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## **Ph.D Thesis**

### **Product innovation success in the Australian defence industry – an exploratory study**

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# TABLE OF CONTENTS

<b>List of Illustrations</b>	<b>vi</b>
<b>List of Tables</b>	<b>vi</b>
<b>Abstract</b>	<b>vii</b>
<b>Declaration</b>	<b>ix</b>
<b>Dedication</b>	<b>xi</b>
<b>Acknowledgements</b>	<b>xiii</b>
<b>1. Introduction</b>	<b>1</b>
1.1 Introduction	1
1.2 Preface	1
1.3 Contextual Background	6
1.4 The Defence of Australia	8
1.5 Equipping the ADF	14
1.6 Australia’s Defence Industry	15
1.7 Defence Manufacturing	18
1.8 Defence Acquisition Policy	24
1.9 Sustainment	28
1.10 Science & Technology (S&T)	29
1.11 Why do R&D?	30
1.12 The role of DSTO	32
1.13 Australia’s other defence innovation mechanisms	40
1.14 Conclusion	42
<b>2. Literature Review</b>	<b>45</b>
2.1 Introduction	45
2.2 Categorisation of models	47
2.3 Linear Models	51
2.4 Functional Models	59
2.5 Predictive Models	61
2.6 Innovation and Commercialisation – the literature	62
2.7 A Wider Literature Review	69
2.8 Factors unique to the defence market	82

2.9 The Customer's Role	84
2.10 Structural issues: the National Innovation System	92
2.11 Discussion	94
2.12 Conclusion	95
<b>3. Research Methodology</b>	<b>97</b>
3.1 Introduction	97
3.2 Aim of the Research	97
3.3 Research Paradigm	98
3.4 Research Methodology	99
3.5 Sampling	100
3.6 Data Collection Method	104
3.7 The role of Defence-related R&D	105
3.8 Data Analysis	105
3.9 Linking to the Literature - Independent Variables	106
3.10 Method of Drawing Conclusions and Implications	117
3.11 Confidentiality and Privacy	118
3.12 Conclusion	118
<b>4. Research Findings</b>	<b>119</b>
4.1 Introduction	119
4.2 Data Issues	122
4.3 Analysis - Testing the Hypothesis	155
4.4 Success Factors – Qualitative Analysis	156
4.5 Effects of the Independent Variables	186
4.6 Defence Industry R&D – Case Study & Survey	189
4.7 R&D Data Issues	192
4.8 Industry R&D Survey	193
4.9 Discussion	196
4.10 Conclusion	197
<b>5. Discussion</b>	<b>198</b>
5.1 Introduction	198
5.2 Classification of Factors	200
5.3 Re-Classification and Refinement of Factors	203

5.4 Comparison with Existing Models	207
5.5 The Forces Acting on the Product Innovation process	210
5.6 A Predictive Model for Product Innovation Success	212
5.7 Conclusion	216
<b>6. Conclusions and directions for future research</b>	<b>217</b>
6.1 Introduction	217
6.2 The Research Questions	217
6.3 Innovation Success Factors	217
6.4 A Model for the Product Innovation Process	219
6.5 The role played by industry R&D	220
6.6 Limitations of the research	221
6.7 Limitations of the R&D Survey	222
6.8 Implications for Theory	222
6.9 Implications for Industry Practice	224
6.10 Implications for Defence Policy and Practice	225
6.11 Implications for Defence Policy - DSTO	226
6.12 Directions for future research	227
6.13 Conclusion	228
<b>Appendices</b>	
<b>Appendix 1:</b> Defence Industry R&D Survey	230
<b>Appendix 2:</b> Australian Defence Industry R&D, Innovation and Competitiveness – the R&D Survey Form and responses	246
<b>REFERENCES</b>	<b>252</b>

## LIST OF ILLUSTRATIONS

1.1:	The forces shaping Australia’s defence industry	5
1.2:	Mapping Australia’s defence market	23
1.3:	DSTO, Defence and Industry – the overlaps	38
2.1:	The Goldsmith Model	52
2.2:	The Andrew & Sirkin Model	54
2.3:	The AIC Commercialisation progression Model	55
2.4:	The Carnegie Mellon Innovation Transfer Process Model	56
2.5:	The UniQuest Model	57
2.6:	The Stage Gate Process	58
2.7:	Jolly’s Technology Commercialisation Model	58
2.8:	The RPDE Model	59
2.9:	The Rothwell and Zegfeld Model	60
2.10:	The Canadian Functional Model	61
5.1:	Product Innovation Success in the Australian Defence Industry – an Object-Oriented Model	211
6.1:	Product Innovation Success in the Australian Defence Industry – an Object-Oriented Model	219

## LIST OF TABLES

1.1:	DMO and Total In-Country Expenditure	21
1.2:	Industry Return on Sales, Assets and Equity	24
1.3:	US, UK and Australian defence R&D 2008-09	36
3.1:	Case Study Projects	103
3.2:	Aggregated Success Factors	110
4.1:	Case Study Introduction	124
4.2:	Case Study Questions and results	125
4.3:	Australia’s Defence Industry – a snapshot	155
4.4:	R&D Investment – by company size	189
4.5:	R&D Investment – comparing success with failure	190
4.6:	R&D Survey - Industry R&D	193
5.1:	Generic Product Innovation Success Factors – a four-way Comparison	207
5.2:	A Rudimentary Predictive Model for Defence Product Innovation Success	213

## ABSTRACT

### Product innovation success in the Australian defence industry – an exploratory study

The research sought to identify product innovation success factors in the Australian defence industry. It found that innovation outcomes are shaped by the Customer-Active Paradigm (CAP), and therefore the customer's characteristics and behaviours, as well as by the characteristics and behaviours of the innovating defence companies. The conclusion from this research is that pre-conditions for Product Innovation Success do exist in Australia's defence market. These relate to the innovator, the customer and the market itself. The fact of identifying these and ascribing them different levels of importance creates a rudimentary predictive tool for innovators and policy-makers.





## DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any other university or other tertiary institution to Gregor Ferguson and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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## **DEDICATION**

**This thesis is dedicated to:**

**my wife, Sabrina Ferguson**

**with all my love and grateful thanks for her support**

**my son, Damien Hunter**

**with my fondest love and best wishes for his own Ph.D journey**

**my daughter, Keelie Ferguson, and her partner and children**

**with my fondest love and best wishes for their life journey**

**my parents, Angus and Frances Ferguson**

**with love and grateful thanks for their love, support and example**



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While many people were generous with their insights and advice, I didn't always follow it. For all the support and encouragement I received, this work is mine alone and I take full responsibility for any flaws and errors of omission or commission.

# Chapter 1 – Introduction

## 1.1 Introduction

This introductory chapter includes a preface and a general introduction to the Australian defence market: Australia's strategic outlook and defence policy, the Australian Defence Force (ADF), Australia's defence budget, how the ADF is equipped and armed, the roles played by Australian and foreign defence firms, the importance of research and innovation, and the roles of key government agencies in research and procurement.

## 1.2 Preface

This thesis explores the complex customer-vendor relationship between the Australian Defence Force, the Australian Department of Defence more broadly, and the Australian defence industry. It seeks to analyse and understand the factors impacting on product innovation generally, and in particular those factors associated with success and failure in developing and selling new high-technology defence equipment to the ADF.

There are many likely causes of both success and failure and these are as complex as the relationship between the ADF and Industry, which itself has a long history.

Before outlining the core research questions that set out the direction of my research and the major themes of this thesis, I believe it is helpful for the reader if I describe the 'problem' the research is designed to address.

The customer-vendor relationship between Australia's defence industry and the Department of Defence (generally and henceforth referred to simply as 'Defence') is unique and complicated. To the extent these two factors shape and possibly hinder the outcomes of industry's attempts at product innovation they can be looked on as 'problems' needing to be addressed in some way. However, these aren't the only factors affecting innovation outcomes and my research examines existing innovation models and theories developed for non-defence markets to determine whether they apply also in the Australian defence market place. This approach has its basis in a business management outlook which holds that there is always room for improvement in organisational strategy and operations which, if achieved, will result in improved business outcomes.



This is a simplified but practical starting point for my research which, so far as can be determined, is the first attempt to examine systematically the factors affecting product innovation outcomes in Australia's defence industry. From the perspective of a 30-year career as a specialist defence writer, analyst and editor I believe this may also be the first attempt to explore how existing innovation models and theories might be extended and applied to the Australian defence sector.

My personal interest in this topic stems from my original vocation which was to be an Industrial Designer specializing in transportation – by inclination and professional training, therefore, I was drawn to those high-technology industry sectors, including defence and aviation, which depend upon innovation. Circumstances led to my becoming a writer and analyst but my training equipped me to observe the defence industry from close quarters (at one time as an employee of a major defence manufacturer in the UK), and to question what I saw. Hence my preoccupation with the relationship between Defence and industry and with the factors which contribute to (or impede, as the case may be) product innovation success in the defence industry.

After describing in more detail the landscape I wish to explore I shall then set out the key research questions.

Australia's defence product innovation landscape is complex and warrants exploration from a number of points of view. Defence buys all of its Australian-sourced goods and services from private sector companies; paradoxically, while it invests significantly in R&D (mainly through the Defence Science & Technology Organisation, DSTO), it makes little real effort to commercialise the fruits of this research so industry tends to be the locus of defence product innovation effort within Australia. Fundamentally, the industry is shaped by four forces: Defence's need for high *technology*; its culture of *risk aversion*; the relatively small *size* of Australia's domestic defence market; and the *monopsonistic* and *monolithic* nature of the defence customer. These last two factors, in combination, especially when compounded by other factors identified in this research, make the Australian defence market unique.

Defence tries to use *technology* to compensate for the small size of the ADF: it explicitly seeks equipment which provides it with a capability edge and is generally not available to Australia's regional neighbours. However, technology, and the complexity that goes with it, has a price: Defence has suffered many

disappointments and much criticism in the past over equipment acquisition projects which have run late or exceeded their budgets. This has made Defence extremely *risk-averse* and therefore more inclined to buy low-risk products off the shelf, and therefore usually from overseas, rather than take the risk of developing new equipment in-country. To some extent it could be argued that Defence perceives risk in the procurement of the equipment and doesn't balance this perception by giving sufficient consideration to the capability.

This inclination is reinforced by Australia's strong alliances with both the USA and the UK and the resulting privileged access it receives to their intelligence, technology and equipment. To some extent also a preference for US equipment, for example, reflects a genuine need for interoperability with Australia's major ally as well as a need to ensure the health of the alliance. Arguably, a major factor in choosing foreign-manufactured equipment in preference to locally manufactured is often the existence of a logistics supply chain and large organisation to which the ADF can turn in time of war or if it encounters technical problems with its equipment. However, this argument isn't always tested with appropriate rigour when equipment acquisition projects get under way, creating the impression of a 'lazy default' which favours imported, off the shelf equipment and tilts the playing field against local industry players seeking to develop new equipment in Australia.

This all highlights the fact that the Defence market in any nation is a *monopsony*: the only customer for defence equipment and services is the Government which, through the way it spends its acquisition and research budgets, exercises complete control over the size of the market, its behaviour and the barriers to entry faced by industry players.

