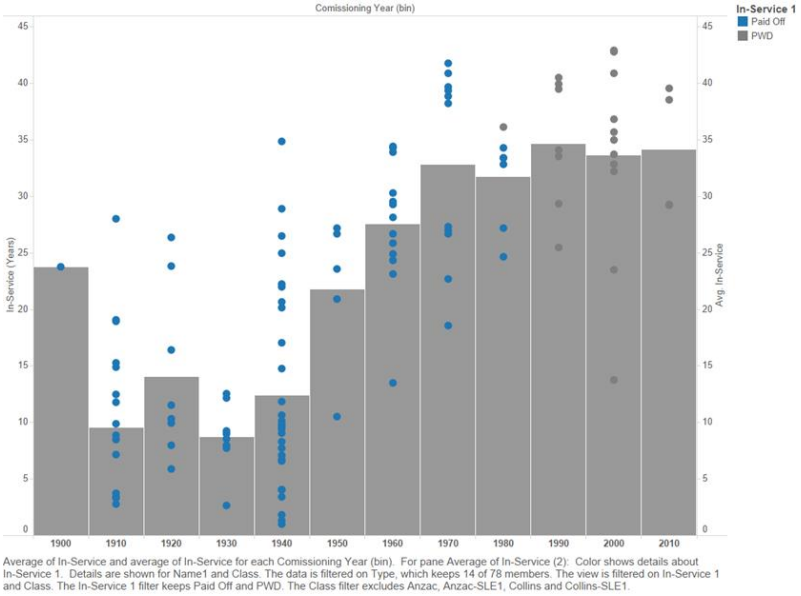

Figure 3: In-Service Duration of Australian Major Surface Combatants and Other Large Vessels (Inc. Submarines) Bar chart binned by commissioning year[3]

The trend of increasing length of service or Life of Type (LOT) is not restricted to the maritime (sea) domain. It is common across Air and Land domains as well. This is a function of the various technology cycles of complex weapon systems that see the structure (hull / airframe) last 30+ years, but combat systems upgraded several times within that period as part of Capability Assurance Programs (CAPs). This in turn is influenced by the capital cost of the

[2] Shown are the commissioning date for RAN Ships against their in-service years (including indicative Planned Withdrawal Dates (PWDs) for the current fleet) data sourced primarily from (Royal Australian Navy, 2019) with Service Life Extensions and PWDs inferred from NSP press releases from CoA and Primes over the period 2016-2019.

[3] This figure excludes Patrol boats and other minor vessels. Outliers to this trend include a number of second hand amphibious ships, where the original (USN) commissioning dates were used.

initial acquisition proportional to the Total Lifecycle Cost (TOTEX)[4][5], and by investments in long term planning to achieve the right balance of spend on new acquisition projects compared to "upgrades".

Most major surface combatants experience a mid-life upgrade, but more recently Service Life Extension (SLE) or Life of Type Extension (LOTEX) programs have also been common. The RAN also has a history of purchasing second hand vessels, in particular Logistic Support and Amphibious Ships (Sea Lift).

Analyses by the RAND Corporation (Birkler & Et al., 2015), commissioned by the Commonwealth, sought to inform strategies to address the looming "Valley of Death" in shipbuilding activity and the associated loss of specialist skills due to the forecast end of the Air Warfare Destroyer (AWD) construction program and the start of Future Frigate construction. Issues of accelerated ageing due to changes of operational usage of the Patrol Boat fleet were also considered for their impact on demand for new Offshore Patrol Vessels (OPVs). Subsequent program decisions, such the draw out of the AWD build, have made marked improvements; however, the forecast "Valley of Death" has not been averted. Whilst the OPV program will mitigate the required maximum growth rate for the skills and workforce required to meet SEA5000, it also adds to the peak demand. RAND (Birkler & Et al., 2015) analyses did not consider the submarine construction workforce requirements, nor those of the sustainment enterprise and its expansion post 2049 when force structure increases. The timing of SEA1000 (Figure 1), concurrent with SEA1180 and SEA5000 further exacerbates the tension in supply vs. demand for key skill types and resources.

QUANTIFYING THE NATIONAL SHIPBUILDING WORKFORCE DEMAND

Building on the previous analyses of RAND (Birkler & Et al., 2015) and others is important to measure the impact of recent program decisions, test assumptions, and move to a unified approach suitable for informing the long-lead-time decisions required for the enterprise to respond. Whilst the range, type and efficacy of response options is a topic of significant interest, the focus of this paper is to offer quantitative estimates of the demand for specific scenarios and related program assumptions.

