DEVELOPING THE AGILE DEFENCE FORCE

Mobilising the power of small to medium industry to rapidly deliver capability to the front line

ABSTRACT

The time to deploy new technologies and capabilities with frontline Defence operators is too long. This project identifies blockers in the culture, structure, and process of the Defence innovation system that limits Industries' ability to rapidly bring innovation in operation and makes recommendations for improvements to improve the transition of innovations into capability.

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Executive Summary

"Our Australian region is in the midst of the most consequential strategic realignment since the Second World War and trends including military modernisation, technological disruption and the risk of state-of-the-art conflict are further complicating our nation's strategic circumstances." (Department of Defence [DoD] Defence Update 2020:3)

The Australian Defence Force (ADF) has recognised that innovation is the key to obtaining and maintaining an advantage in the future battle space. This includes but is not limited to innovations in the way we:

- Think, develop and adapt technology,
- Operate at the strategic as well as the tactical levels, and
- Harness private sector entrepreneurship and ingenuity.

Defence's excessively risk-averse culture, hierarchical structure and lengthy acquisition processes are founded on traditional engineering approaches required for the acquisition of capability centred around large complex platforms.
While large complex acquisitions are still required the adversary is using technology and innovation to comprise Defence capability. The nature of conflict has shifted to the grey zone. There is a need to adapt the delivery of capability and enhance the innovation ecosystem to the nature of the emerging threats.

As members of the Defence Industry Leadership Program (DILP), our diversity of expertise spans fields of Defence, Industry and academia.
Through research and interviews with high-level stakeholders based on our connections within the Defence environment, we have collated findings of where the innovation ecosystem poses a disconnect between the Defence Industry and Defence.

In the research three common themes were identified and investigated:

- Risk Assessment, Acceptance and Management,
- Funding and Resource Constraints, and
- Communications and Collaboration.

This report provides an in-depth exploration of the three themes to then provide alleviating recommendations. The three recommendations identified in this research, and of paramount importance to improve Defence's interaction with the Defence Industry and academia are as follows:

- Defence is to adopt a wartime mindset in all aspects of rapid innovation and capability acquisition.
- Defence is to reduce administrative requirements for Defence collaboration initiatives e.g., Defence Industry Hub (DIH).
- Defence is to further increase its engagement with Small to Medium Enterprises (SMEs) and academia.

By modifying its current approach to supporting the innovation ecosystem, in accordance with the recommendations identified in this report, Defence will gain more efficient and effective access to sovereign expertise and innovations needed to develop capabilities that are superior to our adversaries. At the same time, the domestic Defence Industry and academia will be able to further expand and develop to achieve regional superiority.

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Acronyms

Acronym	Explanation
ADF	Australian Defence Force
ADSUN	Australian Defence Science and University Network
ASRA	Advanced Strategic Research Agency
AUKUS	Australian, UK and US trilateral treaty
AUV	Autonomous Underwater Vehicle
CASG	Capability Acquisition and Sustainment Group
CDIC	Centre for Defence Industry Capability
CLC	Capability Life Cycle
CM	Capability Mangers
DARPA	Defence Advanced Research Projects Agency
DCAP	Defence Capability Assessment Program
DIH	Defence Industry Hub
DILP	Defence Industry Leadership Program
DIU	Defence Innovation Unit
DoD	Department of Defence
DSR	Defence Strategic Review
DSU	Defense Strategic Update
DSTG	Defence Science Technology Group
FPR	First Principles Review
FSP	Force Structure Plan
FTE	Full Time Equivalent
IIP	Integrated Investment Program
NGTF	Next Generation Technology Fund
ODIS	Office Defence Industry support
RFT	Request For Tender
SMEs	Small to Medium Enterprises
STEM	Science, Technology, Engineering and Mathematics
S&T	Science and Technology
TRLs	Technical Readiness Levels

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Introduction

Problem Statement

Defence's excessively risk-averse culture, hierarchical structure and lengthy acquisition process challenge Industry's ability to bring its unique, positive attributes to enable Defence to keep up with this rapidly evolving environment. ***The time to deploy new technologies and capabilities with frontline Defence operators is too long.***

Aim

To identify blockers in the culture, structure, and process of Defence that limit Industries' ability to rapidly bring innovation into operation, and to propose what a successful transition of innovations may be.

Objective:

- Define what a successful transition of innovations into capability may look like.
- Understand what organisations and mechanisms are currently intended to accelerate sovereign innovation.
- Identify through stakeholder interviews, the themes that have a constant impact, transitioning innovation from industry into Defence capability.
- Present high-level recommendations summarised from our findings that will improve the innovation environment in the Defence community.

Background

To reach the objectives of the project the group did some background research on:

- the strategic context in which Defence innovations are needed and the environment it is occurring in,
- the broad elements of the innovation system and how elements internal to Defence work with Defence industry and academia along the innovations pipeline, and finally
- the characteristics of the Defence Industry that are unique to Australia.

We then conducted interviews with engineers, project managers and researchers from industry, academia, and groups in Defence to determine the issues and barriers to innovations that they are currently experiencing. The findings from this research were then synthesized them into key points that were thematically grouped into three major themes Risk Assessment - Acceptance and Management, Funding and Resource Constraints, and Communications and Collaboration.
Finally, recommendations have been proposed for the top issues drawn out from the collected data.

Defence Strategic Context

The 2020 Defence Strategic Update (DSU) [3] and 2020 Force Structure Plan (FSP) [4] recognised the development of Defence strategic drivers previously identified in the 2016 White paper [1]. These drivers consequently accelerated with increased military modernisation, coercion and grey zone activities undermining Australia's security and an increased risk of state-on-state conflict. The warning time for a major conflict has reduced from the ten-year time frame on which Defence's planning is based.

The Australian Defence Force (ADF) relies on technological innovations to maintain superiority in its operational capability over potential adversaries in our region. The increase in the volume of research

and development in technology, that could potentially be used to disrupt Defence capability, from outside of the Defence sector and increase investments in research and technology by our adversaries. The conclusion here is that Australia's operational superiority is under threat. The need for strong collaborative partnerships with academia and industry partners and an increase in the volume of Science and Technology transitioned through to capability is undeniable and critical.

The challenge for Defence is to ensure that innovations with high value and impact on the ADF from the Defence Science Technology Group (DSTG), universities, publicly funded research organizations and businesses are mature and available for use. In this endeavour, strong collaboration with Universities and the Australian Defence Industry is fundamental, however, Australian innovators face real difficulties in finding a pathway for their technology into Defence capability [5]. Technology may be perceived as too risky or costly to adopt or the process and mechanisms for the transition of technologies to capability are insufficient.

The 2016 Defence Industry Policy Statement [2] recognised these difficulties announcing initiatives to strengthen and streamline the Defence Innovation System and stating "Defence will change its culture and business processes to systematically remove barriers to innovation". The Defence industry policy statement announced four key initiatives in its new approach to Defence Innovation

- Next Generation Technologies Fund (NGTF) is an investment in next generation game-changing technologies.
- Defence Innovation Hub (DIH) is an investment in collaborations between industry and Defence throughout the Defence capability development cycle from initial concept, to prototyping and testing to introduction to service.
- Centre for Defence Industry Capability (CDIC), Portal will facilitate engagement between Defence and innovation activities across Australia.
- And Change the culture and process to remove barriers to innovation.

The DIH is the main vehicle for the development of Australian innovations to be bought by Defence or exported, however, the rate of technology being transitioned into Defence capability is low with only 5% of funded projects being exported or acquired by Defence. [9,10].

Earlier this year the Labor Government announced the that Advanced Strategic Research Agency (ASRA) will be established as an independent agency to fund cutting-edge research from universities, industry and other publicly funded research organizations are funded, coordinated, and supported with a particular focus on pulling through innovations into capability.

The design of the ASRA will have elements of the US Defence Advanced Research Projects Agency (DARPA) along with the Defence Innovation Unit (DIU). These innovation organisations have been successful at generating and commercialising Defence innovations in the US. However, any new organisation established by the Australian Government will need to counter the challenge of the Defence department's risk averse culture and complicated, bureaucratic processes to allow them to meet the challenge of developing game-changing technology rapidly which is an inherently risky process [14].

The Defence Strategic Review (DSR) announced on 3 August 2022 [8] aims to better understand where Defence should prioritise its investment to meet the challenges that it faces now and those that are coming. Recommendations from the DSR will affect investments in research and development of innovations and potentially the mechanisms and the structure of organisations responsible for delivering innovations into capability for Defence.