Furthermore, Defence is a *monolithic* customer: if a market exists in Australia for, say, 100 jet fighters capable of carrying out a particular task, aircraft manufacturers will not compete to win a 20 or 30 or 60 per cent market share – Defence will typically buy 100 identical aircraft from a single manufacturer under a single prime contract, though possibly in successive phases or 'tranches'. Market share becomes a binary value – one hundred per cent, or zero. This is logical: it simplifies and allows uniformity in training, logistic support and the development of tactics and operational procedures. But it has important implications for manufacturers, especially as Defence may not replace these aircraft for 30 years or more – the

market is characterised by significant peaks and troughs in demand with significant technology growth between them.

The relatively small *size* of Australia's defence market means that demand is frequently small so local manufacturers may not achieve economies of scale when developing new products for the ADF and therefore may not be able to compete on price with foreign manufacturers whose larger domestic markets (and possibly other export sales) have helped make their equipment cheaper and have spawned a robust engineering and logistics capability to support it.

The *size* of Australia's defence market and the *risk aversion* of the defence customer act as constraints on defence industry's willingness and capacity to innovate as new product developers. These effects are compounded by the *monopsony* and *monolithic* natures of the defence market.

The result has been that Australia's defence industry has been only intermittently successful in developing sustainable R&D, design, systems integration and manufacturing capabilities along with the management and marketing skills that are required to innovate successfully and compete credibly in the market place. For all these reasons barely 40% of Defence's equipment acquisition budget finds its way to Australian companies. The rest goes to foreign suppliers, principally in the USA, Israel and Europe. There are good reasons for this: Australia is in no position to design and build equipment such as the 'stealthy' jet fighters and highly complex guided weapons which consume a significant share of the acquisition budget.

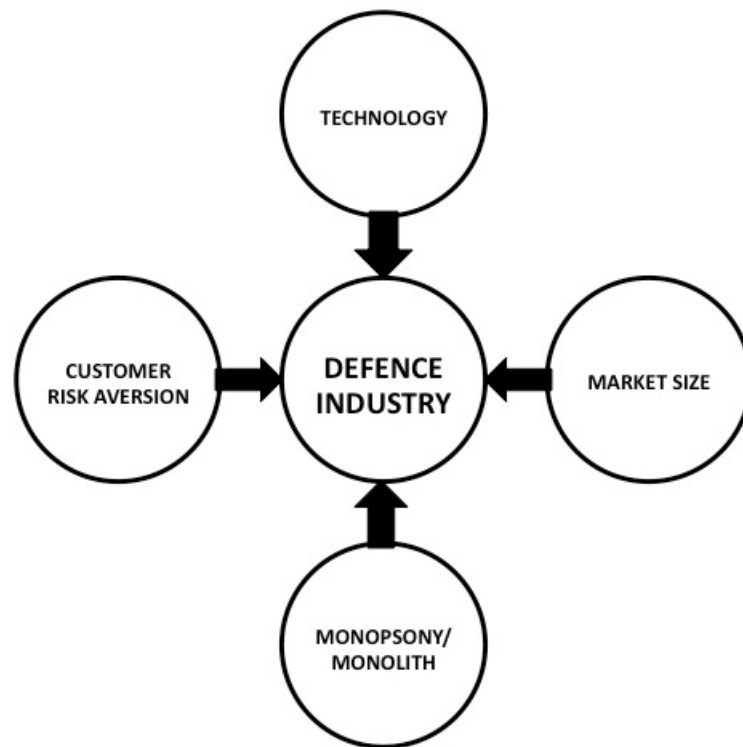
In spite of this, Australia's defence industry has achieved some notable successes. But there is a lingering sense within the Australian defence industry that it could and should supply more locally designed equipment to the ADF (and also to export customers) and my research sets out to discover what factors would make this more likely.

Figure 1.1 somewhat over-simplifies the relationship between the forces shaping Australia's defence market place, but it illustrates the constraints on product innovation success and provides a practical starting point for the research which follows. It also leads to the core questions which are the focus of this research:

- What are the factors which determine the success or failure of product innovation projects by companies in Australia's defence industry?

- Can these factors be measured and used to create a model, or a more general set of pre-conditions, for successful product innovation within Australia's defence industry?
- To what extent is R&D investment an indicator of product innovation success in the Australian defence industry?

It will be seen that the customer, in this case Defence, shapes three of the forces operating on the defence industry in Figure 1.1: risk aversion, market size and monopsony/monolith; and because it actively seeks high technology equipment it provides the channel for the fourth force, technology.



**FIGURE 1.1: The forces shaping Australia's defence industry**

The remainder of this chapter discusses the contextual background to this research – the defence of Australia and the parts played by the ADF, DSTO and the defence industry.

Chapter 2 examines the literature on product innovation and identifies models and success factors in the non-defence market. Chapter 3 examines how these can be extended and applied in the Australian defence market place and sets out a

methodology for exploring this, including case studies of successful and unsuccessful defence product innovation projects and a survey of defence industry R&D investment. Chapter 4 describes the case study and R&D survey findings while Chapter 5 discusses these and seeks deeper causal relationships between factors identified in the case studies. Chapter 6 sets out elements of a model for defence product innovation success in Australia, acknowledging gaps in both the model itself and the underpinning knowledge which future researchers may find it fruitful to explore.

### **1.3 Contextual Background**

The original stimulus for this research was the observation that while Australia conducts a relatively significant amount of defence R&D and is a significant purchaser of high-technology defence equipment, the ADF imports the majority of its major equipment, weapons and platforms such as ships, aircraft, submarines, main battle tanks and guided weapons. Some of this materiel, including highly sophisticated electronic equipment, is imported from countries that have smaller populations, smaller economies and smaller defence budgets.

At the same time, Australia is not a significant exporter of defence equipment and there is a widely held belief within the local defence industry that the quite significant effort and resources invested in defence-related R&D and innovation, in both the public and private sectors, generate only a small commercial return.

This is somewhat surprising given that in 2009 Australia had the 13<sup>th</sup> biggest economy in the world (World Bank 2009), was the 14<sup>th</sup> largest spender on defence equipment in the world, and 5<sup>th</sup> largest in terms of per capita defence expenditure at US\$892 a year, behind only the US, France, the UK and Saudi Arabia (SIPRI 2010; SIPRI 2010).

In the late 20<sup>th</sup> century and early 21<sup>st</sup> century the ADF started evolving rapidly to meet new threats and adapt itself to the challenges and opportunities posed by emerging technologies. It significantly increased the speed with which it is modernising its structures, techniques, tactics, procedures and training to master the technical, military and broader security challenges it anticipates through to the mid-21<sup>st</sup> century. This modernisation program necessarily includes new technology, equipment and weapons to deliver the operational capabilities required by the

ADF's three fighting services, the Royal Australian Navy (RAN), Australian Army and Royal Australian Air Force (RAAF).

To the extent it depends on its mastery and exploitation of existing and emerging technology, the ADF depends upon knowledge, expertise and insight gleaned from the defence-related research carried out in Australia. Much of this R&D is conducted in-house by DSTO, which forms part of the Department of Defence and is funded directly from the defence budget.

The R&D work carried out by DSTO provides unique and often highly classified technological insight and expertise along with some unique tools and capabilities in a rather diverse range of sensitive areas such as intelligence, security, encryption, aircraft structural fatigue and armour protection where an independent, sovereign capability is deemed by the Australian government to be essential. The outcome of this R&D generally consists of Science & Technology (S&T) advice and expertise which DSTO applies to the ADF's needs in these and other areas.

The ADF also depends upon an innovative, technology-rich industry support base which is able to draw upon some of that same research, as well as its own, to support the ADF's equipment once in service and, to a lesser extent, create new products and equipment.

However, the majority of the ADF's capital equipment budget is spent on foreign-designed weapons and platforms (Gumley 2009). The number of Australian-designed and built products in service with the ADF and export customers is relatively low; Australian companies generally seem to fare poorly in developing high-technology defence equipment which can compete successfully with that produced in the US, UK and Europe.

The reasons given by local firms for that lack of success are frequently anecdotal and subjective, and can even appear self-serving in some cases. They range from accusations of direct bias against local industry by the Department of Defence, to the inability of local firms to achieve economies of scale, to the ADF's well-founded fear of the technical difficulties, schedule delays and cost over-runs often associated with indigenous high-risk developmental projects.

The purpose of this research is to look beyond the anecdotal record and identify the factors which actually determine the success or failure of defence product

innovations in Australia. First, however, it is important to examine the context in which Australia's defence industry operates.

#### **1.4 The Defence of Australia**

With a regular strength of 57,700 men and women (Defence 2010) the ADF is small by global, and even some regional, standards. Yet it is charged with the defence of an entire continent and influencing or shaping the strategic and security environment across a far wider region including a maritime area of interest which amounts to some 10 per cent of the earth's surface.

Australia is the sixth largest country in the world; its principal landmass covers 7.6 million square kilometres with a coastline of 35,800km, and its ocean territory is the world's third largest, covering some 12.6 million square kilometres. Australia is roughly the same size as the Continental United States but its population of 22.4 million is not much larger than that of New York State, at 19.5 million (2010). This small population, concentrated mainly in a handful of major coastal cities, presents many social, strategic and security challenges, not the least of which is securing the nation's northern borders – Australia's north has an extremely low population density, but paradoxically its northern neighbours are nations with some of the highest population densities in the world.

Defending Australia with such a small force against the credible threats postulated in the Federal government's 2009 Defence White Paper, Force 2030 (Defence 2009), requires a highly trained defence force equipped with modern, high-technology weapons, sensors and command and control infrastructure. In addition, the ADF has been required in recent years to undertake a variety of other tasks and missions. These range from pacification and peace-keeping in East Timor and Solomon Islands through guerrilla warfare against Taliban forces in the remotest areas of Afghanistan to conventional high-intensity air and naval warfare and high-risk constabulary and nation-building duties during and since the invasion of Iraq in 2003. The ADF also has a key role in wider whole-of-government efforts to address national and regional technical security challenges and respond to contingencies such as natural disasters at home and abroad.

While the current ADF force structure has evolved in response to strategic conditions within Australia's immediate region since the end of the Vietnam War, both India and, more overtly, China have emerged in the 21<sup>st</sup> century as regional

economic and military superpowers. The changed strategic outlook resulting from China's rise, in particular, may in turn result in changes in Australia's strategic and military priorities and in the resources it devotes to defence (Babbage 2011).

That said, and notwithstanding its small population and defence force, Australia's defence budget of \$25.7 billion in 2010-11, or 1.9% of Gross Domestic Product (GDP), is one of the biggest in the region (Thomson 2010) and Australia is widely recognised as the biggest and most technologically sophisticated customer for high-technology defence equipment in south east Asia. Defence invests around 2% of its budget in R&D conducted by DSTO. Its acquisition agency, the Canberra-based Defence Materiel Organisation (DMO) operates semi-autonomously as a so-called Prescribed Agency within the Department of Defence; its 2010-11 budget of \$11.5 billion included \$6.08 billion for the acquisition of major capital equipment and \$5.34 billion for 'sustainment' – maintaining, repairing and upgrading that equipment once in service (Thomson 2010).