A variety of supply and demand scenarios were used to forecast likely slippage in the shipbuilding program due to gaps and growth constraints in the Australian industrial base. They were also used to forecast the peaks and troughs in workforce capacity requirements based on fixed schedules. A high level description of the methodology is provided below.

Methodology

The activity was conducted in five distinct stages:

1 **Data Collection** included detailed review of previous modelling in the literature and of published Defence investment plans; and expert elicitation surveys to generate different

[4] ~50% for Major Surface Combatants and ~70% for Combat Aircraft. (Mislick & Nussbaum, 2015)

[5] "For example, the labour required to build an AWD or assemble an LHD is about three to seven times the labour required for large modernization projects or deep maintenance projects. Moreover, the labour required to build a new ship could be 30 to 70 times more than the labour required for routine maintenance." (Birkler & Et al., 2015)

shipbuilding production scenarios, constraints and risks for the building of each type of naval platform.

2 Confirm **Model Architecture** to accept inputs on workforce structure and fleet plans and perform sequential simulations to determine the scale and type of specific skills required for sustainment, construction and design activities for each vessel.

3 **Exercise the Model** to dynamically grow and contract the workforce to meet demand on a quarterly basis, or alter the production schedule based on a constrained workforce and growth rate.

4 **Verify and Validate** modelling results by comparison with the results of previous analyses with more constrained scope, including effective recreation of the previous analyses of the RAND Corporation conducted in 2015 (Birkler & Et al., 2015) see Figure 4.

5 **Analysis and Presentation** of results in an interactive analytics tool (Tableau) for simple exploration of all scenarios.

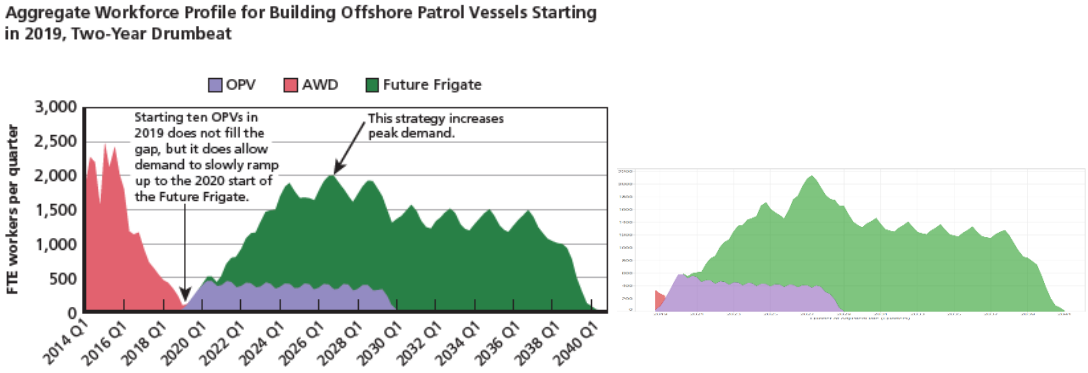

Figure 4: The model (Right) was verified against the RAND model results (Birkler & Et al., 2015)(Left) from Appendix D: Exploring the Option of Producing Offshore Patrol Vessels (Scenario D.6) (Birkler & Et al., 2015)

BASELINE SCENARIO RESULTS

The workforce required to meet the overall production plan can be estimated in several ways. The key differentiators are in consideration of both constrained and unconstrained labour pools i.e. unconstrained assumes the workforce can grow to satisfy both skill demand and schedule. For an unconstrained labour pool the workforce required to deliver the desired acquisition scenario is shown Figure 5. Trade specialisations are separated into categories and sub-categories depicted in Figure 6**Error! Reference source not found.**.