Defence Ecosystem

The Defence ecosystem sits within the broader ecosystem of Australian Science and Technology development with dual-use technologies being developed and advanced by industry outside of Defence. Australia also benefits from strong international relationships with international ecosystems through treaties such as Technical Cooperation Program [19], AUKUS [15] and Australia's Quad partnership with India, Japan and the United States. In scoping our project, we focused on Australian and Defence based mechanisms of support to innovation within the Defence community.

Capability Acquisition and Sustainment Group

ADF has a centralized procurement process that is difficult to break into. It does not cater to innovation that is occurring outside of this process in a decentralised way.

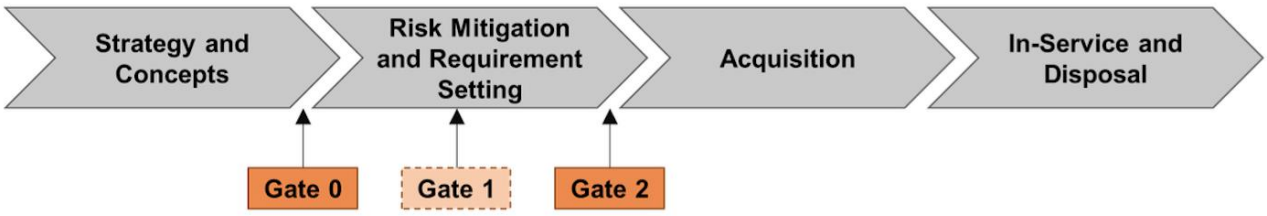
The Capability Life Cycle (CLC) is the process Defence has "for capability development and delivery of capital projects, and associated through life support, related to major capital equipment, infrastructure, and enterprise enablers and information and communications technology. "[20] Through this framework Defence links a rolling budget known as the Integrated Investment Program (IIP) to its Defence Force structure and strategic goals.

The Force Design process translates strategic direction into a future force structure." The DCAP process determines the force packages needed to meet Defence needs. This process yields a set of requirements and needs for the domains. Capability Managers (CM) within the groups and services have the responsibility for generating programs that will deliver force packages needed to deliver effects identified by the Defence Capability Assessment Program (DCAP). "[22])

CMs delegate responsibility to program, project and product sponsors to work collaboratively with program delivery managers and integrated Project and Product managers in the Capability Acquisition and Sustainment Group (CASG) to develop project proposals that go through the CLC. (See Appendix B.2 for the high-level outline of this process [22])

The CLC process has four phases: Strategy and Concepts, Risk Mitigation and Requirements setting, **A**cquisition Phase and In-Service and Disposal phases depicted in Figure 1.

Figure 1 Capability Life Cycle process [22]



Strategy and Concepts where capability needs are identified through a force design process. This phase concludes with the development of a business case which is considered by the Investment Committee at gate 0. "In order to initiate a new project, there must be an agreement on the priority and a source of funding will need to be identified. This is normally achieved through the DCAP process." [22]

Risk Mitigation and Requirements setting phase are where options for developing capability are developed. This phase is supported by Technical Risk assessment done by DTSG, risk mitigation activities that could include prototyping, test and evaluation activities and consolation with industry to further develop. This phase finishes after two rounds of development of the program strategy by an

integrated project team and an assessment of the Program Execution Strategy by the Investment Committee.

Large IIP projects are geared toward Primes who have the capabilities required to integrate technology and the contractor managers, lawyers and personnel to interact with Defence's procurement process.

Defence Innovations Centers

There are many Defence innovation centres, for example, Jericho and Win where smaller innovation projects are funded out of the sustainment fund of the group or service. These centres are proactive in engaging communities of SMEs and academia develop solutions to Defence problems on a smaller scale to large IIP projects. Jericho provides funding for innovations to be prototyped and tested and typically taken through to TRL7-8. SMEs are connected to the end-user, however, the innovations still require pathways through to CASG projects for innovations developed under their program. Jericho now seeks a connections to a capability manager and program sponsor who are generating plans for an IIP program before proceeding with an innovation.

Office Defence Industry Support

The Centre for Defence Industry Capability (ODIS) was replaced by the Office of Defence Industry Support (ODIS) in 2021 in response to a growing demand. Furthermore. ODIS provides advice, guidance and mentoring services to SMEs. ODIS links SMEs to Defence programs and end-users to support innovation, provide services to help SMEs become "Defence ready" as well as providing information to Capability Managers, end-users and Primes of the expertise and capability of Industry SMEs.

Defence Innovation Programs

Next Generation Technologies Fund (NGTF) and the Defence Innovation Hub (DIH) innovations programs were introduced in the Defence Industry Policy Statement to provide a "single Defence innovation pipeline" with the "Innovative technologies and concepts researched under the NGTFcould be further developed and realised into capabilities through the DIH" [23]

Defence Innovation Hub

"The DIH has been allocated over $1 billion to 2030 to invest in the development of innovative technology, from early concept stage through to demonstration, prototyping and integration." [23]
The hub was designed as the one-stop shop for innovations to be pulled through to capability.
The DIH program can fund projects in four different phase Phase1 Concept, Phase2 Demonstration, Phase3 Prototyping and Phase4 Integrations covering TRL 1-8[26].

Callouts from DIH are focused on certain capability areas and tender proposals are assessed by certain criteria outlined in the call. Most projects enter the DIH in Phase 1 or 2. A proposal from Industry in response to a call out or an unsolicited proposal will be assessed by DIH's technical team and sent out to Defence for a program sponsor if a sponsor has not already been identified. The team with a successful proposal will receive a request for tender which will be evaluated and then prioritised by the DIH governance board.

The process of moving from one phase to the other for a company successful in delivering requires entering another competitive process that the company may or may not win depending on the competing priorities the Hub's governance board is balancing. This creates uncertainty and delays in the innovation process for the SMEs relying on funding to develop their innovation.

The DIH has had some notable successes in the transition of innovations into capability over a 10-year time frame, Xray machine MicroX and Project Rocklobster led by L3 Harris [25], however, these are the exception rather than the norm. The pathway into a capability project in the IIP is difficult to secure

and "depends on having a strong Capability sponsor who understands the value of the innovation and is able to champion this innovation with the CASG Project team" [23]. "Program Managers in CASG are not required to look at Australian innovations when considering the retirement of technical risk of their program execution plans." [23]

Eco-Jet Engineering in 2019 produced very small and efficient turbine technology "In applications requiring extremely lightweight and high-power devices. Whether for deployable power, micro unmanned vehicle systems, directed energy or other use cases, Eco-Jet's Ultra-Micro Turbine Engine provide flexible on-demand power in the 500W – 5kW range".[27] They won Defence grants to develop this technology and run a number of successful trials of the technology. During the acquisition phases, the value-for-money settings were such that CASG invested in an overseas product, leaving Eco-Jet Engineering with no local pathway to market.

Next Generation Technology Fund

$730 million over the decade 2025-26 has been invested in the NGTF to research emerging technologies and future technologies that can be used for a future Defence force.
NGTF is run by the DSTG and is focused on research in priorities areas such as Trusted Autonomous Systems, Space Capabilities, Cyber, Advanced Sensors, Quantum Technologies and more. There is a range of mechanisms for partnering under the NGTF depending on the size and scale of the project which includes Grand Challenges, Defence Cooperative Research Centers, University Research networks and others.

Each propriety area has a Program Lead responsible for developing a program around their particular technology focus targeted at low TRL research, TRL1 - 4. Calls are put out through the NGTF fund for partners to respond to proposals addressing the research interests. Activates under the NGTF have seen larger more coordinated research programs with industry and academia. However, few of NGTF's programs have been taken up by the DIH [23, 24].

Defence Science Technology Group

DSTG has a range of core, extended core and supporting roles that it plays for Defence. Its core roles are as a trusted S&T advisor to Defence in operations, sustainment, acquisition and future Defence Force concepts. These roles place DSTG across all TRL levels depicted in Figure 2. DSTG does a lot of work in the lower TRLs, doing Research and development.