Australia is an island continent and its defence policy explicitly recognises that any direct threat to the mainland must come from the sea. The most likely route such a threat might take is from the north, through the archipelagic waters making up Australia's northern approaches. Therefore, defence policy seeks first to shape and support a benign security environment within Australia's region and further afield through diplomacy and a network of alliances, treaties and other multilateral and bilateral relationships.

In the early 21<sup>st</sup> century Australia's national security policy has also sought to address other threats which are not so easily defined by geography. These include cyber warfare and terrorist acts perpetrated by extremist ethnic or religious groups. Defence policy has become a more integrated component of this broader approach to national security.

Secondly, Australia's defence policy calls for high levels of 'situational awareness', based on intelligence (including Signals Intelligence, or SIGINT) and surveillance carried out by a number of ADF assets, including AP-3C Orion Maritime Patrol Aircraft (MPA), Collins-class submarines, surface warships and patrol boats, the Jindalee Operational Radar Network (JORN) and the strategic and tactical intelligence, surveillance and reconnaissance assets of other Federal government agencies and key allies such as the US, UK and France, whose Pacific Ocean territories lie relatively close to Australia resulting in many shared interests. Future



ADF plans include enhanced manned and unmanned surveillance aircraft and access to satellite-based surveillance capabilities.

Thirdly, if the deterrent of a credible defence force fails Australia's defence policy is to intercept and defeat any threats as far offshore as possible in the so-called 'Air-Sea Gap'. As well as placing an emphasis on naval and air forces, this may also require the ADF to forestall a direct attack or attempt to re-shape the regional security environment by, for example, deploying to the aid of a threatened regional neighbour and operating alongside him in a common cause, possibly for extended periods. Therefore, the ADF also has a growing expeditionary capability alongside its standing forces of submarines, surface ships, strike and air defence fighters and airborne early warning aircraft and tankers.

The concept of 'Defence Self-Reliance' underlying this policy holds that the ADF should be able to meet and defeat a credible threat by itself, requiring only intelligence, diplomatic and logistics support from key allies.

Fourthly, Australia's defence policy recognises the nation's role as a 'global citizen' along with the insidious threats to its interests and national security posed by circumstances and crises even further afield. This has resulted in the ADF deploying ships, troops and aircraft as part of coalition forces operating in Iraq and Afghanistan; this continues a history of global engagement which saw Australians make an important contribution to allied efforts in the Middle East, Mediterranean and Europe during the two World Wars, as well as closer to home in south east Asia. The force structure and equipment which underpin Australia's defence self-reliance is deemed to be sufficient also for these other tasks further afield in support of Australia's interests, either alone or as a member of a coalition.

The ADF has historically sought to compensate for its small size by maintaining a significant capability edge over its neighbours based on technology and training. Successive Defence White Papers published by the Federal government (the most recent in 2009) have maintained this emphasis on training and technology and to achieve this the ADF normally seeks to acquire the best equipment available to it.

While sourcing some critical capabilities from within Australia, Defence enjoys privileged access to the defence equipment developed by Australia's key allies – particularly the USA and the UK. This equipment frequently embodies state of the art technology and advanced capabilities which are generally denied to most other

defence forces in the region. Not only does this provide a capability edge, it provides high levels of interoperability with those allies which delivers important logistics benefits and financial savings. This is an increasingly important consideration: up to 80% (in some cases) of the whole of life cost of a major item of defence equipment can be attributed to maintenance and logistics support; operating common equipment with an ally or neighbour can reap significant recurring savings.

This interoperability also enables the ADF to fit more easily and comfortably into US and UK-led coalitions when deploying on peace-keeping or combat operations. Australia's carefully tended alliances with these powers in particular also provide critical strategic and operational intelligence which would otherwise be unavailable to the Australian government and the ADF. Developing such intelligence itself would require Australia to invest very significant additional sums over a lengthy period to develop and sustain the requisite technical and human intelligence resources. This naturally colours the ADF's preferences for equipment, platforms and weapons.

To ensure these assets deliver the maximum operational effect, the ADF invests heavily in its Command and Control (C2) capabilities. In this acronym-enriched environment the means of Command and Control are delivered by the equipment and people who make up the ADF's Command, Control, Communications, Computing, Intelligence, Reconnaissance and Surveillance (C4ISR) capabilities. The framework within which these capabilities are employed is known by the acronym Network-Centric Warfare (NCW). NCW is the conceptual construct in which information, orders and targeting data pass rapidly, seamlessly and securely between sensors, weapons, platforms and C4ISR assets and organisations. The purpose of NCW is to improve commanders' situational awareness, aid their decision-making and then hasten the implementation of their orders and instructions.

The NCW framework provides essential leverage to extract the maximum combat effect from what is a small force – the nearest western equivalents to the ADF in terms of budget, equipment inventory and manpower would be The Netherlands which has a population of 16.6 million and a defence budget of US\$12.23 billion, or approximately 1.5 per cent of GDP, and Canada, with a population of 34.1 million and a defence budget of US\$19.2 billion, or 1.3 per cent of GDP (SIPRI 2010). While

the proportion of GDP appears a somewhat arbitrary measure of defence expenditure, it does provide a benchmark for comparing the resources a nation is willing to devote to defence spending, albeit one which sometimes requires contextual interpretation.

The Netherlands and Canada spend less of their GDP on defence than Australia, but both are NATO alliance members sharing land borders with their allies and integrated into common defence architectures which spread financial and operational burdens across the group's membership. Australia, by contrast, is an island standing alone between the Pacific and Indian Oceans and bears sole responsibility for the security of its borders. It is not part of any standing regional security structure designed to enhance its protection directly.

Australia can, however, invoke the tripartite Australia New Zealand US (ANZUS) Treaty, signed in 1951, which binds the three signatories to come to the aid of each other when faced with a direct military threat (DFAT 1951); then-Prime Minister Mr John Howard invoked the ANZUS Treaty in September 2001 to mobilise Australia's military response to the so-called 9/11 terrorist attacks on the USA.

The Five Power Defence Arrangement (FPDA) was established in 1971 to provide for the air defence of Malaysia and Singapore (DFAT 2010). This agreement doesn't enjoy Treaty status and commits Australia, New Zealand, Singapore, Malaysia and the UK only to consult each other in the event of an attack on, or threat to, Singapore and Malaysia. Established following the 1962-66 'Confrontation' between Indonesia and Malaysia and the United Kingdom's subsequent withdrawal from 'East of Suez', it provides for an Integrated Air Defence System (IADS) whose permanently manned multi-national headquarters is in Malaysia, commanded by an Australian Air Vice Marshal.

Australia plays a senior role in the FPDA by virtue of the size and power of its armed forces, but the arrangement is focussed primarily on the security of Singapore and Malaysia. Within the ANZUS Treaty, however, Australia is very much a dependent of the United States. Given the differences in size between the two countries' armed forces it could be argued that Australia provides the US with 'flag in the sand' support in coalition operations, along with some useful niche military capabilities and access to intelligence, training areas and logistics support in a key part of the world. But in return Australia's national security is underwritten by the military and diplomatic powers of the US and much of Australia's defence

and foreign policy is directed towards ensuring the integrity of the alliance. Arguably, this also influences the ADF's choice of equipment.

Research and Development and the resulting S&T advice and expertise play a vital role in enhancing the ADF's capability edge in conventional conflict, as well as its ability to combat emerging threats such as terrorism, including Improvised Explosive Devices (IEDs), and Weapons of Mass Destruction (WMD) in the hands of rogue states and non-state players.

The ADF also derives added leverage from the application of new and emerging Information and Communications Technology (ICT) to the warfighting process. The ICT domain is now a major focus of DSTO's S&T effort: the 2009 Defence White Paper noted the science, technology and capability challenges posed by the so-called 'Revolution in Military Affairs' (RMA), driven by the concept of NCW which harnesses and exploits ICT developed originally for the civil and commercial markets (Defence 2009).

Defence forces are increasingly adopting this commercial technology and applying it to defence needs (Sutton 2007). The use of so-called Commercial Off The Shelf (COTS) products and systems is widespread; COTS equipment is frequently much cheaper than specialist military equipment though effort is frequently required to adapt it to unique military architectures and demands for very high levels of security.

Network-Centric Warfare, or Network-Enabled Warfare as it should more accurately be known, depends very heavily on blending off the shelf ICT products and systems with specialist military equipment such as sensors, platforms (aircraft, ships and vehicles) and guided weapons.

The ADF has embraced the opportunities presented by NCW and associated emerging technologies such as 'stealth' and 'smart' weapons. These have changed radically the way military force is applied and the ADF has been determinedly innovative in seeking to exploit them, to the extent of developing both an NCW Roadmap (launched in 2007 and now in its second edition) and setting out modernisation plans for the three services. So ICT and NCW have been, and will probably continue to be, a significant cause of transformational change in both the ADF and industry (CDG 2007).

## 1.5 Equipping the ADF

It is useful at this point to understand the mechanism by which the Department of Defence identifies the ADF's needs and then seeks to satisfy them. The mechanism has evolved in response to problems identified during the 1990s and early 21<sup>st</sup> century (Defence 1997; Kinnaird 2003; Mortimer 2008; Defence 2009; DMO 2010) and consists in essence of two separate but closely related processes which run almost concurrently: Capability Development and Acquisition. While complementary, and often closely integrated, quite separate organisations are responsible for these activities.

Capability Development is Defence's internal process for identifying existing and emergent defence capability needs, establishing priorities, examining options for meeting those needs, determining appropriate budgets, managing an ongoing investment program, and doing so within financial guidance and with high levels of accountability. The responsibility of the ADF's Capability Development Group (CDG), this is necessarily a complex, rigorous, time-consuming and resource-intensive process (CDG 2006). The three services are responsible for capability development studies within their own environmental domains: Maritime by the Navy; Air and Aerospace by the RAAF; and Land by the Army. A separate Joint directorate is responsible for other specialist operational capabilities (particularly in Joint or 'corporate' IT and logistics areas) or for major capabilities (such as amphibious shipping) that straddle environmental domains. The Capability Development process generally requires intensive internal discussion and experimentation to refine and then validate the ADF's needs so these can be expressed in a form that is able to be satisfied by new equipment, processes, procedures and training. This also generally requires CDG to engage with outside experts, including research organisations, friendly defence forces and equipment manufacturers in order better to understand emerging threats, technologies and potential equipment solutions. To be efficient and successful the Capability Development process requires its practitioners to demonstrate considerable expertise, both operationally and technologically, so they understand the job the ADF is required to do, the role of technology and the mechanisms by which industry exploits and harnesses that technology in helping the ADF do its job safely and effectively.

Once a new requirement is formally endorsed by the Australian government it becomes part of the Defence Capability Plan (DCP) – in effect, an officially endorsed medium-term shopping list which is revised and updated regularly to keep pace with external events and changing priorities.

The existence of the CDG and the formal Capability Development process provides a portal for research organisations and industry to act pro-actively: to brief officials on emerging technologies and threats quite independently of any existing operational requirement. While an unsolicited ‘sales pitch’ may fall on barren ground, new knowledge and product information may have a significant role in shaping CDG’s understanding of the current and emerging operational environment and of its options for responding to these changes.