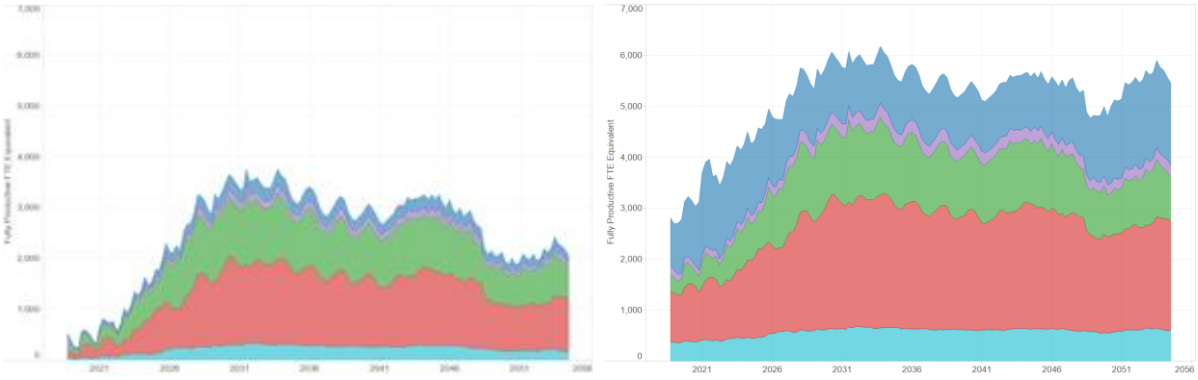

Figure 5: Shipbuilding workforce forecast by Shipbuilding Skill Sub-Category (Trade Type), unconstrained baseline scenario (Left - Surface Ships Only, Right – Submarine Design and Construction Included), both scenarios include follow on builds for AWD and OPVs only.

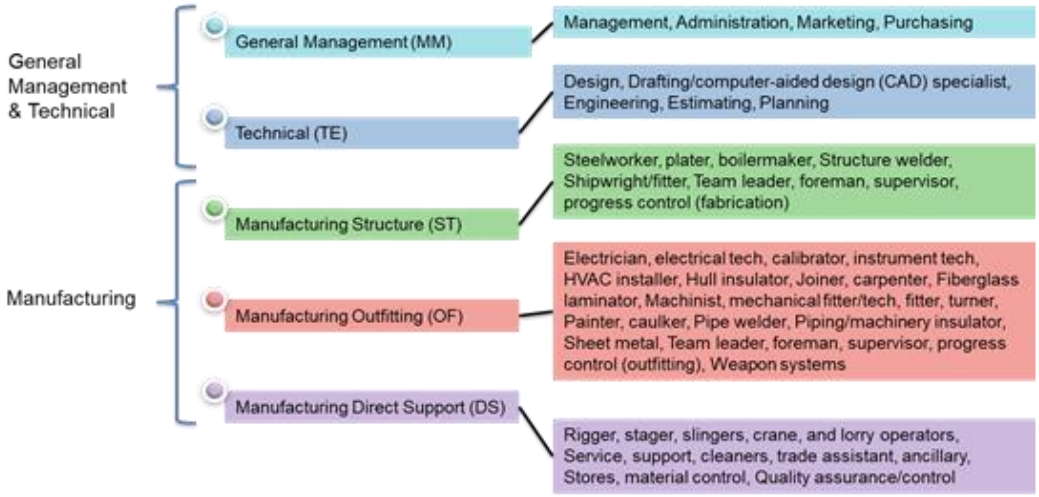

Figure 6: Shipbuilding workforce trade descriptions and identifiers consistent with RAND 2015 (Birkler & Et al., 2015) showing skill categories, specific skills, and skill competencies.

Figure 7 illustrates the demand by class and hull (A), trade type and experience level (B), and geography and shipyard (B).