The More together: Defence S&T strategy 2030 released in response to the changing context sets the role of DTSG to "harness the efforts of the national Defence S&T enterprise to deliver mission-directed research aimed at providing Australia with a critical capability advantage. "[6]. At the heart of this strategy is a set of STaRShot challenges focused on capabilities that are critical to Defence Capability. STaRShots [7] challenges aim to harness innovations and expertise in Universities, Start-ups, Small Business, publicly funded organisations, to focus research efforts, scale up research efforts on S&T that will have the most impact on developing Defence capability.
STaRShot Challenges each have a Program Leader responsible for designing and building up the STaRShot program, building collaborations with universities and Industry and providing support to the development of the STEM pipeline as well as the development of industry in sovereign capability areas. The STaRShots have a range of activates in them from lower TRLs 4 to 7

High-level representation of the Defence ecosystem

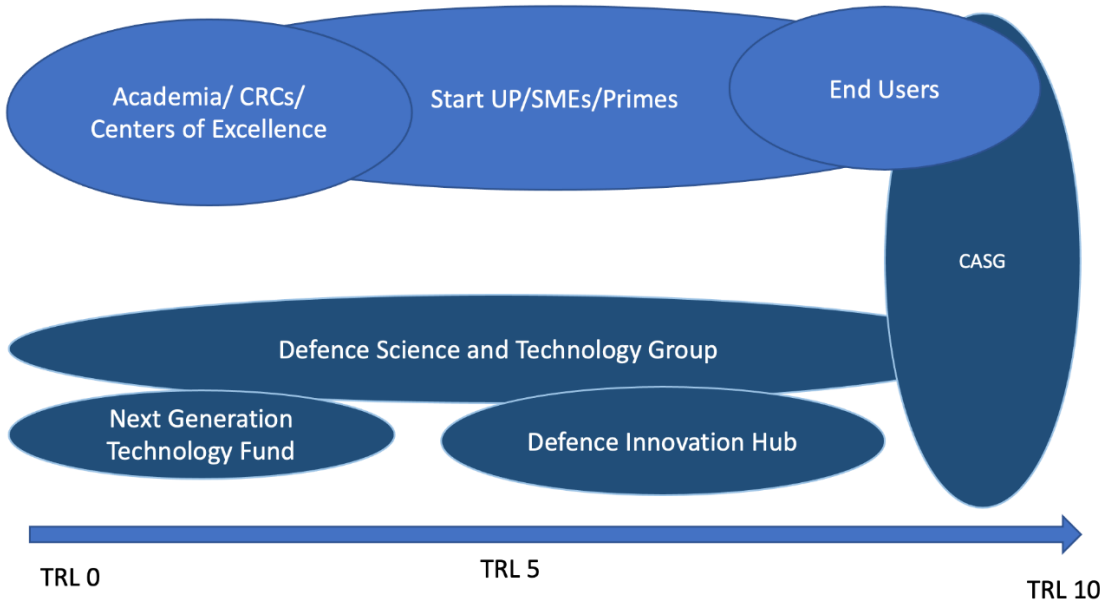
We have considered the roles of parts of the Defence Ecosystem as viewed through a lens of technical readiness levels Technical Readiness Levels (TRL). The TRLs define the maturity of the innovation by the tasks needed to take a concept to a fully developed and integrated capability. For example, TRL 1 is basic research while TRL 2 is applied research (See Appendix B technical readiness levels definitions and descriptions [29]).

Figure2 is a high-level representation of the Defence Ecosystem. It shows where academia and industry are seeking to engage with a variety of organisations and funding sources throughout the innovation process depending on where in the TRL maturity hierarchy they enter the Defence Ecosystem. NGTF, DIH, CASG and the end-users are placed roughly on the TRL map from TRL 0 basic research of a concept through to TRL 10 a fully integrated system in service. CASG is the delivery agency for transitioning capability into Defence and sits approximately at TRL 7. This is where a pilot of an integrated system is tested and evaluated through to TRL 10.

Innovations developed by SMEs must find a pathway into the CLC process through the complicated and lengthy process used by CASG to ensure that the IIP programs and projects are targeted at gaps in Defence's capability. The different parts of the innovations system are effectively performing their task of developing innovations and SMEs, however, there is a poor connection between these elements. In particular there are no clear pathways for SME's innovations into CASG. It is critical to secure a pathway into CASG through any of the innovation streams required by the Capability Manager and Project Sponsor to strongly champion the local innovation for its inclusion in the program strategy of an IIP project.

The diagram in Figure 2 also shows that in the early stage of concept development the SMEs and DSTG are not strongly connected. It is therefore a challenging task to ensure communication between the SMEs, end-user and CASG to safeguard that the innovations developed will meet the end-users needs and the contracting requirements of CASG.

Figure 2 High-level depiction of the Defence innovations pipeline



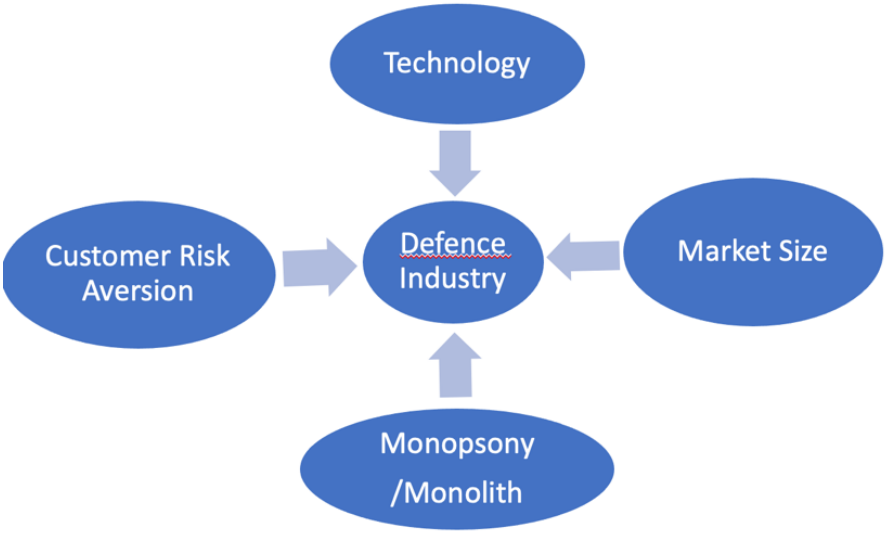
Pressures on Defense Industry

The pressure operating of the Australian Defence Industry due to Australia's size and relative physical isolation from its allies are shown in Figure 3 and explained by Ferguson 2012 in their report on product innovations in Australia [18].

Defence acquires its goods and services from private companies while it invests in research and development mainly through DSTG, NTGTF and DIH while making much less effort to commercialize the results of this investment.
The main forces that shape Defence Industry are:

- The need for continual innovations driven by reliance on technological superiority used to compensate for a relatively small ADF.
- A culture of risk aversion developed over a long span of time due to acquisition projects which have run over time and budget drawing a lot of criticism to the Defence Department.
- Monopolistic and monolithic nature of the Defence customer governed by:
    - The only customer for Defence services is the Government. Through its spending, it exercises control over the size of the Defence Industry and sets the condition of entry for Defence partners.
    - Defence tends to buy its services through a few high-value acquisition projects using only a few prime companies. This sets up a binary condition for the industry who receives 100% share of the market if they are the preferred contractor while SMEs are left with a share of work, they obtain through cultivating a relationship with the prime.
- The size of the market is relatively small making it difficult to achieve economies of scale for a company developing new products particularly if demand is small and inconsistent.

Figure 3 Pressures on the Australian Defence Industry [18]



Methodology

To address our aim *to identify the perceived issues within the Defence ecosystem that limit bringing innovation to the frontline*, we ran a series of interviews with subject matter experts across the Defence ecosystem. Our guiding principles were:

- **Rigorousness** – we aimed to gather findings across the entire Defence ecosystem.
- **Robustness** – we sought to ensure that the analysis of the findings were supported by the evidence and not skewed by a single interviewee.

The interviews were semi-structured, whereby an interview outline was designed to guide the interview process and ensure robustness of the results, but also affords the ability to adapt the interview to the interviewee's area of expertise. The results from the interviews were collated by the project investigators, and then synthesised into common themes using a thematic analysis.

Interview outline design

Semi-structured interviews provide a method to gather a rich qualitative impressions of complex topics while maintaining a robust approach to data collection. This is achieved by providing interviews a consistent structure around open-ended questions (i.e. questions where the interviewee can provide more than a yes/no answer). To design the interview outline, we ran a series of workshops to identify a series of open-ended questions seeking to elucidate and address the project aim. Specifically, we were seeking to understand the subjective, personal experiences across the following areas:

- **Behaviour**—what are they doing?
- **Motivation**—why are they doing this?
- **Outcome**—what are they trying to achieve?
- **Ecosystem**—what is the network of relationships?
- **Mindsets—**who they think about their relationships in the network?