The Acquisition process has its genesis during Capability Development. Generally, the two processes inform each other through some degree of concurrency and a feedback loop. However, they have sometimes been sequential rather than concurrent leading to charges that CDG has created a project with unrealistic schedule, cost and capability goals which the DMO is then required to meet (in the Defence vernacular this is known as ‘throwing a dead cat over the fence’ and was a common complaint during the 1990s and early 21st century). In the Acquisition process Defence, via the DMO, formally solicits industry quotations and estimates based on the Government-endorsed operational requirement developed during the Capability Development process. The preferred (though not universal) acquisition method is through a competitive tendering process, even where one or all of the potential equipment options are ‘developmental’ – that is, they cannot be acquired off the shelf and so must be developed specifically to suit the needs of the ADF. Once a supplier has been selected and a contract has been signed the DMO is responsible for the acquisition process (including any development work) and delivery of the equipment to the user.

## **1.6 Australia’s Defence Industry**

The imperative of defence self-reliance (defined loosely as having sufficient independence in its defence policy and sources of equipment supply that the nation can act unilaterally where necessary in its own sovereign interests), along with Australia’s unique strategic and geographic environment, means Australia needs to maintain a sophisticated, sustainable defence industry base. As noted earlier, this is necessary to adapt imported defence equipment, develop niche products and

expertise which are unavailable elsewhere, support imported equipment through its service life, integrate it with other equipment to create systems and 'systems of systems' and, where necessary, repair, modify and upgrade this equipment to serve the ADF's evolving needs.

The ADF has traditionally been somewhat suspicious of Australia's defence industry, believing (often with good reason) that local companies sometimes lack many of the design, management and manufacturing skills required to deliver sophisticated equipment on schedule and to a competitive price (Bruni 2002). During the 1940s, 50s, 60s and 70s there was indeed good reason to be sceptical about industry's abilities: except for privately owned aerospace engineering firms such as the Commonwealth Aircraft Corporation (CAC) and De Havilland (both subsumed into Boeing Australia), most of Australia's defence, naval and aerospace design and manufacturing capabilities were government owned, the majority having been established during World War 2. While strategically essential during the 1940s, by the late 1950s they had generally become over-manned, inefficient and uncompetitive

For this reason much of the ADF's new equipment during the 1960s and 70s was acquired off the shelf from foreign suppliers with little or no local industry involvement. Exceptions were the RAAF's Sabre and Mirage fighters; the former was assembled by CAC, with some significant design modifications including a different engine; the latter was assembled by the Government Aircraft Factory (GAF – also now part of Boeing Australia). Industry was generally at the mercy of policy debates within and between the various components of Defence, including the three armed services and the Department of Supply (later Office of Defence Production, or ODP) which was Australia's defence procurement agency during these decades. The government-owned defence factories and shipyards were rationalised under the ODP during the 1980s, and then corporatised and privatised in a generally successful attempt to make them more efficient and competitive.

The 1976 Defence White Paper set out the framework for the policy of 'Defence Self Reliance' which developed more substance during the 1980s following the 1986 Dibb Review (Dibb 1986) and the 1987 Defence White Paper. Under this construct the defence industry was expected to play a key role in equipping, and especially in sustaining, the ADF. As a result, the 1980s saw considerable investment in Australia by foreign defence manufacturers on the back of key acquisition programs. While a

number of British firms (now generally consolidated into BAE Systems) had been active in South Australia since the late 1940s as a result of the UK-Australia missile and defence research program at Woomera, the 1980s and 1990s saw significant additional investment by US and European firms such as Boeing, Thales, Lockheed Martin, Raytheon and Saab.

The large prime contractors in any defence market are supported by smaller sub-contractors and suppliers, most of them Small to Medium Enterprises (SMEs) employing less than 200 people (ABS 2002). In Australia these have tended to 'cluster' around the prime contractors or around major centres of industry or technical expertise: electronics companies have proliferated around DSTO's Edinburgh (formerly Salisbury) laboratory in South Australia, for example – this is one of the biggest defence electronics research centres in the southern hemisphere and has been intimately involved in the Woomera research program. Not surprisingly, the prime contractors have a significant presence around Edinburgh also: BAE Systems, Saab Systems, Lockheed Martin Australia and Raytheon Australia, to name a few. Similarly, manufacturing and aerospace companies tended to cluster around the traditional automotive and aerospace manufacturing centres of Melbourne and Geelong.

The 1980s saw the Collins-class submarine and Anzac-class frigate programs get under way, along with local assembly of 73 F/A-18 Hornet fighters and 39 S-70A Black Hawk helicopters for the RAAF, 16 S-70B Seahawk helicopters for the RAN and the Jindalee Operational Radar Network (JORN). All of them were projects of national significance with levels of local industry involvement well above the historical trend - as high as 70-80% for the submarine and ship building projects (Bruni 2002). However, the defence budget never rose to the levels required to meet the spending goals in the 1987 White Paper – between 2.6 and 3.0% of GDP - and the high tide of Australian industry involvement during the late 1980s and early 1990s began to recede quite quickly once these projects were completed. The defence budget remained at a fairly constant 2% of GDP from the early 1990s until 2012 when deep cuts to government spending across the board saw the defence budget fall to 1.6% of GDP – its lowest proportion since before World war 2.

Technical problems with the Collins and JORN programs in particular (though others also encountered significant problems) triggered a number of reviews of Defence's procurement practices and arrangements during the 1990s and early 21<sup>st</sup>



century. Defence's current risk aversion can be attributed directly to these troubled projects and the criticism it received because of them in both Parliament and the media.

But even during the late 1980s and early 1990s there was an emerging awareness within Defence that a limited defence budget could not tolerate inefficiencies and delays in defence procurement and the perceived shortcomings of Australia's defence industry manufacturing base were considered to represent an unacceptable level of risk (Bruni 2002).

### **1.7 Defence Manufacturing**

In 1992 Dibb's report to the Department of Defence on the strategic priorities for Australia's defence industry acknowledged the need to be able to design and build some materiel in-country, but placed greater emphasis on the ability to modify, maintain, repair and upgrade equipment acquired overseas (Dibb 1992). This fundamental policy position was reinforced by subsequent reviews and reports for successive defence ministers over the next 16 years (Defence 1997; Kinnaird 2003; Mortimer 2008; Pappas 2009).

The Report of the Defence Efficiency Review of 1997 summarised elegantly the policy position which Defence has held ever since:

Defence should involve local industry, using competition and all the other tools at its command (mainly the timing and structure of demand) to ensure that suppliers are seeking the maximum possible competitiveness through innovation and other efficiency measures... Ideas that defence is so important that inefficiency and waste (usually not so defined but amounting to the same thing) should be tolerated are ill-conceived and damaging. (Defence 1997)

Noting that subsidised industries inevitably become less innovative and efficient and therefore consume a disproportionate share of Defence's resources, the Report pointed out this was exactly what had happened to the government-owned defence factories and shipyards created during World War 2. It urged the privatisation of those defence companies still in government hands – ADI Ltd, the corporatised reincarnation of the ODP, and the partially government-owned Australian Submarine Corporation, ASC. While acknowledging that certain strategic industry capabilities such as sonar manufacture may need to be supported in some way because they are simply too important to be allowed to die, the Report adds bluntly:

Defence, on behalf of the citizens and taxpayers of Australia, does not owe company managements or shareholders a living and should certainly not be involved in subsidising complete firms or activities in them which are not defence priorities.

The report advocated a free market approach to defence industry and defence procurement in Australia, except for those critical niche technologies mentioned above for which some mechanism was required to ensure their survival at an acceptable cost to the Australian taxpayer. The mechanisms recommended by the Report were “competition and demand manipulation – essentially defining what defence wants to buy and when.” (Defence 1997)

This approach, enshrined and endorsed in the Defence Industry Policy Statements published by successive governments in 1997, 2003 and 2010 (DMO 2010), has shaped Australia’s defence market, defence business environment and therefore the size and make-up of the defence industry.

While estimates of the number of companies in the defence industry vary, and therefore also estimates of the size of the industry, the journal Australian Defence Magazine publishes an annual listing of the Top 40 Australian defence companies and Top 20 Australian Small-Medium Enterprises (SME) which provides some idea of the sector’s scale and revenue. In 2010 the Top 40 companies recorded a combined revenue of \$7.1 billion, while the Top 20 SMEs, of which ten ranked in the Top 40 overall, recorded a combined revenue in 2009 of \$531 million (Hinz and Ziesing 2011). Between them the aggregated Top 40 and Top 20 SMEs turned over \$7.26 billion in 2010. The DMO estimates that Australia’s defence industry employs approximately 29,000 personnel (DMO 2010).

Defence’s policy guidance over the years on its needs of industry has been quite consistent (DMO 2010). The emphasis has been on capabilities such as systems integration, maintenance and modification rather than equipment design and manufacture, except in critical niche areas – today designated PICs and SICs, or Priority and Strategic Industry Capabilities. The result is that the majority of the ADF’s equipment has been sourced from overseas, and even where a local company acts as a prime systems integrator many of the products that it integrates into systems and platforms for the ADF, such as naval radars, guided weapons and command and control systems, are still largely imported.

This is not a problem in an operational or strategic sense: since the middle of the 20<sup>th</sup> century the Australian Department of Defence has worked more or less successfully to ensure its dependency on overseas suppliers doesn't result in glaring vulnerabilities. But the Australian government has been unusual among middle ranking powers in not encouraging significant investment in major indigenous defence equipment design, development and manufacturing capabilities.

As noted in the preface Australia's defence industry is incapable of meeting all of Defence's equipment needs; and given Australia's unique access to equipment and technology from its major allies there is no reason why Defence should encourage local firms to duplicate what is already available to it from overseas.

Industry, for its part, is driven by its perceptions of the risks and rewards of doing business with Defence. A risk-averse monopsony customer, who controls absolutely the size and behaviour of what is by global standards a small market for the very high technology equipment it generally seeks, offers few incentives to take significant technical and commercial risks, especially when that customer spends around 60% of its equipment acquisition budget overseas (see below). It is no coincidence that in 2010 four of the top 10 companies in the ADM TOP 40 were specialist service providers, two of whom specialise in delivering low-technology, low-margin 'hotel' and site management services rather than high-technology, high-risk equipment design and manufacturing.

That said, in 2011 the prospects for Australia's defence industry looked promising, at least on paper: the 2009 Defence White Paper set out an ambitious re-equipment program for the ADF focussing on expanded maritime capabilities and enhanced air combat, land, strategic strike, C4ISR and cyber security capabilities worth between \$245 billion and \$275 billion.

To facilitate this, the December 2010 Update to the 2009 Defence Capability Plan (DCP), which set out the ADF's major capital equipment acquisition plans ten years ahead, contained new projects worth some \$153 billion at 2009-10 prices (DMO 2010). The then-Prime Minister, Mr Kevin Rudd, stated at the release of the 2009 Defence White Paper the Defence budget would grow steadily by about 3% per year in real terms until 2017/18 and then by 2.2% annually thereafter to help pay for these.