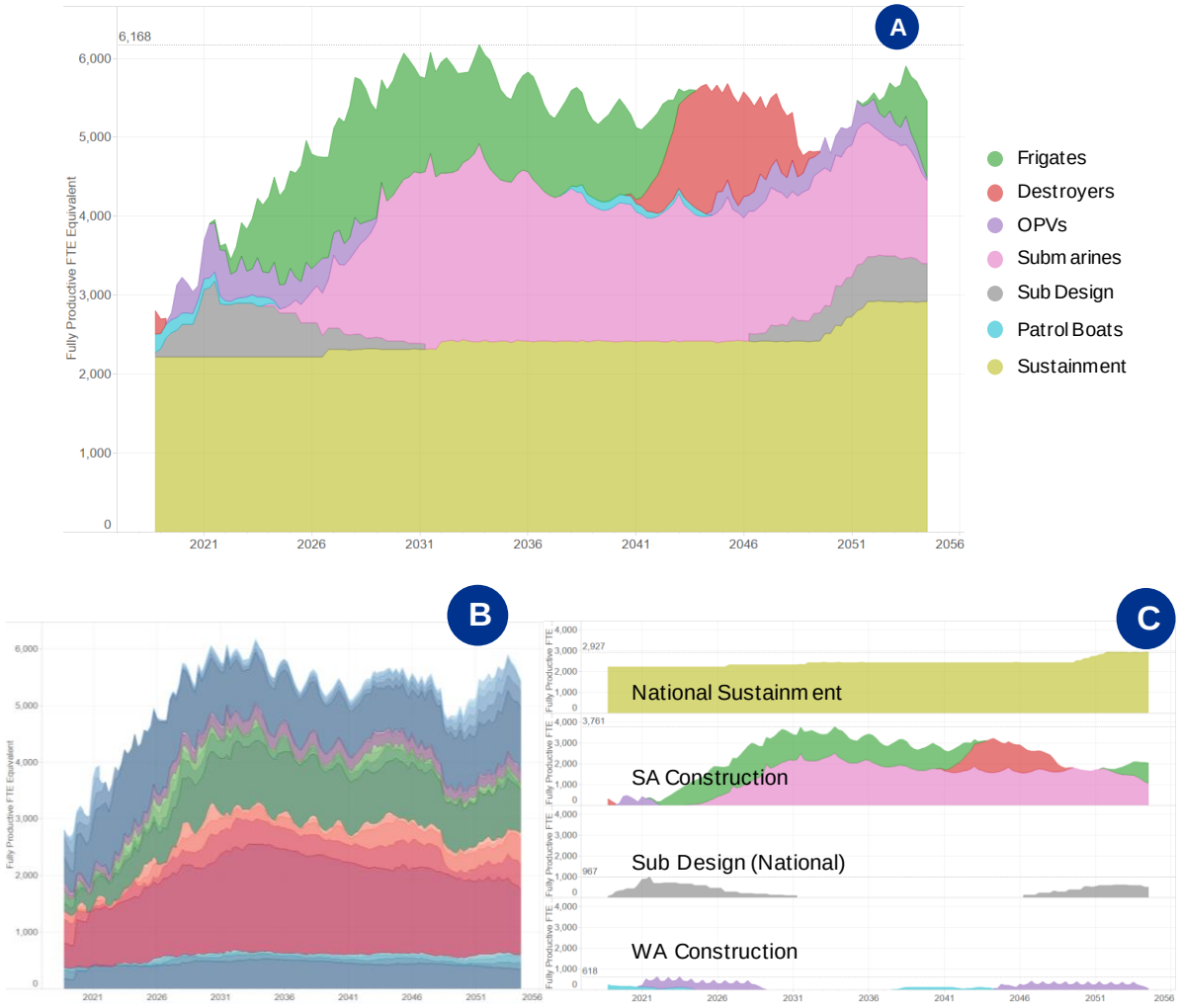

Figure 7: Shipbuilding workforce estimate example outputs for the New Baseline. A: Overall Demand by Program, B: Demand by Skill Type and Experience Level, C: Demand by Program and Location.

Figure 8 shows how trade types break down further to specific skills and skill competencies which enable direct translation of the workforce estimates to associated demand for vocational, graduate and post graduate education and training. This is a fundamental next step required of the Shipbuilding enterprise, and must be taken in collaboration with the education sector to quantify and plan for demand nationally and regionally in coordination with the other levers available (see *OTHER CONSIDERATONS* section of this paper).

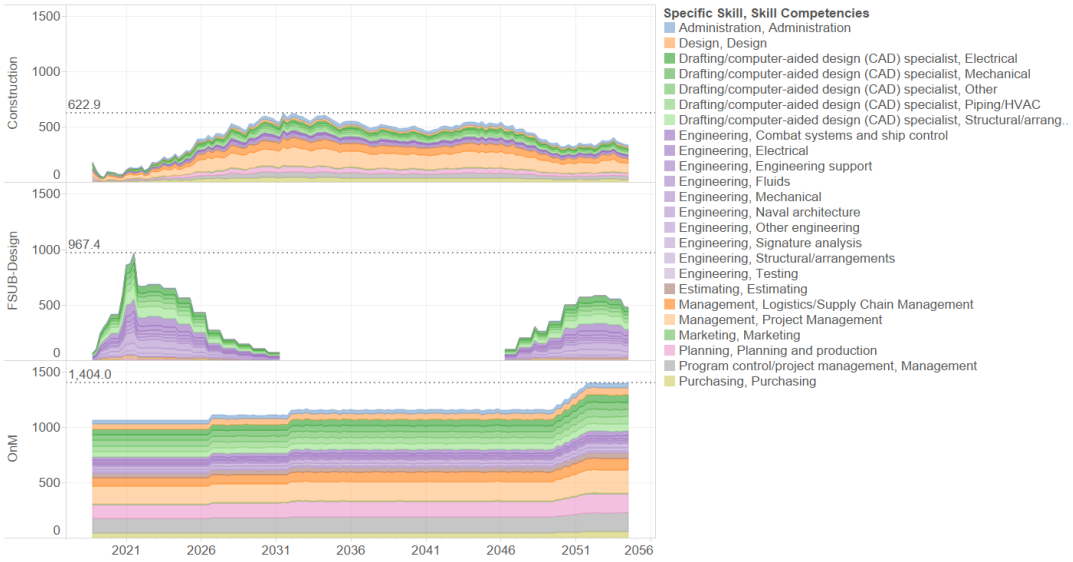

Figure 8: Shipbuilding workforce estimate, showing demand for specific skill competencies for the New Baseline by location and skill competency