The results of the interview outline design workshops were nine key open-ended questions (and four potential follow-on questions) grouped into themes of **Technology**, **Engagement**, and **Improvement Innovation**. It is important to note that these are the themes of our interview questions, and do not reflect the final themes identified from our results synthesis (described in the Findings section). The interview outline is presented in Appendix A.

Interviewees

We identified six key areas across the Defence ecosystem that we would gather findings from: Defence, Defence Primes, Defence SMEs, Academia, Supporting Organisations, and international Defence innovation groups. We interviewed 11 subject matter experts across these areas, as summarised in Table 1.

Table 1: subject matter experts interview across the Defence ecosystem

Area	Subject matter expert background
Defence	• Commander, Naval Shipbuilding and Sustainment Group, Navy • Major, Army • Chief SSPE Division, DSTG • Group leader Strategic Innovations Pathways, DSTG • Program manager, Defence Innovation Hub (DIH)
Defence Primes	• Senior sales director, SAAB
SMEs	• National manager, Defence SME • General manager, Defence SME
Academia	• Associate Professor in collaboration with Defence, R&D, Adelaide University
Supporting organisations	• AIDN-SA President
International Defence innovation groups	• Lt Col, US Defense Innovation Unit

Synthesis

From the interview process, we collected:

- 13+ hours of interview material;
- ~80 key findings; and
- ~20 recommendations.

To robustly synthesise these findings, we used a semi-blind open-coding approach [31] to identify themes. This involved each investigator individually coding the findings by theme. We then met to

collate the themes to reach consensus. Seven themes were individually identified in the interviews, which we reduced to the themes of: 1) Risk assessment, acceptance, and management; 2) Funding and resource constraint; and 3) Communication and collaboration. We aligned identified recommendations against these themes.

Findings

In this section, we present the three major themes of our findings.

Theme 1: Risk Assessment, Acceptance and Management

Risk was prevalent in interviews with Defence enterprise partners, particularly when investigating the apparent barriers and negative pressures applied to rapid technology development and deployment with Defence. Research into the theme revealed the Australian Government and Defence Forces have robust processes for the assessment, acceptance, and management of risk associated with Defence acquisition projects. Due to the broad nature of Defence procurement, these processes are required to manage the acquisition risks for everything from uniforms through to highly complex submarines. While these risk management processes offer flexibility to accommodate this, it is not always taken advantage of particularly, it appears when assessing risks related to innovative technologies.

The inference of the authors and some interviewees was that the Government process is a significant restriction and potential barrier to rapid innovation and deployment of new technology to Defence. This appears unfounded with little evidence supporting any recommendation to change existing risk management processes. Although any reasonable assessment would conclude that overall risk increases as project timelines reduce, higher risk levels (when correctly assessed) were not identified as a barrier to success for such projects. A sound example of this is the rapid acquisition and implementation of a new weapon capability into HMAS *Brisbane II* (DDG 41) circa 1990. *Brisbane II* was to support Gulf War operations, however, prior to deployment a significant vulnerability in her armament was identified. Despite the high risk nature of the project, within three months of identifying the vulnerability, a new weapon capability was implemented and the deployment schedule maintained. The success of this rapid capability insertion for *Brisbane II*, being both high risk and short timeframe, is in stark contrast to an example from the Collins Submarine Program where a low-risk initiative to implement portable commercially available thermal imaging cameras for maintenance and fault finding has essentially failed after several years and the capability lost.

With the evidence presented, the investigation concluded that barriers to starting and succeeding with this type of project are introduced through the assessment, acceptance and management of risk rather than the credible hazards themselves. The investigation determined the causes of this to be:

- Lack of training and experience in assessing risk,
- Ill-informed assessment of risk, particularly regarding new technologies,
- Unfamiliarity of the risk assessors and acceptors with the actual hazards, and
- Peacetime mindset toward risk.

A particular frustration of one RAN Commander interviewed was that “risk assessments, although following an approved process or framework, still boil down to the “gut feel” of the individual assessing the risk”. Essentially if the Executive Authority accepting the risks is not invested in the success of the project, or their “gut feel” is that the risk is too great for them, the project will either not go ahead or likely fail if it does. Unfortunately for Defence, this results in many good innovations and potentially potent future capabilities die on the vine. In summary, there appears sound evidence that extraneous governance processes are not necessarily a barrier to rapid innovation projects for Defence. It may just be that “where there’s a will, there’s a way” and if suitably qualified and experienced individuals assess the risks and appropriately authorised and positioned individuals are willing to accept the risks and champion initiatives, success is probable.

Regarding new capability acquisition, the investigation noted a significant difference in the mindset and behaviours of the Defence enterprise during peacetime and wartime. An example offered by a RAN Commander of a peacetime project executed with a wartime mindset was the implementation of a ship launched aerial surveillance drone capability for the Royal Australian Navy completed within two months. Notably, the HMAS *Brisbane II* example discussed earlier was motivated by a wartime need and the surveillance drone was not, yet both were successful due to the mindset of key project stakeholders. Further supporting this mindset theory is that no correlation is observed between project success and risk i.e. high risk projects are just as likely to succeed as low risk projects provided the mindset is that of wartime. Of further note is that the successful projects identified in the investigation all had an invested champion. It is of course difficult to define what the wartime mindset is, however, in the capability acquisition context it seems to be one of greater perspective and appetite to accept risk to achieve a common goal.

Theme 1 Recommendations

Qualified Risk Assessors

Mandate that the assessment, acceptance, and management of risk must only be performed by suitably qualified and experienced persons. The assessment and management of risk is a skillset requiring training and experience to be deemed competent. In the Defence capability acquisition context there was no evidence formal qualification and experience requirements to assess and manage risk. Underqualified and under experienced persons will typically assess risk as higher than a suitably qualified and experienced person and this leads to less process tailoring and higher process burden on the Defence enterprise.

Wartime Mindset

Adopt a wartime mindset in all aspects of rapid innovation and capability acquisition projects particularly when assessing risk. Our research found strong correlation between a wartime mindset of the key individuals and project success.

Project Champion

Rapid innovation and capability acquisition projects need champion to maintain focus, drive, and perspective. The examples presented and other successful projects all had a champion invested in the project's success.

Theme 2: Funding and Resources Constraints

The second domain of findings identified in the undertaken research has in this report been labelled "Funding and Resource Constraints". In this section, the impacts of these constraints have been exemplified, analysed and suggestions for rectifying recommendations have been presented.

Existing frameworks and support initiatives

As mentioned in the section "Defence Strategic Context" above, there are several Defence related plans, policies and strategies e.g. Defence White Paper, Defence Industry Policy Statement etc. in place in order to explain and guide how dedicated funding should be distributed across the Defence community. These are excellent initiatives by the Government, federal as well as local, to support

innovative initiatives from the Defence Industry and Academia in Australia, of which a few have been depicted in Figure 4.

Figure 4 Government initiatives to financially support Defence Industry and Academia in Australia

Difficult and slow process to access dedicated Defence innovation funding

It is generally accepted that accessing funding for Defence Industry innovation initiatives with the purpose to be implemented in frontline Defence can be difficult, this is amongst other issues due to the high level of competition for Government funding and the stringent formal requirements, complex and time-consuming application process, that must be met in order to be eligible access to the funding. Furthermore, the Defence bureaucracy is very bureaucratic and thereby making the process even slower which results in the process being too slow for the intended purpose.

In the interviews undertaken as part of the research for this report, it was established that there seems to be an exception to the rule where a much quicker process is prevailing according to both industry and academia interviewees, and this is in the "Special Forces" domain. When an entity of the Special Forces is the customer the cumbersome Defence bureaucracy appears to be considerably less onerous and access to funding is quick and easy, and runs outside of the conventional funding pathway. This has been taken as an indication that Defence recognises that the regular pathway is slow and cumbersome. However, when it is required for tactical or other operational reasons there are ways around the bureaucracy in a more streamlined and effective pathway as exemplified in Theme 1 above. This is again likely to be related to Defence's increased risk appetite in situations involving genuine deployments and/or tactical use of Defence Force entities.