However, the lingering effect of the Global Financial Crisis of 2008-09 and persistent delays in a number of defence capital equipment projects, resulted in a fall in defence procurement spending in the 2011-12 budget which analysts believe will persist through 2013-14 and possibly later (Thomson 2011). Along with the requirement to save some \$20 billion, or about 8% of the defence budget, over the decade from 2009 as part of Defence's Strategic Reform Program (SRP), the government's ability to maintain a 3% annual increase in defence spending has been seriously undermined.

The then-Chief Executive Officer of the DMO, Dr Steve Gumley, stated in 2009 that the DMO's budget amounted to some 41% of the total Defence budget, and approximately 0.9 % of Australia's Gross Domestic Product (GDP). Including future acquisition and sustainment over the coming decade, his organisation had \$130 billion-worth of work under management (Gumley 2009).

Table 1.1 sets out the DMO's spending plans from 2008 to 2020, including capital equipment acquisition and sustainment, and the proportion of the acquisition and sustainment budgets which will go to Australian industry.

**Table 1.1: DMO Total and In-Country Expenditure (constant-year A\$ billions):**

Financial Year	In-country Sustainment	In-country Acquisition	Total In-country	Total Sustainment*	In-country sustainment % of Total#	Total Acquisition*	In-country Acquisition % of Total#	DMO Total*	In-country share of DMO Total#
2008-09	3.00	1.60	4.60	4.84	61.98%	4.40	36.36%	9.24	49.78%
2009-10	3.50	2.00	5.50	4.40	79.55%	5.40	37.04%	9.80	56.12%
2010-11	3.30	2.20	5.50	4.75	69.47%	5.84	37.67%	10.59	51.94%
2011-12	3.30	2.00	5.30	4.60	71.74%	5.21	38.39%	9.81	54.03%
2012-13	3.40	1.80	5.20	4.70	72.34%	4.63	38.88%	9.33	55.73%
2013-14	3.50	2.20	5.70	4.90	71.43%	5.36	41.04%	10.26	55.56%
2014-15	3.70	2.30	6.00						
2015-16	3.70	2.30	6.00						
2016-17	3.80	2.60	6.40						
2017-18	3.90	2.70	6.60						
2018-19	4.00	3.00	7.00						
2019-20	4.30	3.20	7.50						
<b>CAGR 2010-20</b>	<b>2.68%</b>	<b>3.82%</b>	<b>3.15%</b>						

Sources: DCP 2009 and December 2010 Update; \* denotes 2009-10 and 2010-11 Portfolio Budget Statements; # denotes author's estimate; CAGR = Compound Annual Growth Rate

This table includes both direct expenditure by the DMO in Australia and funding which trickles down to local suppliers and sub-contractors from foreign companies who get paid directly by the DMO.

It will be seen that between 2010 and 2014 (the limit of Defence's forward budget estimates) the DMO expects to spend around 60% of its acquisition budget overseas, and about 70% of its sustainment budget in Australia. To a great extent this is natural: wealthier northern hemisphere allies are better able to fund the development of high-technology equipment such as jet fighters, guided weapons and very complex command and control equipment to the point where they can be acquired off the shelf as proven, relatively low-risk products, or re-configured and integrated to meet the ADF's requirements at an acceptable level of risk.

This purchasing policy is partly the result of a hard-headed approach to defence acquisition, which seeks maximum value for money in buying equipment, the most cost-effective arrangements for providing logistics support, and the least exposure to risk; and in part the consequence of widely reported technical problems and schedule delays with major defence projects during the 1990s and early-21st century. These triggered a number of government reviews and resulted in calls for Defence to acquire advanced equipment and weapons off the shelf, or at least to benchmark the cost-benefits of developmental solutions (both indigenous and carried out overseas on Australia's behalf) against available COTS and Military Off The Shelf, or MOTS, equipment (Kinnaird 2003; Mortimer 2008; Pappas 2009).

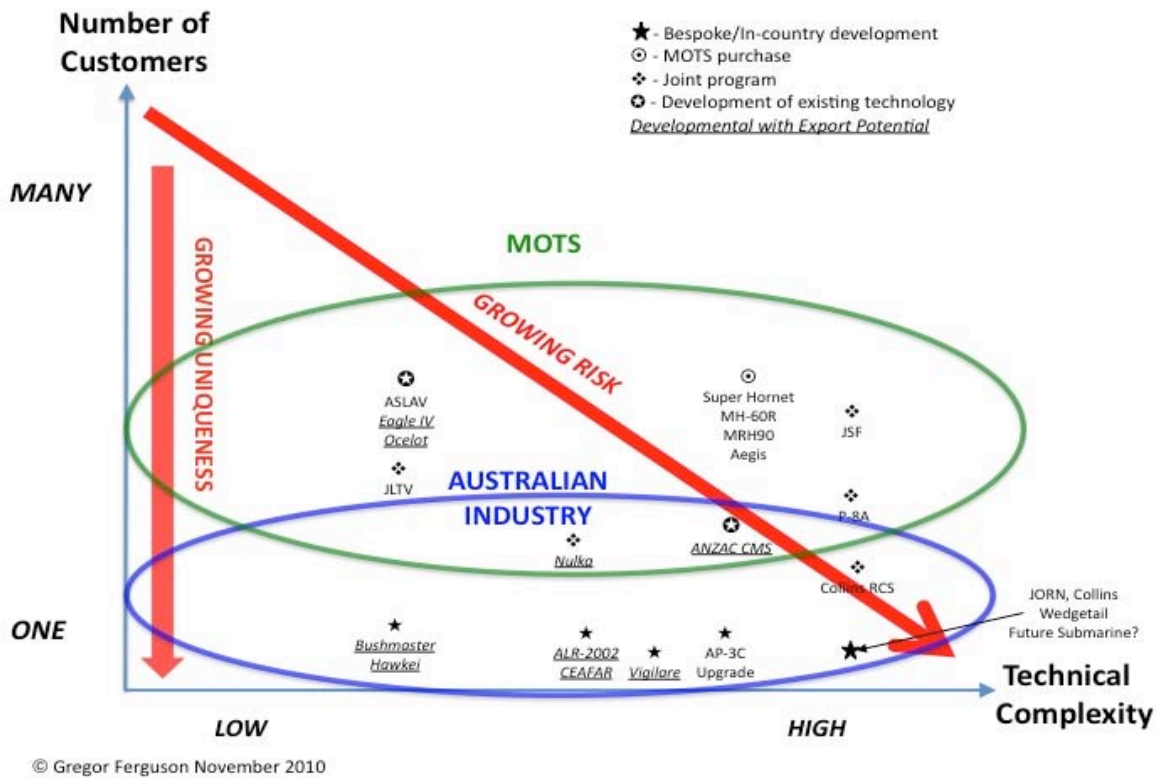


Figure 1.2: Mapping Australia's Defence Market

Figure 1.2 maps the challenges facing Australia's defence industry. The vertical axis represents the number of customers there are for a particular piece of equipment; the horizontal axis represents the complexity of the equipment. The graphic includes equipment and platforms either in service with the ADF or likely contenders for future contracts. The Australian defence industry is generally positioned towards the bottom of the graph where Defence is the first and sometimes the only customer for a new, locally developed product. Being risk-averse Defence prefers to shop higher up the graph where more mature, lower-risk products are available, generally from overseas suppliers. In some cases (eg Nulka, JSF and JLTV), Australian industry is part of the international team developing the equipment. The highest risk for Defence lies at the bottom right of the graph, where Australia must either develop, or pay to have developed, a unique, complex and usually expensive capability not available anywhere else (Ferguson 2010).

## 1.8 Defence Acquisition policy

An important factor driving the DMO's acquisition policy is the imperative to maintain competition. Competitive tendering, ideally with a MOTS product as a benchmark for assessing cost, capability and risk, is the DMO's principal mechanism for pursuing value for money and determining who best delivers it. By definition, all brand new defence equipment is the product of a developmental project. Conversely, once an item of equipment has been developed and has entered service it becomes a MOTS product – but usually only to an export customer after domestic demand has been met. This means Australian companies may be at an inherent disadvantage because new, innovative equipment developed locally to meet the specific needs of the ADF carries risks and costs which Defence may find hard to justify when MOTS equipment already available from an overseas supplier, though perhaps less innovative, represents reasonable value for money at lower risk. Thus Australia's relatively small defence market does make it difficult for indigenous companies to compete against foreign suppliers from countries with much larger defence forces and bigger research and procurement budgets.

The resulting pressures on Australian defence companies and the rewards they can expect to glean from their work is highlighted by the DMO's own figures. The DMO has attempted to evaluate defence industry performance by tracking key indicators reported by its top seven Australian materiel suppliers (whom it did not name). The indicators were the pre-tax Return on Sales (ROS), Return on Assets (ROA) and Return on Equity (ROE, see Table 8). These fluctuated significantly over the period in question, and it is possible they are heavily affected by the performance of just one or two large companies. Nevertheless, they show an average return on sales over the decade of less than 6%. In only four of the 10 years did the ROS and ROA exceed 5%, and these dropped as fast as they climbed.

**Table 1.2: Industry Return on Sales, Assets and Equity (ROS, ROA, ROE - %)**

NOTE:  
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Source: DMO 2010 NB - Top 7 materiel suppliers to DMO

By way of comparison, during the same period the Boeing Company in the USA aimed to achieve double-digit margins; by that company's measure, the top seven

Australian defence materiel suppliers were consistent under-performers, notwithstanding the cyclical nature of the defence market and the Australian industry's growth over this period.

However, risk is unavoidable when seeking new and improved operational capabilities. There are inevitably circumstances where the MOTS option delivers insufficient capability, or is obsolescent and therefore will require early replacement, or is unacceptably expensive to operate or maintain, or some unpalatable combination of all three. Under these circumstances Defence is forced to contemplate a developmental project – in other words, a new product innovation.

The inherent risks in a developmental project can be mitigated, or at least shared, by collaborating with a foreign ally who has a similar operational requirement at the same time – such as the joint US-Australian Nulka active decoy and Collins replacement combat system projects, for example; or by joining an existing developmental program such as the US Joint Strike Fighter (JSF) or Joint Light Tactical Vehicle (JLTV) projects: this is an approach increasingly adopted by Defence since the start of the 21<sup>st</sup> century. The risk associated with this approach is that the ADF, as a junior partner, is then at the mercy of the project leaders and sometimes lacks the power to influence cost and schedule in any beneficial way. If the project encounters delays or costs increase, Canberra has little or no power to change things.

Defence has also eschewed the mechanism employed by many countries to support their national defence industries: driven by value for money and reluctant to intervene in the function of markets, Defence no longer demands 'offsets' in return for placing orders with overseas suppliers. Offsets require the equipment manufacturer to place work in the customer's country to an agreed value. This could be local assembly of the equipment, or manufacture of significant components of it, or even work on a different product entirely which better suits the capacity and capability of local suppliers.