COMPARISON WITH THE NATIONAL SHIPBUILDING WORKFORCE DISCUSSION PAPER

Comparison between the analysis presented in this paper and the NSWDP is challenging due to the differences in fidelity of the respective approaches. The analysis in this paper shows time based variations over a 35 year period and were generated for various scenarios, which provide limited comparison opportunities with the single point estimates in the NSWDP.

The scenario selected for comparison against the NSWDP modelling results took into consideration the latest announcements regarding Anzac class Service Life Extension (SLE) and Hunter class Frigate construction plans and is shown for selected data points in Table 1.

Two major points of difference between the two estimates are clear. The NSWDP does not include workforce requirements for design activities for the Attack class submarine (which this analysis forecasts to peak at over 600 FTE in the early 2020s), nor is the sustainment workforce considered. In this analysis the sustainment workforce is forecast to remain relatively consistent at around 2200 FTE until 2049 where the introduction of additional submarines expands the force structure and the associated sustainment resources required.

This analysis estimates the fully productive FTE and the forecast number of actual personnel required to deliver that productivity. The latter can be substantially higher based on the workforce experience mix and skill specific productivity levels; and can be heavily influenced by industrial relations policies related to staff employment continuity in periods of slow down. Table 1 shows the peak direct jobs estimated from the analysis presented in this paper as well as the quarter the results approximate the workforce peak estimated by the NSWDP.

Table 1: Comparison with NSWDP total workforce estimates (2018-2050). In parentheses is the quantity and quarter where the results described in this paper approximate the workforce peak estimated by the NSWDP.

Program	NSWDP Direct jobs	Analyses presented in this paper, completed in 2018 Direct jobs Fully Productive[6]	Direct jobs Personnel[7]
Guardian class pacific patrol boats	200	225 Peak Q4 2018	249 Peak Q4 2018
Arafura class patrol vessels	400	453 Peak Q1 2020 (SA) 560 Peak Q1 2022 (WA)[8]	734 Peak Q1 2020 (SA) 665 Peak Q1 2022 (WA)[8]
Hunter class frigates[9]	1,500	1832 Peak Q2 2028 (1539 Occurs Q4 2025)	1864 Peak Q2 2028 (1675 Occurs Q4 2025)
Attack class submarines construction	1,100	2475 Peak Q3 2031 (1146 Occurs Q2 2028)	2777 Peak Q3 2031 (1509 Occurs Q2 2028)
Attack class submarine design[10]		967 Absolute Peak Q3 2021[11] 682.6 Long Term Max Q1 2023	1311 Absolute Peak Q3 2021[11] 694 Long Term Max Q1 2023
Overall Peak	3,200	3752 Peak Q2 2030 (3439 Occurs Q1 2028)	4108 Peak Q2 2030 (3816 Occurs Q1 2028)

There is an unquantified risk of increased competition for specialist technical skills. This is specifically between the Hunter class and Attack class design activities in the years 2019-2026, which if not effectively managed could significantly delay one or both programs. The modelling presented in this paper included a higher design (technical trade-hours) requirement in the first of class for what was still Future Frigate at the time of analysis, however in relation to an Australianised Military off the Shelf (MOTS) acquisition of the type-26 frigate this was likely an underestimate. The model already showed tension between the technical trade requirement for this program and the Attack submarine design, generating a backlog of submarine design work that resulted in a rapidly growing workforce, oversized to meet the longer term requirements. If this is constrained to a more sustainable ceiling there would be even greater delay implications for the start of submarine construction.

In summary, the major points of difference to the NSWDP analysis are:

- Under the baseline assumptions, with a relatively unconstrained model, it is predicted that the proposed delivery of the 2017 NSP will be delayed.
- With Attack class design resources included, the NSWDP underestimates shipbuilding workforce growth to 2030 by approximately 17%.
- However, with revision of the 2017 NSP schedule to incorporate proposed service life extension of the Anzac Class Frigates, under the same conditions, the NSP can be delivered on time (i.e. to a New Baseline). This assumes relatively unconstrained workforce growth during the peak period 2019 to 2030 which requires significant coordination.