Barriers to entering the Defence market are not being removed as intended

A large part of the reason for setting up the DIH and the NGTF was to bring the Defence Industry and Academia closer together. Another purpose of the dedicated funding was to improve (speed up) the pathways for introducing innovations and new technology into frontline Defence. Furthermore, the initiatives are intended to provide opportunities and support (remove barriers) for smaller companies and institutions to enter the Defence market. However, this objective seems to have failed and according to the research undertaken, there are several examples of slow, difficult and expensive circumstances preventing the Defence Industry and Academia from accessing the funding and to collaborate in an effective and efficient way. It is also worth noting that by 2025-26 the DIHb and the NGTF collectively will have supported the Defence community in excess of $1.5 billion over the last decade. Hence, the Defence Industry and Academia are not necessarily lacking funding, it is rather the difficult and slow and cumbersome process to access the funding that is one of the major barriers to a rapid process to provide the frontline Defence with much-required innovations.

One example of this that was identified in the research was the turn-around time and cost for a Defence Prime to respond to a Request for Tender (RFT) for a major Defence contract. The technology required to be successful in this tender was new and "unproven" and therefore was associated with a high technical risk. The Prime spent three months with a team of 24 FTEs at a value of approximately $1.1 million (self-funded) to respond to the RFT. Defence then spent 18 months evaluating the industry response. A process like this drastically limits the number of Defence Industry participants who can

afford to respond to this type of request, and it is only well-established Primes who can afford an endeavour like this.

No tailored pathway for Small to Medium Enterprises, Start-ups and Academia

In spite of what can be expected there is no "tailored" quick and easy pathway to access Defence Innovation Funding that can be utilised by SMEs, start-ups and small university entities. It is very much a "one-size-fits-all" approach here that creates a situation where these small entities are excluded from opportunities to enter the market due to insufficient funding and the big primes are the only entities with the "financial muscles" to survive. One interviewee from Academia explained how the university had to spend 3 weeks utilising one FTE at an approximate value of $12,000 to apply for a one-year grant of $150,000. This was close to 10% of the funding that the university applied for, which is seen as far too expensive and ineffective.

Short posting cycles and limited access to competent staff

According to several interviewees, Defence can be slow to adopt and progress new ideas, which to some degree can be contributed to the limited knowledge in some areas of Defence mainly due to the short posting cycles, predominantly 2 - 3 years, and this is particularly prevalent for uniformed staff. In addition to this, several of the Defence Industry interviewees complained about the difficulties in accessing custodians and decision-makers in Defence, once again this can be contributed to short posting cycles and resource constraints. It is therefore a reasonable conclusion to assume that the short posting cycles are potentially preventing a deeper understanding of complex problems and the true potential in new technology and innovations proposed to Defence by the Defence Industry and Academia is either completely lost the "red tape" or unnecessarily delayed.

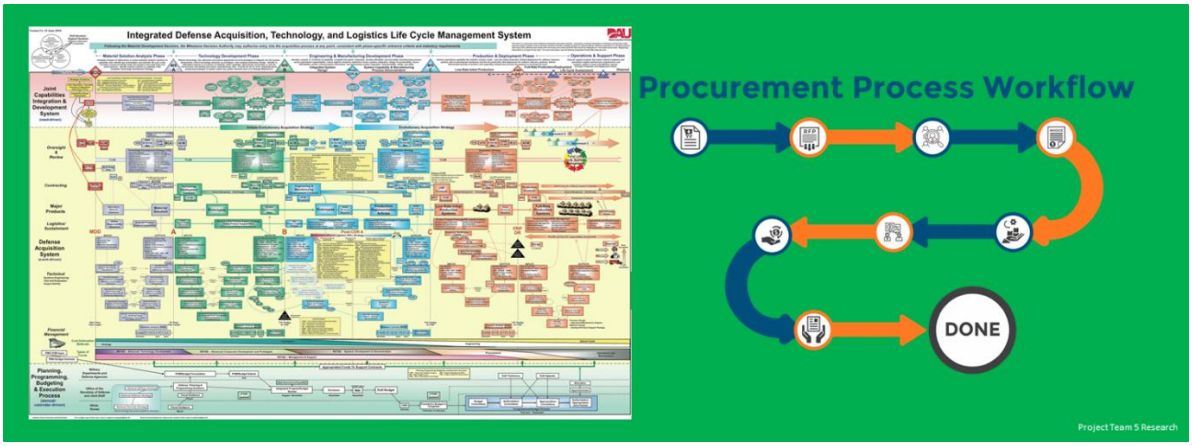
Recommendations for future improvements regarding funding and resource constraints

A selection of recommendations has been presented below in order to rectify some of the issues identified within Theme 2 - Funding and Resource Constraints. There is, however, no "one-size-fits-all" solution to the funding issue, as the amount of funding available for Defence Industry innovation in Australia varies depending on the specific project or initiative being undertaken in combination with Defence's risk appetite as identified in this section

a. Recommendations related to the difficult and slow process to access dedicated Defence innovation funding:

- Reduce administrative requirements, and
- Tailor and streamline processes based on sound risk assessments as indicated in Figure 5.

Figure 5 Streamline and simplify processes to access Defence Innovation funds



b. Recommendations related to barriers entering the Defence market are not being removed as intended:

- Create dedicated rapid pathways for small innovations, and
- Introduce panels of trusted entities for rapid turnaround

Defence should keep improving opportunities for collaboration within single domains. However, more importantly, Defence should promote a deeper collaboration across joint domains.

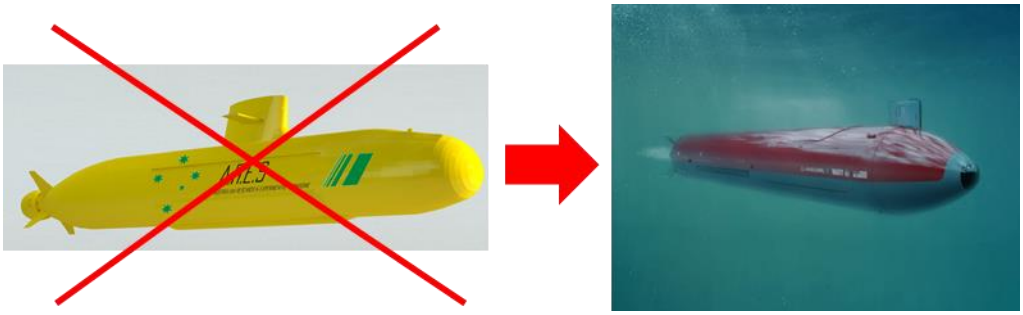
c. Recommendations related to trust and support for domestic Universities, research and development.

- Demonstrate confidence in and support for domestic Universities and Research.

This can be exemplified by the poor outcome from an indigenous research perspective when overseas research was supported rather than domestic assets for Autonomous Underwater Vehicles (AUVs) as depicted in Figure 6.

"Defence Minister Peter Dutton has announced that the federal government will co-fund a three-year $140 million unmanned undersea vehicle development program with military tech firm Anduril." [28]

Figure 6 Anduril's UAV promoted ahead of University of Adelaide's ARES



Theme 3: Communications and Collaboration

The final domain of findings identified in this report been labelled as "Communications and Collaboration". It is obvious that the quality and extent of communication and collaboration between Defence and Defence Industry will be essential for Australia's preparation for tomorrow's conflict. This section will highlight the strengths of current communication and collaboration as well as the issues identified and potential areas of improvement.

Strengths

We know that over the past decade, Defence has increased collaborations with industry, especially with the Primes. There are greater opportunities of collaboration with the increased number of Defence Expositions (Land Forces, Indo Pacific, and Avalon) over the past three to five years, and the number of opportunities are increasing each year.

I was fortunate enough to attend the Land Environment Working Group (LEWG) 2022 earlier this year. It was obvious that the higher levels within Army are aware about the need for greater communication and collaboration between Defence (Army in this case) and Defence Industry, especially in the face of the greatest threat faced by Australia over the past 80 years. Recognising that

fixing communication and collaboration will enormously enhance Australia's capacity to defend itself is the first step in addressing it.

Issues Identified

Multiple issues had been identified within this domain:

a. *Defence engagement with Academia and SMEs*
We appreciate that Defence has engaged with Academia (predominantly via DSTG with multiple universities) using StarShots and other programs. However, these programs are siloed, with very few opportunities to new organisations to engage or become involved.