Such work can generate welcome volume and cash flow for the local companies involved and help sustain important skills and industrial capabilities, and many countries use an offsets policy as an industry development and economic support tool. However, Defence and the DMO argue instead that offsets add to the price they pay for the equipment concerned, and do not deliver lasting value to the participating companies. Offsets rarely involve challenging design work: they have



traditionally been undemanding 'build to print' contracts limited in scale and duration by the size of the customer's order. So an Australian order for, say, 100 aircraft might see a local company assemble only 100 aircraft or build only 100 'ship sets' of some component or sub-assembly, with no guarantee of follow-on work and possibly no technology transfer to help them secure more of such work in the future. And tooling up to build only 100 components when the prime contractor may expect to sell several thousand is likely to be inefficient and so add to the price paid by the customer demanding the offset.

Defence's Australian Industry Capability (AIC) program is more strategic in its intent. In major capital equipment programs above a threshold value of \$20 million, prime contractors are required to prepare and implement an AIC plan which provides opportunities and work for local suppliers, and specially SMEs. This helps ensure the work done by local companies positions them to support the equipment once in service. It is also designed to integrate these companies into the global supply chains of the overseas prime contractors by creating opportunities on a 'best value for money basis and helping them become more productive and competitive so they can secure long-term supply contracts which aren't limited by the number of examples of the equipment the ADF is buying. The AIC program does not guarantee work for Australian firms, but is designed "to apply leverage on prospective suppliers", principally foreign prime contractors, to provide opportunities for local companies to compete on their own merits (DMO 2010). The onus is on those local companies to be as efficient and competitive as possible, and this in turn requires them to be innovative.

In any case, Australian companies cannot count on the volume and cash flow generated by offset programs, so must strive to deliver value for money as well as world-class performance and operational capability.

Industry offsets, and the policy arguments surrounding them, highlight two important features of the global defence market. Firstly, it is heavily distorted by national and alliance strategic considerations (no member of the NATO alliance, for example, is likely to acquire Russian-made equipment, regardless of its price or performance). Secondly, national political and economic considerations, including the creation of jobs or simple national prestige, can over-ride value for money and outright capability.

It could be argued that as the distance between the end user and the innovator increases, the focus of a company's innovation activities shifts in important ways. The company supplying direct to the end user competes (usually) with others to understand and then satisfy the user's needs by designing a product which offers the best value for money. A company which supplies sub-systems or components to a prime contractor becomes part of that prime's value chain and plays a role in helping him deliver the necessary value for money.

The lower down the supply chain the sub-contractor is, the less directly it is affected by Defence's policy and processes. Thus for some companies the defence market is not monolithic: while the ADF or some other agency within Defence may be the end user of a piece of finished equipment, a component manufacturer's customer may not be Defence itself. For small specialist companies there may be several target customers, each of them a company higher up the industry supply chain and competing with each other to sell to the end user or to the prime contractor. The product in this case might be a sub-system which the company designs and builds by itself, or a simpler component manufactured to a design or specification provided by the customer. And the company may face competition from a number of rivals for the same order.

While the cycle and timing of defence acquisitions, and the budgets allocated to them, are still dictated ultimately by Defence, the lower a company sits on the supply chain, the more its market resembles a conventional non-defence market for industrial products and services. To a growing extent the balance shifts from developing products to providing skills, quality and capacity; in turn the focus of innovation activity increasingly becomes process efficiency, quality and cost, as a component of the performance and value for money delivered by the product in question which will be designed and developed by a company at or near the top of the supply chain.

This is illustrated by the R&D being carried out under the aegis of the Melbourne-based Defence Materials Technology Centre (DMTC) in areas such as the construction of ships, submarines and armoured vehicles and the machining of titanium components for aerospace applications. This R&D isn't directed towards new designs and the development of new products, except to the extent some of its research plays an enabling role in allowing manufacturers to contemplate new configurations and new types of functionality. Instead it focuses on very specific

aspects of product performance such as developing improved armour materials and on reducing the time required to carry out complex industrial processes such as the welding of steel armour plate and the high-speed machining of extremely hard materials such as titanium.

This research could have two outcomes. Firstly, in niche areas where Australian companies can compete credibly to develop and build armoured vehicles, for example, it helps improve and optimise aspects of the vehicle's performance, as well as helping manufacturers become more efficient and competitive. Secondly, in the global aerospace market Australia no longer designs and manufactures military aircraft and airliners, but local firms do design and manufacture complex, high-technology titanium and carbon fibre composite aerostructures and components. The DMTC's research is designed to make Australian companies more competitive in this market and so better able to win work manufacturing components and sub-assemblies in the global supply chains for major aircraft programs such as the US-made F-35 Lightning II Joint Strike Fighter (JSF).

Referring back to Figure 1.2, this suggests that Australian firms with the appropriate skills, quality and capacity could generate significant volumes of export work by moving 'up the graph' and manufacturing components and sub-assemblies for the overseas suppliers of MOTS equipment from whom the DMO prefers to buy equipment.

### **1.9 Sustainment**

Since the early 1990s the ADF has outsourced most of its maintenance and repair capability to local contractors. This process began with the Commercial Support Program (CSP) in 1991 which was intended to harvest recurring savings to the defence budget of around \$200 million a year.

Sustaining complex defence equipment work requires high levels of technical mastery and specific domain knowledge, but in an environment where technologies and threats evolve and grow in increasingly rapid cycles, it is arguable that these are very difficult to sustain unless companies are intimately involved in designing and developing this (or similar) equipment in the first place. Industry argues, therefore, that it needs regular, consistent work that is both technically challenging and can support the regular investment required to sustain and extend key skills and capabilities. There is considerable scope for innovation in this sector of the

market, especially in areas such as health and usage monitoring and the rectification of structural and component damage and age-related deterioration (DMTC 2010).

However, Defence's SRP drive to reduce the cost of owning and operating its equipment will see Defence expenditures on sustainment drop (Defence 2009). To some extent this will be the result of increased internal efficiencies within Defence itself, but Defence's external expenditure will also drop resulting in falling industry revenue which places the onus on companies to become even more efficient and competitive and therefore even more innovative.

### **1.10 Science and Technology (S&T)**

If the ADF depends for its military superiority on largely imported equipment and technology, it also needs to understand this technology, its limits, vulnerabilities and shortfalls, and how to exploit it proficiently. It also depends, as noted previously, on a technology-rich domestic industry support base which can maintain, repair and upgrade imported as well as locally-manufactured equipment in-country. Therefore, Defence needs to understand how industry acquires, develops and husbands technology and then applies it to the needs of its customers.

Over the decade from 2010 the ADF plans to spend \$150 billion acquiring and sustaining new and existing defence equipment (Gumley 2010). Defence invests around 2% of its budget, or over \$480 million a year (mostly through DSTO), on R&D which generates the S&T advice necessary to help it select, operate and sustain this equipment (Defence 2010). However, very little of that R&D spend goes towards developing new platforms and weapons. Most of DSTO's R&D effort underpins the S&T advice it provides the ADF on enhancing the performance of equipment already in service, addressing urgent and emerging operational problems and supporting Defence's capability development and acquisition processes by conducting technology and risk assessments. This role is set out in DSTO's mission statement: "The Defence Science and Technology Organisation (DSTO) is part of Australia's Department of Defence. DSTO is the Australian Government's lead agency charged with applying science and technology to protect and defend Australia and its national interests." (DSTO 2010)

Notwithstanding the significant operational benefits it delivers DSTO's research is not driven by the need to commercialise its Intellectual Property (IP). This is a sharp contrast with its equivalents in the US, UK, France and elsewhere, whose roles

explicitly include developing technology and IP for commercialisation in the form of weapons and equipment for their national armed forces and export customers. It also contrasts with Australia's government-funded non-defence R&D organisation, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), which has an explicit mandate to commercialise the fruits of its R&D. That said, Trenberth notes some very significant commercialisation successes based on IP developed from DSTO's own R&D (Trenberth 2004).

In Australia the responsibility for carrying out R&D to create new defence equipment and industry capabilities shifted during the '90s and early 21<sup>st</sup> century from DSTO to industry itself and a small number of specialist R&D organisations. The exception to this rule might be when a unique and complex capability is required which cannot be acquired from overseas and which cannot be developed by Australian industry alone – a typical example would be the Jindalee Operational Radar Network (JORN), which was based on DSTO's research and IP.

### **1.11 Why do R&D?**

By virtue of its relatively small size the ADF alone has never represented a market base sufficient to justify the public and private sector R&D investment needed to sustain and grow the massive industry, skill and technology base necessary to design, develop and manufacture economically major items of defence equipment such as combat and transport aircraft, guided weapons and armoured fighting vehicles. Australia has never been politically isolated, like South Africa, Israel and Taiwan, and so has never been forced to bear the burden of trying to become self-sufficient in defence terms.

So it's worth asking why Australia invests in defence R&D at all: thanks to the privileged access it enjoys to the arsenals of its key allies, the United States and United Kingdom, there's very little the ADF needs that can't simply be bought off-the-shelf. Advocates of the so-called 'free riding' approach argue that Australia should stop spending government money on defence R&D, and eschew local construction of ADF equipment (which often attracts a cost premium) in favour of MOTS solutions. The result, it is argued, would be a net saving that could be invested in other more productive areas of the economy, creating greater national wealth which would in turn allow the ADF to buy more and/or better equipment.

In an economic sense, this would allow Australia to take advantage of the distortions in the international defence market and the self-inflicted inefficiencies that many foreign countries have created by investing heavily in defence R&D and distorting the defence market to support their own manufacturers, both domestically and in export markets. This contrasts with Australia's long-standing economic policy of minimising or eliminating government interference in industry and the operation of markets (Davies and Layton 2009)).

There are several arguments against this economically dry outlook. Firstly, there are some things deemed essential to both national defence and sovereign self-reliance that can't be sourced anywhere else at any price. In this view, Australia needs both the research and industry capacity to create things like the JORN over the horizon radar, Collins-class submarines (and their successors) and certain types of electronic warfare, signals intelligence, cyber warfare and encryption capability.

Secondly, Australia would sacrifice its independence—in a barren Australian technology landscape not only would it become impossible for DSTO and the local defence industry to develop sophisticated new equipment, it would also become increasingly difficult even to maintain and upgrade imported equipment using local skills and resources. The ADF would become dependent on key foreign suppliers who are themselves answerable ultimately to their own national governments, not to Canberra. Australia would also lose its ability to evaluate others' R&D - a critical skill for a would-be 'smart buyer' - as well as their operational capability.

Thirdly, Australia depends on its alliances. These in turn depend partly on Australia's ability to contribute credibly to the relationship by providing unique, niche technologies and a secure portal for intelligence and technology sharing and transfer between governments. These are among DSTO's most vital roles and DSTO's portal to US technology, in particular, is highly prized by the ADF. In return, DSTO's expertise in peculiarly Australian defence technology challenges, such as surveillance over wide areas and extending the lives of platforms such as ships and aircraft, provides the credible 'trade goods' that Australia brings to its alliances with the US and the UK, in particular.