[6] Baseline scenario, Fully Productive FTE Equivalent.
[7] Baseline scenario, Number of Personnel (FTE).
[8] This number occurs after the Guardian construction completed, and assumes that of the total 560 jobs, 335 are new and 225 would be met from the Guardian program.
[9] Body of effort excludes Detailed Design (It was assumed that this was a relatively off the shelf acquisition).
[10] This number is quite high, but mitigates the absence of detailed Frigate design.
[11] Heavily influenced by demand from submarine design in the initial 5 years

WORKFORCE SUPPLY SCENARIOS, CONSTRAINTS AND POTENTIAL IMPACTS

Translating Forecasts into Reality

This paper presents an unconstrained scenario, however there are practical limits to the overall workforce size, the local workforce size which can be productive around a fixed number of vessels, and the minimum duration of each production activity. For example a single shipyard can typically build two large ships simultaneously: one alongside being outfitted, the other under construction. Similarly, submarine construction cannot start in earnest if design has not been completed.

The concurrent build restrictions or "slot constraints" in combination with the estimated demand profiles (which include resource requirements and build durations) for shipbuilding programs, and assumptions around drumbeats for construction and learning curves, means slippage in the 2017 NSP production schedule results even with relatively unconstrained workforce growth rates.

These schedule impacts are summarised as follows:

- Under the baseline assumptions the 2017 Naval Shipbuilding Plan is forecast to be delivered late.
- However, if this schedule is revised from the 2017 NSP to incorporate recent plans to extend the service life of the Anzac Class Frigates, a revised production schedule can be delivered with significantly reduced risk of delays (New Baseline). To achieve the fully productive FTE required to deliver the Technical Engineering and General Management disciplines, peak quarterly growth rates of 22% and 10.3% respectively are required. Growth in Technical Engineering peaks relatively early due to the demands of submarine design, whilst General Management peaks at the height of construction (see Figure 9).
- Comparison of the New Baseline against different levels of constraint for the 2017 NSP acquisition and construction schedule is shown in Table 2. This highlights that for the 2017 NSP, practical limits to the productive workforce size at both national and local levels results in schedule slippage for the production program. In the constrained cases, where workforce variation rates are lower, greater impacts are observed.

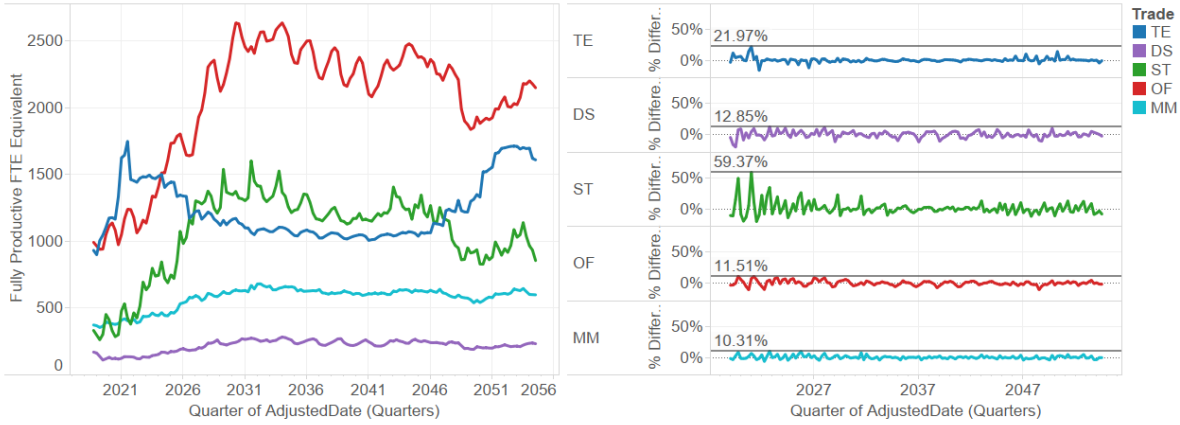

Figure 9: Forecast fully productive FTE and quarterly growth rates for each skill category

Table 2: Forecast production impacts from minimal practical constraints to a relatively unstrained workforce model. Without an ANZAC SLE, practical constraints impact the future submarine and future frigate most significantly.