Direct engagement of Defence with SMEs is almost non-existent. SMEs have to engage with Primes to be involved with Defence. This creates major problems because the priority for most Primes is not the SMEs. Often, larger SMEs such as Redarc, APC Technologies and others who have been entities for several decades are able to land contracts with Primes whereas smaller or younger SMEs find it too difficult.

b. *Extensive bureaucracy and excessive 'top-down' approach*
and short staff postings makes Defence-Industry collaboration difficult

c. *Defence contact points for communication and collaboration*
Defence do not provide contact points for communication and collaboration

d. *Unclear identification of actual technology needs*
Identification of the actual technology needs are often unclear

e. *Insufficient focus on the 'end-users'*
There is insufficient focus on 'end-users' within Defence

Potential areas of improvement

Our team has highlighted a number of areas that Defence and Defence Industry communication and collaboration can improve

a. *Defence engagement with Academia and SMEs*
Defence needs increase engagement with SMEs and Academia

b. *Remove extensive bureaucratic policy*
Current excessively bureaucratic policy that restrict collaboration should be removed (e.g. with the US Defence Innovation Unit)

c. *Clear identification of Defence points of contact*
Points of contact within Defence needs to be clear to ensure that communication, interaction, and collaboration is efficient

d. *Asking the right questions*
Defence-Industry interaction needs to improve to ask the right questions in order to ensure the right solutions are met (thereby avoiding cost blowouts and delays in project delivery)

Recommendations

The main problems identified by our group preventing Defence to be more agile revolve around two major aspects: a) The culture within Defence; and b) The structure within Defence. The key

recommendations subsequently generated by our group explores ways to change the cultural and structural limitations, thereby enabling greater engagement between Defence and Defence Industry, which in turn will make Defence significantly more agile.

A. *Urgent change in the culture within Defence*
    a. The excessively risk-averse mindset within Defence needs to change to adapt to consequences of tomorrow's conflict.
    b. There needs to be an urgent reduction of the current Defence policy requirements that stifles innovation and collaboration
    c. 'Fail-fast' concepts required for rapid innovation needs to be incorporated within Defence culture immediately

B. *Changing the structure within Defence*
    a. 'Top-heavy' approach of decision-making prevents Defence from being innovative
    b. Mid-to-high ranking officers need to get better exposure to SMEs and businesses (sabbaticals) to understand difficulties faced by SMEs

Improved innovations pipeline

We have identified that there are gaps between different originations and programs that are in place to for industry and academia to produce innovations around the TRL4-7 . The various parts of the innovations system do their jobs well however once the contact is finished there is no plan for what comes next. Need to cultivate a relationship of trust with universities and industry in the innovations system to ensure that there is true collaboration. Ensuring that there is a plan for what comes next is important to this relationship.

Strategic Innovation pathways job as providing the glue between these different innovation mechanisms to ensure that these parts of the ecosystem work well together.

The Requirement for reliable pull through for SMEs is to have high levels of **desirability, feasibility**, and **viability**. (From interviews with DSTG [24])
Where

- desirability: innovation is wanted by the end user and solving a Defence problem that has been prioritised,
- feasibility: subject matter experts verify that the innovative solution is scientifically possible, and
- viability: industry has identified they can build the innovation at a cost acceptable to Defence.

"Stronger confection between Awareness of Defence problems a big part of dealing with Defence and having Defence engaging with SMEs to understand their capabilities.", (From industry interview.)
In ensuring that the innovations are desirable increase industry's awareness of DCAP gaps and opportunities needs and Defence's priorities. The DST PLs for NGTF and StarShots and need to be across the needs statements and priority areas for Defence coming out of the DCAP and raise the awareness of industry and academia of the problems that are important to Defence and shape where industry focuses its efforts in developing their Technology. In this way the new innovations are connected to a CM and a sponsor are **desirable** to the end-user. The development programs in the NGTF and the STaRShots produce opportunities to partner through Challenges/Grants/Contracts.

The Smart buyer process in the early stages of the CLC assess the **viability,** the value for money of the procurement strategy and the **feasibility** of the technical solution through TRA done by DST) of the program.

Recommend that the procurement policy include a requirement for Australian innovations to be considered ahead of other options and that the Smart buyer criteria be broadened to consider the benefits to the ecosystem gained through the adoption of Australian innovations.

Benefits such as the

- development of a highly trained workforce,
- development of sovereign capability. Whether this STEM experts, software, or manufacturing capability,
- generation of intellectual property that can be commercialized and exported overseas, and
- IP in niche areas that can be used to in international forums to gain greater cooperation with our allies and access to their technologies.

The selected partner may not offer the cheapest option or the least risky solution. Other considerations in broadening the Smart Buyer Process are:

- what does the definition of sovereign capability actually mean. Does it mean manufactured in Australia, the company is Australian, the company has a footprint only in Australia or the whole supply chain is in Australia?
- which technologies and industries are appropriate to develop as sovereign capability?
- how will the selection of and SME affect the integrator Prime?
- how can the SMEs' level of business readiness and level if technical risk be assessed?
- how can the SMEs be supported to improve the outcome of the assessments undertaken?

Encourage and assist SEMs identify dual use for their technologies to mitigate the uncertainty of the funding that occurs when priorities and needs of the Capability Manger change.

Design and Role of ASRA

Advanced Strategic Research Agency (ASRA) will be established as an independent agency to fund cutting edge technology and pull technology through to capability. ASRA can act as the coordinator of parts of the innovations ecosystem that are not well-connected covering TRL 4 - 7 where the valley of death lies.

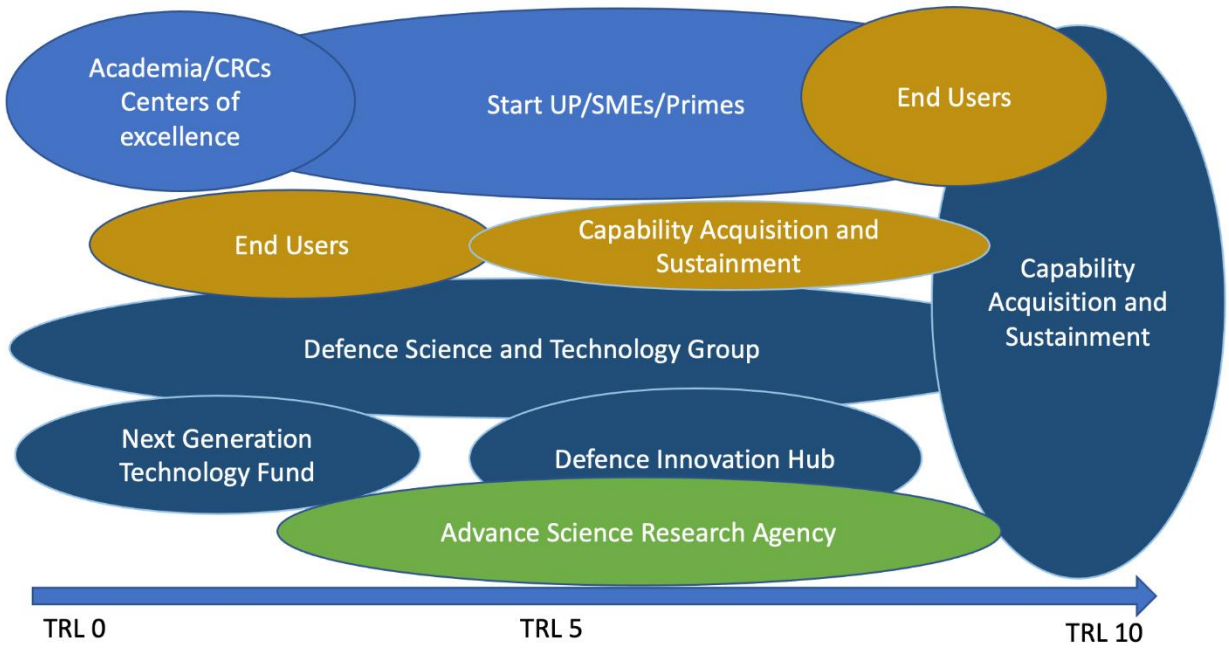
Success looks like: Ensure that the ASRA funds mission driven research with a Defence sponsor and Capability Manager that can provide a pathway in to the CLC process

- ASRA takes on the risk and supports development of innovations in partnership with industry until it can be received by CAS.
- Partners are supported in the produce of the artefacts CASG required to enter the CLC.
- Provide enough on ramps into the innovations system for industry partners through mechanisms such as NGTF, STaRShots and DIH grants.
- Provide more certainty for strategic partners that are developing innovations that are viable, feasible and desirable by eliminating the need to under good multiple competitive processes to secure funding.