The opportunity cost to Australia if it were to significantly under-invest in defence R&D was summarised by a senior Australian defence scientist (who declined permission to be identified publicly) in an interview with the author in 2005:

“[W]e end up beholden to the market with no control over the price we pay for equipment and the capability we receive. Local production (based on local R&D) leaves us options and some leverage in the market place. The advice that DSTO provides Defence in policy/buyer/user areas is backed by its R&D, so defence R&D is an essential component of defence capability. The long-term consequences of bad decisions can be unexpected and persistent, so good advice is essential.” (Ferguson 2005).

This Australian scientist’s view finds an echo in recent British research which found a statistically valid correlation between levels of R&D investment and the quality of a country’s defence equipment 25 years later (Middleton, Bowns et al. 2006) - noting, of course, that UK defence research is far more likely to be commercialised in order to develop new equipment. These findings were reflected in the UK Defence Technology Strategy (UKMoD 2007) and summarised thus (Sutton 2007):

- The quality of military equipment is highly correlated with absolute R&D investment (no other factor correlates anything like as well).
- The benefit in terms of equipment quality depends equally on R&D investments made about 20 years before going into service (the research phase) and on those made five years before going into service (the development phase).
- Innovation is critical to achieving effective military capability.
- Whilst innovation is necessary at all levels within the equipment supply chain, there is a need to stimulate greater innovation and inventiveness at the earlier stages of R&D.
- The UK MoD needs access to highly capable scientists and engineers, within both government and the private sector

To the extent the ADF relies on indigenously developed equipment, these findings apply to Australia also. While the US continues to dominate global Defence R&D in absolute terms, Australia continues to benefit from its access to US equipment and technology, and to that of the UK which still holds a strong position though its relative position is declining (Middleton, Bowns et al. 2006). However, a relative decline in Australian defence R&D investment by either the government or the private sector would likely condemn Australia to increasing irrelevance as either a technology source or ‘trading partner’ within the alliance and could undermine the nation’s sovereign self-reliance in the planning and conduct of military operations.

## 1.12 The role of DSTO

It's a common misapprehension in the wider community that Defence seeks to shop locally and that DSTO's main purpose is to develop new equipment for the ADF either by itself or in partnership with industry. Wylie's November 2004 study, "*A Profile of the Australian Defence Industry*", notes that one of DSTO's key roles (then, as today) is advising the DMO and the CDG on technology risk, conducting Technology Risk Assessments (TRA) in support of major capital equipment programs, and providing defence policy, smart buyer and smart user advice to Defence and the ADF (Wylie 2004).

During the 1950s, '60s, '70s and '80s many of the component organisations from which DSTO was assembled were at various times parts of the Department of Supply or the ADF and had greater autonomy than is the case now when DSTO is part of the Department of Defence. These organisations (including DSTO itself during its early days in the late-1980s) could therefore choose to invest a higher proportion of their resources in developing new IP, technologies and equipment. This approach resulted in technically and commercially successful products such as Ikara, JORN, Nulka and LADS which were all conceived between the 1960s and 1980s. Commercialisation of its R&D between 1990 and 2005 in these projects, and other work such as aircraft structural testing, generated direct income or measurable defence budget savings equivalent to DSTO's own total budget for that period (Trenberth 2004). DSTO effectively paid for itself during this period by commercialising IP developed as much as 25 years before (reflecting Sutton's comments cited above); but it's not clear it could claim similar results from its research activities in the 21<sup>st</sup> century.

DSTO reshaped itself significantly during the late 1980s and early 1990s to align more closely with the S&T needs – mainly advice and technical expertise - of its principal 'client', the ADF. From being an R&D organisation during the 1950s, 60s, 70s and 80s, it has become primarily a Research organisation devoting very few resources towards Development.

The senior Australian defence scientist cited earlier stated:

“Most of DSTO's budget...does not go on activities which are intended to generate IP which can be commercialised. Much of DSTO's activity is designed



to provide policy/smart buyer/smart user advice relating to decisions which the Dept of Defence will make over the next 2-3 years.” (Ferguson 2005)

The proportion of DSTO’s budget devoted to what it calls ‘enabling research’ – that is, to investigative research which is not directed towards furnishing S&T advice or assessing technical risk – has fallen over the past two decades to less than 15% (Ferguson 2005). And commercialisation of any resulting IP is not a major priority (Trenberth 2004); indeed, its Key Performance Indicators in the Department of Defence’s Annual Report don’t mention ‘commercialisation’ (Defence 2010).

This has evidently not been considered a problem within Defence: as an organic part of the Department of Defence, DSTO’s work delivers a quantifiable benefit, but the organisation’s core business is not to develop new equipment; and as noted earlier Defence increasingly favours MOTS equipment acquired from overseas firms and allies. That said, much of DSTO’s most important work for the ADF is classified and therefore unreported: since 1999 DSTO has responded to the ADF’s heightened operational tempo and the threats it has faced in East Timor and then Iraq, Afghanistan and elsewhere by increasing its enabling research in priority areas such as personnel protection, NCW, undersea warfare and cyber security. This research has led directly to improvements in the ADF’s operational capabilities in these and other areas.

It must be understood that, except for a small but critical portion of ADF capability, Australia faces no overpowering strategic imperative to develop its own high-technology defence equipment. It would be pointless and wasteful to try and duplicate within Australia much of what is freely available from overseas. One of the key challenges for Defence, therefore, is not that of developing the equipment needed by the ADF, but understanding how to make the right choice of what is in general freely available, and then make best use of it once in service.

Dr Richard Brabin-Smith was the Chief Defence Scientist between 1993 and 2000 and steered DSTO through its period of greatest change, particularly in its relationship with the ADF to whom it sought to become more relevant and responsive. He laid out the policy foundations for DSTO’s investment in R&D during the mid 1990s and explained them in an interview with the author in 2005:

“ ‘R&D’ is a much-abused term. When I was CDS, I tried to avoid using it unless it were clear that a line of scientific investigation was likely to lead to a

product that would demonstrate a new and relevant application of science or technology to Australia's defence priorities, or, preferably, a product that sooner or later would enter service.

"In part, I did this because the most important "scientific" need in Defence was (and still is) to know how best to use the technologies developed by others. This is not so self-evident for it not to need to be stated explicitly."

"To my mind, the priorities for Australian Defence R&D (i.e., where there's a clear need for a product to be developed) will continue to be in relatively limited niche areas. When I was CDS, I set up four broad policy guidelines, and I imagine that they are still relevant: where Australia's defence needs are sufficiently different from those of other nations for it to be necessary in effect for us to develop our own solutions; where the security sensitivities are so high that not even our closest allies will share their secrets with us; where our own security concerns are so great that we would prefer not to share with even our closest allies; and where, from time to time, we come up with an idea that is just so good that it would be silly not to take it further. I stress that these were guidelines, not tramlines, and their application still needed judgement. I found them very useful for sorting out what would get worked on and what wouldn't.

"The need for "services and expertise" is much broader than this, and is best summed up in the expression that I used along the lines of "DSTO's job within Defence [is] to give impartial and professional advice on how best to apply science and technology to Australia's defence and security needs." Again, the conceptual framework embodied in these words helped sort out what was a priority and what wasn't, and had the added benefit of focussing DSTO on the people being advised, i.e. 'the customers'." (Brabin-Smith 2005)

Brabin-Smith's policy guidelines would seem to represent prudent stewardship of public funds. They are consistent with the broad thrust of successive expressions of Defence's needs of Australian industry, and they significantly determine the scope and nature of DSTO's interactions with industry. However, they ignore the restless, entrepreneurial nature of private enterprise: while DSTO may not be able to justify stepping outside these guidelines, private sector organisations have every right to ignore them if they wish, and at their own commercial peril. Australian companies

that have done so have sometimes been conspicuously successful; the industry's track record is examined elsewhere in this thesis.

These policy guidelines also conflict with other expectations: during the 1990s, under [then] Ministers for Defence Science and Personnel Bilney and Kelly, and then again in the early years of the 21<sup>st</sup> century, a definite expectation developed within the Federal government that DSTO, along with other government-funded research agencies, should make a more direct contribution to national wealth through the commercialisation of its R&D (McGauchie 2004).

The fact that DSTO is part of the Department of Defence means its budget is not subject to the same competition for resources as other publicly funded research organisations. That said, internal scrutiny and contestability within Defence is designed to ensure its research directions and activities are properly justified. It could be argued also that the unique imperatives of national defence, including the need for unhindered Australian access to high quality foreign-made equipment, means that DSTO's role is unique within the community of public research organisations in Australia.

Given the massive asymmetries in defence spending, DSTO doesn't attempt to duplicate research that key allies such as the US, UK and others are already doing, nor to help local industry develop equipment others can produce more economically. Table 1.3 compares Australia with the US and UK – the difference is enormous.

**Table 1.3: US, UK and Australian Defence R&D 2008-09 (then-year A\$ Billions):**

Country	Defence Budget	Defence R&D Budget	R&D % of Defence Budget
Australia	22.9	0.49	2.1%
USA (FY 09)	523.5	80.4	15.4%
UK	62.4	3.4	5.45%

Sources: UK MoD Defence Statistics 2010, US DoD FY2009 Budget request, ASPI Defence Budget Brief 2010-11

Exchange rate calculated December 2010: AUD\$1 = US\$0.99 = GBP0.63

**NB:** US Total RDT&E budget is US\$79.6 billion. Basic and applied R&D amounts to US\$11 billion, or 2% of defence budget

Arguably, DSTO's 2.1% share of Australia's defence budget is the price the ADF must pay to be a technologically 'smart' buyer and user of high-tech equipment.

Most comparable defence forces also devote a comparable proportion of their budget to defence research.

However, countries from which Australia has bought significant amounts and types of high technology defence materiel are either wealthier nations which can afford to spend more on defence R&D or, like Norway, Sweden and Denmark which spend less than Australia on defence, are prepared to spend a greater share of their national wealth on defence research. These countries make the necessary R&D investment and buy (and frequently export) the resulting equipment and live with any resulting distortions of the free market and consequent cost premiums borne by their taxpayers.

From the economically dry outlook which prevails within Defence generally, it's questionable whether DSTO needs a local defence industry to justify its existence. Most of the \$486 million which Defence spent on S&T in 2008-09 made little direct contribution to national wealth through the mechanism of commercialisation and industry innovation. That's not to understate DSTO's contribution to safeguarding national prosperity by its support for the ADF and to national security more broadly. As noted earlier much of DSTO's best and most important work is highly classified, so unreported and therefore unexamined in this context.

The status quo seems to suit DSTO and Defence. The Trenberth report on DSTO's external interactions recommended in 2004 that knowledge transfer and collaboration with industry should become an explicit part of DSTO's core business (Trenberth 2004). Specifically, Trenberth recommended:

*“To assist with the reorientation of culture and processes required to achieve enhanced commercial outcomes in DSTO, and in other publicly funded research agencies, the Government make it plain, through a statement, that: “The Government wishes knowledge transfer and collaboration with industry to become part of the core mission of both public sector research establishments and universities, so that investment generates the maximum benefits in the form of jobs and prosperity for the nation.””*

Defence's response to this recommendation, agreed by [then] Minister for Defence Senator The Hon. Robert Hill, was this:

“The recommendation was referred to the [then] Department of Education, Science & Technology (DEST) and the Minister for Defence agreed that Defence will not take any further action at this time.” (Trenberth 2004)

Clearly, DSTO and Defence felt no need at that time (or indeed since then) to make fundamental changes to this aspect of DSTO’s activities.