Program	New Baseline Unconstrained	2017 NSP Unconstrained	2017 NSP Constrained Growth for General Management & Technical
Guardian class pacific patrol boats	16th Hull onwards delayed 2-3 Quarters due to prioritisation of OPVs	14th Hull onwards delayed 4 Quarters due to prioritisation of OPVs	No Change from 2017 NSP
Arafura class patrol vessels (OPVs)	2nd of class (SA) 2 Quarters delayed, WA On time	2nd of class (SA) 3 Quarters delayed, WA On time	No Change from 2017 NSP
Hunter class frigates	2nd of class onwards 1 Quarter delayed	2nd of class 1 Quarter delayed	2nd of class onwards 2 Quarters delayed
Attack class submarines construction	2nd of class 1 Quarter delayed, 12th of class 9 Quarters	2nd of class 8 Quarters delayed, 12th of class 16 Quarters	1st of class 12 Quarters delayed, by the 8th of class the program is 16 Quarters delayed

In Figure 10, shown in blue is the 2017 NSP production scenario (unconstrained rate of labour pool growth). Applying a constraint on the maximum growth rate of Technical Engineering and General Management trade types only of 15% per quarter results in further schedule delays of:

- 0.5 year schedule slip on the delivery of the 2nd-9th Future Frigates
- 4 year schedule slip on the Submarine program.

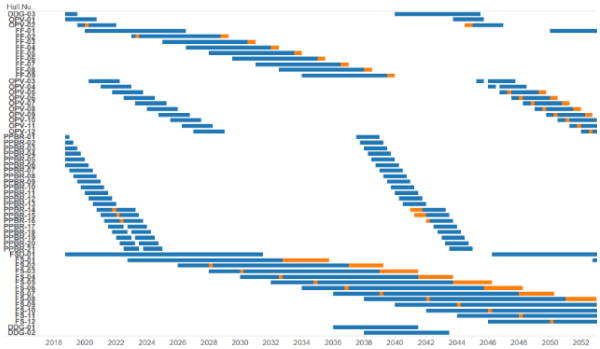

Figure 10: Forecast 2017 NSP production scenario (blue) and delayed scenario (orange) due to limits on rates of workforce growth

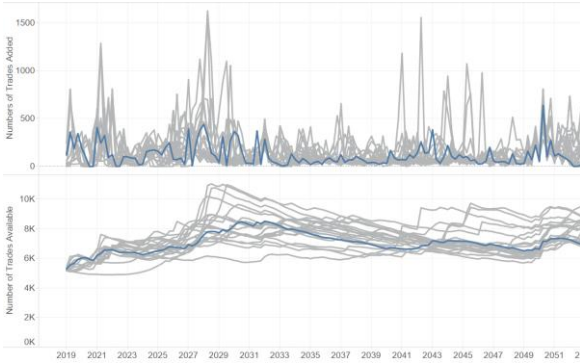

Figure 11: Trades person demand showing the baseline scenario (blue) and several other scenarios (grey) which vary considerably in growth requirements at different times (due to inefficient schedule overlaps which result). These estimates are for total number of personnel and include maintaining a sustainment workforce of approx. 2200 FTE.

Table 3: Estimated peak resource demand and the compound annual growth rate from 2018

		Peak		
Skill Type	**2018 Q4**	**Personnel**	**Quarter**	**CAGR[12]**
Technical Engineering	932	1749	2021 Q3	26%
Manufacturing Direct Support	171	275	2031 Q3	4%
Manufacturing Structure	333	1603	2031 Q3	13%
Manufacturing Outfitting	993	2635	2030 Q2	9%
General Management	374	683	2032 Q2	5%
Overall workforce	2802	6073	2031 Q3	6%

The required growth rates for specific skills and trades (including experienced personnel) is quite high and consistent (though does experience localised fluctuations) (see

[12] Compound Annual Growth Rate (CAGR) between Q4 2018 and peak

Table 3). This has implications for the domestic education sector, and in particular the pipeline of vocational training in relevant courses to balance supply and demand.

The baseline scenario shown in Figure 11 reflects the impact of the ANZAC Class SLE. The New Baseline avoids several peaks of activity associated with more aggressive production schedules. These points of concentration reflect the sensitivity of the overall system to variations in the production program and therefore the benefits of harnessing dynamic models during the decision making process.