Other recommendations following the design of the DARPA organisation include the hiring of Program Managers and Program Leads for a tenure of five years responsible for designing and delivering programs. Program Leads are supported by core set of employees providing expertise in business, risk management, Intellectual property and procurement [13, 14]

Figure 7 is the picture of the improved Defence ecosystem where communications between end-users and CASG occurs earlier in the development process of the innovation and ASRA performs a coordination role across the valley of death at TRL4 - 7.

Figure 7 Updated Innovation System



Conclusions

- Current relationships between Defence-Industry shown to be suboptimal
    - Budget blowouts (>$6B)
    - Delivers blowouts (>98 years)
- Current strategy for Defence innovation is flawed
    - Risk-averse culture
    - Overbearing policy requirements
- Defence needs to make significant changes in mindset, policy and culture to prepare for rapidly changing geopolitical global environment
- Rapid prototyping, better communication and collaboration channels, and smarter funding will help Australia and Defence prepare for tomorrow's conflict faster

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Appendix A Interview Material

Question Guide

Key objective:

- What is the cultural environment with Defence around innovation

The project group will interview representatives from the Defence innovation system to understand how they define their role in their organisation and the role of their organisation in providing innovative solutions to Defence.
We have selected representatives from Industry, Defence end users and Government across a variety of position levels in each sector to gain some insights into how these parts of the innovation system work internally and interact with each other.
The questions are designed first to understand the technology and the capability of the organisation and then to discover

- **Behaviour** – what are they doing?
- **Motivation** – why are they doing this?
- **Outcome** – what are they trying to achieve?
- **Ecosystem** – what is the network of relationships?
- **Mindsets** - who they think about their relationships in the network?

Theme	Questions
Technology	Describe your company's or department's area of focus (including TRL level you operate/intend to operate at):
	What capability does your company have - research, - test and evaluation - manufacturing - consulting
	What is the most important thing for you/your team right now in terms of developing and delivering technology/capability? - i.e., resources (people, facilities, business support etc.); - funding; - time; - security; - strategic alignment with Defence proprieties; - current contractual mechanisms; - other? Why is this the most important?
	What worries you about your capability/technology focus area? - Can be technical or non-technical
Engagement	To help deliver your capability, what is your current arrangement with: - Defence business units (both support and capability)

	- Other Defence industry players including Academia, government, PFRAs etc
	How would you characterize this engagement (including frequency)? - What works? - What could work better?
	What challenges/pain points have you faced when attempting to deploy new technology with (frontline) Defence?
	What additional engagement support would be ideal for your capability to prosper?
Improving Innovation	Improving Defence Innovation - What improvements to Defences business practice would you like to see? - What areas of your business do you think could be impacted by these improvements? - What criteria is of the most benefit to your business the short-term/medium-term/long-term?
	How would you define a success? - How would you measure success? - What end-product/output would it need to accomplish to be defined as successful?

Collated and Sorted interview finding

Key Finding	Recommendation
Risk Assessment, Acceptance and Management	
The understanding of the context of changes to existing, or the introduction of new capabilities is extremely important as it informs the assessment of risk.	
The understanding of the context of changes to existing, or the introduction of new capabilities is extremely important as it informs the assessment of risk.	
Risk adverse; Defence takes a reactive approach to decisions that hinge on the rapid acquisition of capabilities, improving innovation within each sector.	
There is a significant difference in the mindset and behaviours of the Defence enterprise when making changes to, or introducing new capabilities during peacetime verses wartime. That said, there are examples where wartime behaviours employed during peacetime has resulted in successful projects. The difference I feel is the assessment of and appetite to accept risk with a wartime mindset.	
Innovation timelines; Defence's hesitancy to "pull the trigger" on projects means that industry innovation progresses' far more rapid than what Defence is prepared to move at.	

The CLC is geared up work with Primes and not SMSs, geared for very large expensive, not requiring an agile process. In many cases risk must be reduced to zero and this is not viable for smaller more innovative projects. There is a poor understanding of how to manage risk built into the process and into the culture of CASG driving the implementation of the CLC for smaller innovations projects. No off ramp from innovation phase and on ramp to commercialisation and aquistion phases	Provide a pathway and funding for innovative ideas to be trialed in Defence applications and assist the SME to pull the innovation through to technology. (Jericho does this by idenifying sponor up front (can they pull through with procurememt rules? (DUI do this)
There is higher risk attached to developing new IP and then pulling this through to capability. There is not a route for an SME to take the IP through to TRL 10 without going through primes that are connected into the centralized procurement process.	
Communication and Collaboration	
Collaboration; It is paramount that multiple EMOS service providers work together in generating innovative practice that is unified nationally, to maximise the benefit to both the Defence client and to the sector. It is of paramount importance for a successful outcome to get Defence Industry involved early in the development process of new concepts and technology, preferably before the requirements are decided. Unfortunately, this is rarely the case.	
Communication is difficult mainly due to extensive bureaucracy and short staff postings (three years or less).	Defence, DIH and DST be proactive in identifying industry talent early. Use technically trained personnel in a technical area, with the ability to do technology fore sighting. This is important for being able to identify the potential of new startups or SME's very early on their journey.
There are insufficient communication channels and opportunities for communication between Defence and Academia which creates major roadblocks for academia to get through and connect with Defence. This is a prevalent issue even though the Defence Innovation Hub and several R&D targeted programs have been launched through DSTG and other Commonwealth of Australia (CoA) entities.	Influence the start-ups to design their business in a way that is compatible for doing business with Defence.
Communication; everyone is busy but where are the right people to talk to & that have the time answer industry's concerns. Access to these designated people to be clear & direct. It seems that the administrative people within DIH are not innovative people.	Engage with industry widely on the problems to be solved rather than on deliverables required. Use industry and acidemia to assist in finding ways to solve the problem. More risk is attached to this.
Defence should seek Industry expertise and not assume Defence are the experts in technology needs.	Communication of Defence problems to industry Unclassified and Classified briefings of industry by Defence CMs to increase industry awareness of Defence problems.
CoA initiatives are being managed too much as a "top-down" heavy operation where the usefulness of the innovations/technologies newer reaches the "end users". There should be more focus on the end users and easier access to them for academia.	Better channels of communication needed by Defence. Within Defence ranks – there needs to be more cross communication within Defence. For example with DST, despite being within the same organization
CoA in general but particularly Defence and DSTG struggle to capture specific and clear requirements that in conjunction with Defence Classification rules and regulations can drastically obscure the understanding of what Defence is after.	

Defence's ability to make a decision and its lack of understanding of the needs of business (SMEs)	
Fact that Defence in Australia is not capable of dealing with any SMEs directly, and force all SMEs to work with primes who have only the focus is on primes profit margin - unlike US where primes will actively go to SMEs and A lot more openness to SMEs - Defence has very little interest in dealing with SMEs.	
Funding and Resource Constraints	
4. Funding is probably the most pressing area in the end for academia to be successful in progressing and developing innovations.	**Separate funding stream** that is more flexible can fund higher risk activities, operational trials of technology, and the transition of innovations into capability (DAPRA like organization and or DUI provides a pathway=new Australian Strategic Research) T**o work within the system** need a keen awareness of how the funding is distributed over Defence. Innovation units within Defence use their influence to convince CMs to set aside a % of their budget for innovation projects.
Funding; even though industry is design ready with the backing of notable rankings within Defence. Without funding companies aren't in a position to rapidly progress capability	Change their process and consider what the US has done with the DIU project, though recognise that is a different ecosystem
Short staff posting cycles was identified as an issue for successful adoption of innovation.	Build a new separate Rapid Acquisition Agency (This needs to be similar to the US DARPA based DIU)
There is "not an unlimited supply of money and staff" to process and implement changes and therefore change proposals are prioritised and actioned accordingly.	
Industry developing proof-of-concepts or prototypes such as the Abrahms X before they has been procured is potentially good for innovation. While it is expensive (requires funding), it may help to lead Defence into innovating solutions.	
CLC long development cycle with an inflexible budget allocation, More flexible buckets of money NGTF, DIH etc are over allocated meaning new ideas are not flowing into that system	
-Very hard to make your way through the maze about who to talk to about innovation initially, and even if you get through, DIH lots of time and effort with little feedback, -Another problem is trying to understand who to talk to.	
Long periods of delay with changing rotation cycles. Too many gaps in innovation cycles, especially with SMEs where products have a need but no champion Additionally, there are long response times after the go ahead is given by Defence with execution of contracts. Defence don't seem to understand the way business works with respect to SMEs.	
ADF have a centralized procurement process that is difficult to break into. It does not cater to innovation that is occurring outside of this process in a decentralized way.	
Uncategorised	
HO/TO process for project delivery; discrepancies between DLP dates; infrastructure ownership; stakeholder boundaries/ requirements are a	

common thread of difficulty amongst project contractor due to the lack of process accountability	
Platform and system complication and the high level of interconnectedness can be a real barrier to successful rapid deployment of change in some areas of Defence.	
CoA and Defence in general are very “reactive” and seem to lack the ability to think and plan ahead to establish efficient and effective collaborative relationships early in the development process.	
The interviewee’s industry engagement was primarily through industry representatives and service contractors, though that engagement was identified as “a little bit”.	

Appendix B Supporting Material

Technical Readiness Levels Definitions and Descriptions

	Technology Readiness Level Definition
TRL 1	**Basic Research:** Initial scientific research has been conducted. Principles are qualitatively postulated and observed. Focus is on new discovery rather than applications.
TRL 2	**Applied Research:** Initial practical applications are identified. Potential of material or process to solve a problem, satisfy a need, or find application is confirmed.
TRL 3	**Critical Function or Proof of Concept Established:** Applied research advances and early stage development begins. Studies and laboratory measurements validate analytical predictions of separate elements of the technology.
TRL 4	**Lab Testing/Validation of Alpha Prototype Component/Process:** Design, development and lab testing of components/processes. Results provide evidence that performance targets may be attainable based on projected or modeled systems.
TRL 5	**Laboratory Testing of Integrated/Semi-Integrated System:** System Component and/or process validation is achieved in a relevant environment.
TRL 6	**Prototype System Verified:** System/process prototype demonstration in an operational environment (beta prototype system level).
TRL 7	**Integrated Pilot System Demonstrated:** System/process prototype demonstration in an operational environment (integrated pilot system level).
TRL 8	**System Incorporated in Commercial Design:** Actual system/process completed and qualified through test and demonstration (pre-commercial demonstration).
TRL 9	**System Proven and Ready for Full Commercial Deployment:** Actual system proven through successful operations in operating environment, and ready for full commercial deployment.

TRL 1 Definition	TRL 1 Description
Basic Research. Initial scientific research begins. Examples include studies on basic material properties. Principles are qualitatively postulated and observed.	Basic principles are observed. Focus is on fundamental understanding of a material or process.
TRL 2 Definition	**TRL 2 Description**
Applied Research. Initial practical applications are identified. Potential of material or process to satisfy a technology need is confirmed.	Once basic principles are observed, practical applications can be identified. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies. Supporting information includes publications or other references that outline the application being considered and that provide analysis to support the concept. The step up from TRL 1 to TRL 2 moves the ideas from basic to applied research. Most of the work is analytical or paper studies with the emphasis on understanding the science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work.
TRL 3 Definition	**TRL 3 Description**
Critical Function, i.e., Proof of Concept Established. Applied research continues and early stage development begins. Includes studies and initial laboratory measurements to validate analytical predictions of separate elements of the technology. Examples include research on materials, components, or processes that are not yet integrated.	Analytical studies and laboratory-scale studies are designed to physically validate the predictions of separate elements of the technology. Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical components. At TRL 3 experimental work is intended to verify that the concept works as expected. Components of the technology are validated, but there is no strong attempt to integrate the components into a complete system. Modeling and simulation may be used to complement physical experiments.
TRL 4 Definition	**TRL 4 Description**
Laboratory Testing/Validation of Alpha Prototype Component/Process. Design, development and lab testing of technological components are performed. Results provide evidence that applicable component/process performance targets may be attainable based on projected or modeled systems.	The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Supporting information includes the results of the integrated experiments and estimates of how the experimental components and experimental test results differ from the expected system performance goals. TRL 4-6 represent the bridge from scientific research to engineering, from development to demonstration. TRL 4 is the first step in determining whether the individual components will work together as a system. The goal of TRL 4 should be the narrowing of possible options in the complete system.

TRL 5 Definition	TRL 5 Description
Laboratory Testing of Integrated/Semi-Integrated System. Component and/or process validation in relevant environment- (Beta prototype component level).	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Supporting information includes results from the laboratory scale testing, analysis of the differences between the laboratory and eventual operating system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. The major difference between TRL 4 and 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical. Scientific risk should be retired at the end of TRL 5. Results presented should be statistically relevant.
TRL 6 Definition	**TRL 6 Description**
Prototype System Verified. System/process prototype demonstration in an operational environment- (Beta prototype system level).	Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include fabrication of the device on an engineering pilot line. Supporting information includes results from the engineering scale testing and analysis of the differences between the engineering scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. TRL 6 begins true engineering development of the technology as an operational system. The major difference between TRL 5 and 6 is the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the final system. The engineering pilot scale demonstration should be capable of performing all the functions that will be required of a full manufacturing system. The operating environment for the testing should closely represent the actual operating environment. Refinement of the cost model is expected at this stage based on new learning from the pilot line. The goal while in TRL 6 is to reduce engineering risk. Results presented should be statistically relevant.
TRL 7 Definition	**TRL 7 Description**
Integrated Pilot System Demonstrated. System/process prototype demonstration in an operational environment-(integrated pilot system level).	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Final design is virtually complete. The goal of this stage is to retire engineering and manufacturing risk. To credibly achieve this goal and exit TRL 7, scale is required as many significant engineering and manufacturing issues can surface during the transition between TRL 6 and 7.

Capability Life Cycle

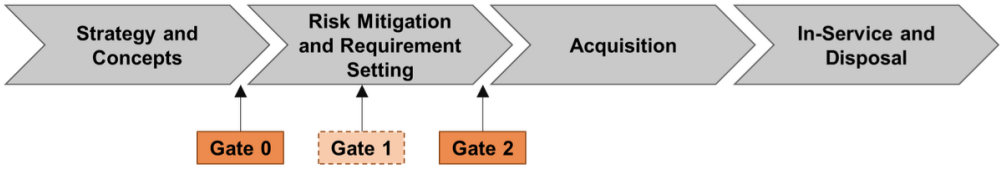

Figure 1.2 – Phases of the Capability Life Cycle

a. **Strategy and Concepts.** The purpose of the Strategy and Concepts Phase is to identify capability needs, through the force design process, that are informed by assessments of our ability to meet the Strategic Effects set out in strategic guidance, within the broad funding guidance provided for Defence. The Strategy and Concepts Phase concludes with Investment Committee consideration of the Gate 0 Business Case.

b. **Risk Mitigation and Requirement Setting.** The Risk Mitigation and Requirement Setting Phase involves the development and progression of capability options through the investment approval process. The outcome of this phase leads to a Government approval of acquisition. The phase commences when the Gate 0 business case is approved by the Investment Committee and concludes with Second Pass government approval.

c. **Acquisition.** The Acquisition Phase involves each Group undertaking relevant design, development and delivery of their allocated FIC elements or sub-elements, including contracting with industry. The integration of these FIC elements and sub-elements creates the high level product that is introduced into service as a new or enhanced capability. The phase commences with Second Pass government approval and concludes with Acceptance into Service.

d. **In-Service and Disposal.** The In-Service phase involves sustaining the product through its life. Disposal involves withdrawing the product from service, managing the transition to a replacement (if required) and final disposal of the product. The phase commences with Acceptance into Service and concludes with final disposal of the product.

Defence Innovations Hub Contracts

Investment phases and average contract values [26]

The below table also indicates the actual contract value ranges and average contract values for each phase as well as an indicative contract length.

Investment phase	Actual value rang	Indicative timeline	TRL
1. Concept exploration The focus of this phase is to explore your proposed innovation and demonstrate how it will be matured.	$50k-$1.7m Average: $340k	Contract delivery 2-12 months	1-3
2. Technology demonstration The focus of this phase is to demonstrate the concept, which may include analytical or laboratory studies and testing.	$100K-$5.4m Average: $1.8m	Contract delivery 1-3 years	3-4

Investment phase	Actual value rang	Indicative timeline	TRL
3. Prototype system The focus of this phase is to develop a prototype in a system context with an increased focus on systems engineering principles.	$300k-$7.9m Average: $3.1m	Contract delivery 1-3 years	5-6
4. Integrated Capability Development The focus of this phase is to demonstrate the prototype in an integrated and relevant capability environment (e.g. in an aircraft, ship, network etc.).	$700k-$8.7m Average: $3.7m	Contract delivery 1-4 years	6-8