OTHER CONSIDERATIONS

Measures to increase workforce productivity and potentially reduce the peaks in skill demand should be considered, along with increased support for workplace relations negotiations. Shipbuilding must also learn from other sectors and position itself as the industry of choice for longer term sustainability. The following workforce planning considerations were not covered in this paper but are presented here to highlight key considerations and control levers which should be factored into coordinated planning across the shipbuilding enterprise:

- Understanding of and understudying in critical roles
- Structural sustainability of trade professions
- Growing skills not qualifications
- Consideration of technical capability in the Australian Public Service
- Establishing shipbuilding as an Industry of Choice for new workforce entrants
- Workforce management at an industry level; including critical factors such as productivity, flexibility and leveraging lessons from other sectors to encourage diversity and retention
- Forecasts of competing workforce demand from other sectors with similar skill requirements

CONCLUSIONS

A national and coordinated approach needs to be taken to quantify resource demands, understand the critical roles and skill areas, and assist the strategic planning of industry, Government and education institutions in order for successful delivery of the National Shipbuilding Plan. The Naval Shipbuilding College provides a significant opportunity to deliver and continuous improve such an approach.

In addition to these measures, clear lead indicators of a mobilised and growing shipbuilding sector need to be established and tracked. An enterprise approach requires resource estimates to be continually updated; and effective coordination mechanisms put in place across the NSP programs, and between government and industry, to introduce appropriate incentives and support mechanisms and minimise delays which could introduce or exacerbate resource boom and bust cycles.

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APPENDIX A – KEY PROGRAM AND MODELLING ASSUMPTIONS

The following provides key assumptions used modelling the National Shipbuilding Plan construction schedule.

1) The size of the future fleet is fixed:
   a) 12 OPVs: 2 in SA to be built by ASC at Osborne, and 10 in WA to be built by Civmech at Henderson.
   b) 9 Frigates to be built at Osborne South. 12 Submarines to be built at Osborne North.
2) The construction of the future fleet will not employ module consolidation:
   a) This assumption should be challenged through stakeholder engagement. The impact of changes to this assumption would potentially be less man-hours, or shorter duration builds.
   b) This also impacts the number of hulls that can be in construction concurrently. Note that while this is typically two for large ships, Naval Group has indicated that a modular approach to Attack class construction was intended, hence this model allows up to 4 future submarines in construction at once.
   c) A similar argument could be made for the use of advanced manufacturing such as digital shipyards with higher levels of automated manufacturing. Whilst standard learning curve rates have been incorporated into the modelling, no consideration has been included for such disruptive elements which would likely result in major reductions in labour required in particular for structural, management and technical trade's types.
   d) For the purposes of modelling workforce, we will look at the constraints associated with build location and labour availability.
   e) The size of the workforce required to achieve the acquisition/production plan is an output of the model. Further input from shipbuilding and industry experts is required to define final inputs (i.e. acquisition/production plan).
3) 100% of all construction occurs in Australia.
4) As of July 2018, the Osborne South and North, and Civmech's new shipbuilding facilities have yet to be built or are still under construction. This may introduce further risk of delayed production start dates and should be considered as part of industry engagement.
5) Combat Systems Integration (along with its risks) is included as part of construction.
6) The aim of the Commonwealth's acquisition schedule is to roughly align with the planned withdrawal dates (PWDs) of the current fleet:
   a) This may not be achievable resulting in capability gaps or requiring life extensions
   b) This may require a larger peak workforce that does not achieve the desired stable workforce, one of the design intents of the NSP is a Continues Shipbuilding program and Rolling Submarine Acquisition
   c) This analyses considered the Future Force Structure with the original PWDs for the Collins class Submarine and with a Service Life Extension (SLE) program
   d) The analyses considered the Future Force Structure with the an assumed in service life of approximately 30 years for Anzac class Frigates, which factored in a minor Service Life Extension (SLE), about half that referenced in the recent ANAO report (ANAO, 2019)

e) Multiple scenarios where run with combinations of 1.5 and 2 year drumbeats for Frigate construction and 25 and 30 year in-service lives, delayed starts to various programs, different man-hours per hull (larger more complex builds – size variations), different learning curve rates
f) Further information from industry is required to determine the likely capability gaps or SLE requirements to replace current baseline assumptions.

7) At the time of this analysis, announcement of BAE Systems Type 26 as the winner of the SEA5000 competitive evaluation process had not occurred.
   a) Size of vessel and estimated man-hours were not known (Baseline assumed 5M man-hours for future frigate, based on an AWD sized vessel), Hunter class vessels appear to have a larger full load displacement than the AWD.
   b) Design requirement and prototyping was not factored in, instead:
   c) Start date for Hunter class was modelled as 2020 instead of 2022 (prototyping to start in 2020), but with a longer build for the first of class, but without a proportionally different trade distribution build profile.
   d) Drumbeat and Anzac SLE were also not known at the time. It became clear though through modelling of various scenarios that an Anzac class SLE would most likely be needed. Also that a drum beat of 1.5 years and LOT of 30 years meant that the continuous shipbuilding program would run out of ships in the mid 2040s.