The author’s research has confirmed that Australian companies do not consider DSTO an important source of product-related IP (this will be discussed in Chapter 4) but, paradoxically, the defence industry’s levels of R&D haven’t grown to compensate for DSTO’s gradual withdrawal from the product innovation arena. With the exception of a handful of critical defence programs, local companies generate their own IP or work with other defence R&D organisations in Australia.

So while DSTO’s advice will help Defence spend the \$150 billion it plans to invest in new capital equipment and sustainment wisely, and use the equipment effectively, the relationship between what Australia spends on defence research and what it plans to buy with its defence budget looks surprisingly tenuous.

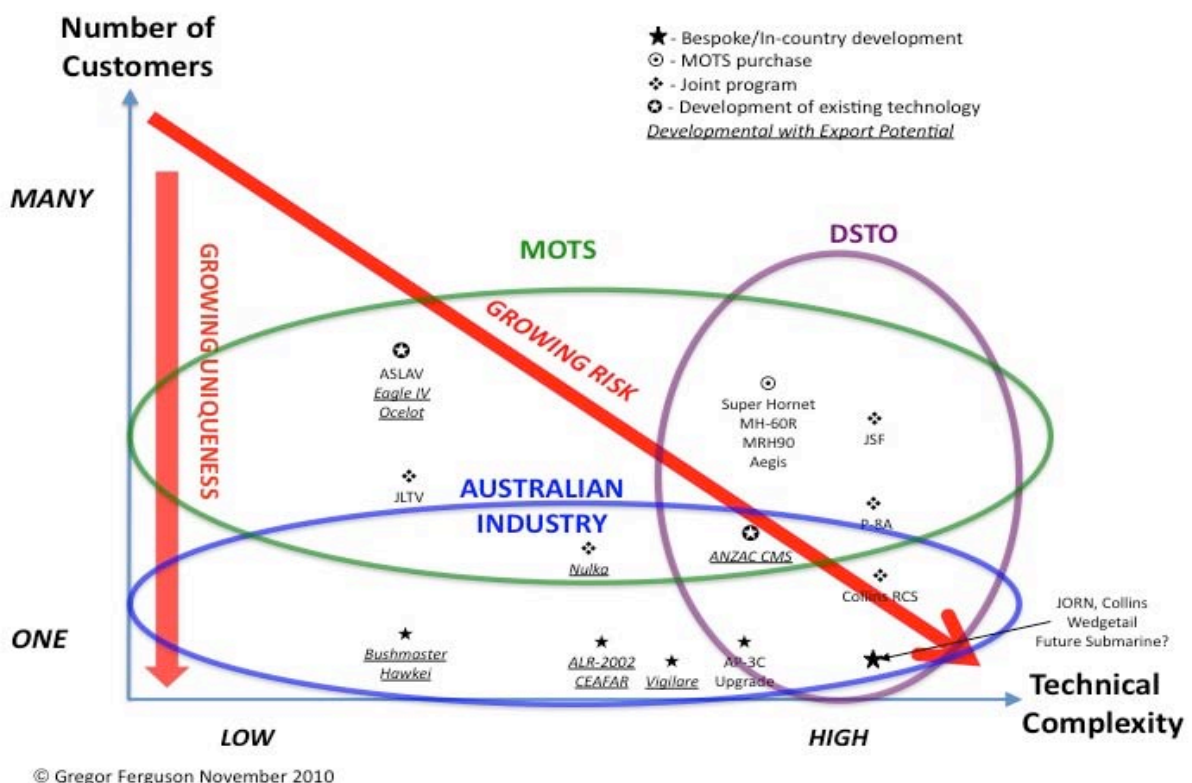


Figure 1.3: DSTO, Defence and Industry – the overlaps

Figure 1.3 builds on Figure 1.2 to map the spaces within which industry, DSTO and the DMO operate, and how their research priorities overlap. DSTO patrols the high end of the defence technology spectrum (purple ellipse); while it has a watching brief over most of the areas covered by this diagram it focuses especially on the right hand side, where the technology and integration challenges are greatest.

Arguably, this area has shrunk in recent years - DSTO is no longer in the business of creating new capabilities such as ALR-2002 and Nulka, both of which were developed from its IP, although understanding the technology behind them remains part of its core business.

The vertical axis represents the number of customers there are for a particular piece of equipment; the horizontal axis represents the complexity of the equipment. The diagram includes a selection of equipment and platforms either in service with the ADF or likely contenders for a future contract. The products lying within the green 'MOTS' ellipse have all been developed initially for an overseas customer and then acquired off the shelf, or in a joint venture with that customer (the JLTV, or Joint Light Tactical Vehicle), or have been evolved from an existing, proven product (Saab's Anzac frigate CMS, or Combat Management System). These represent relatively low technical, financial and schedule risk to the ADF.

The blue 'Australian Industry' ellipse contains those products developed entirely or mainly in Australia by local firms with the ADF as the launch (and possibly sole) customer. The complexity of some of this equipment along with the relatively small domestic Australian market and defence industry compounds the technical, schedule and financial risks associated with these products.

The highest risk for Defence lies at the bottom right of the graph, where Australia must either develop, or pay to have developed, a unique, complex and usually expensive capability not available anywhere else. Generally, however, Defence is reluctant to court what it considers to be unnecessary risks associated with local development of new equipment when excellent equipment is available off the shelf from its close allies the UK and USA.

These territories overlap imperfectly. It will be seen that DSTO's research contributes little to either the MOTS equipment available from overseas or the locally-developed equipment manufactured by Australian industry. Indeed,

research conducted by the author and described later shows that Australia's defence industry does not generally consider DSTO a useful source of IP.

DSTO still actively seeks collaborative relationships with industry in order to foster information exchanges and shared awareness of the defence technology and industrial environment, but successful commercialisation is an increasingly rare outcome. Industry seeks relationships with DSTO for the same reason - principally to gain market intelligence and an understanding of the ADF's technology requirements and risk tolerance, and only rarely to gain access to IP that it can commercialise.

### **1.13 Australia's other defence innovation mechanisms**

Overall, Australia has three defence R&D 'strands':

- DSTO, whose S&T activities are vital in an operational sense, but aren't focussed on commercialisation
- the private sector, whose R&D investment and risk appetite is conditioned by its commercial assessment of the defence market place and a growing reliance on sustainment and services rather than equipment design and manufacture as a source of income
- a 'middle ground' occupied by a number of smaller defence R&D players.

The middle ground is occupied by other mechanisms for conducting what might be termed 'applied defence R&D' or innovation and which are designed to help create new capabilities and equipment for the ADF.

The first is the Capability & Technology Demonstrator (CTD) program, funded by the Capability Development Group (CDG) to the tune of \$13 million a year but administered by DSTO. A CTD project is designed to demonstrate the utility of a new technology in specific military applications but not to create a production-ready prototype. A typical CTD would take a new technology from a Technology Readiness Level (TRL) of 4 – defined as "Component Validation in Laboratory Environment" through TRL 5 – "Component Validation in Operational Environment" to TRL 6 – "Prototype Demonstration in Relevant Environment". (Trenberth 2004)

Of ninety-one projects funded up to the end of 2010, some fifty-five had been judged successful. But of those less than a dozen have generated sufficient user interest and development funding to take them through TRLs 7 to 9 and transform them into finished products. A CTD Extension Program was introduced in 2009 to

provide additional funding of \$13 million a year (again from the DMO) to advance a handful of promising CTD projects, but this is only funded through 2011–12, and the funds were fully allocated by 2010.

The second mechanism is the Rapid Prototyping, Development and Evaluation (RPDE) program, established in 2007 also by the CDG with an annual budget of \$12 million (partly funded by the DMO) to apply defence and industry expertise to pressing operational problems in the NCW domain. Because RPDE actively involves the end users as well as CDG, DMO and DSTO, it has proven an effective mechanism for stimulating and then applying innovation right across the defence community. A number of RPDE projects, which necessarily began on a small scale, have spawned larger capital equipment acquisition projects to address the ADF capability shortfalls which triggered the RPDE activity in the first place.

DSTO has close collaborative research links with the Defence Science Institute (DSI) at the University of Melbourne, established in 2010, and a number of current and former Cooperative Research Centres (CRCs), such as the CRC for Advanced Composite Structures (CRC-ACS), as well as CRC-like organisations such as the Defence Materials Technology Centre (DMTC), which it supports with both cash and personnel. DSTO also has links with a number of university research centres and collaboration agreements with bodies such as the CSIRO and National ICT Australia (NICTA), the country's centre of excellence in ICT research.

The CRCs and DMTC are run by the Department of Innovation, Industry, Science, Research and Tertiary Education (DIISRTE), which has an effective model for both governance and the delivery of measurable research results, although the DMO funds the DMTC to the tune of \$4.4 million a year. This investment in turn has leveraged another \$8.5 million a year in DMTC funding from industry and academic participants, including DSTO and the Victorian government; the Victorian state government contributes funds to the DMTC and DSI precisely because their research has the potential to deliver direct industry and therefore economic benefits.

From DSTO's point of view these links generate expertise and insight into a variety of specialist technologies ranging from biological and chemical threats, armour protection and lightweight aerostructures to submarine batteries. This supports and strengthens DSTO's advisory function. However, these organisations conduct applied R&D and incorporate proven mechanisms for transferring IP and expertise to industry and thence to the Defence customer in the form of products and



services. Indeed, this is the fundamental role of the CRCs and organisations established using similar models such as the DMTC.

Much of the IP developed from research at the DMTC and CRC-ACS typically relates to materials performance and manufacturing processes rather than product development. This has direct benefits for Defence (lower costs, higher capability and quality and the sustainment of important industry skills and capacity) and also has very significant benefits for Australian firms seeking work in, for example, the global supply chains of multi-national prime contractors.

While the relationship between what Australia spends on defence research and what it plans to buy with its defence budget looks somewhat tenuous, IP flowing from research by bodies such as the DMTC and CRC-ACS is providing Australian companies with design and manufacturing skills which enable them to compete against rivals around the world for manufacturing work on projects such as the Joint Strike Fighter. This research also strengthens local companies seeking to design and develop complete products for the ADF, such as armoured vehicles and warships.

#### **1.14 Conclusion**

To summarise this chapter: Australia is a large country with a small population and small defence force. However, it has strong alliances with the USA and UK and therefore unique access to their defence equipment and technology. Australia is also wealthy enough, and has a population that is sufficiently educated, that it can afford to buy significant quantities of this equipment and operate it proficiently alongside its allies in coalition operations of one kind or another. At the same time Australia is industrially advanced to the point where it can contemplate significant investment in local design and manufacture of certain types of highly sophisticated defence equipment.

Defence and the ADF do not own the means of production for military equipment. Almost every product and service consumed by the ADF is acquired from a commercial supplier, either in Australia or overseas.

Defence has articulated a defence industry development policy which both addresses its strategic requirements and recognises the need for a strong, sustainable (and therefore, by definition, profitable) defence industry sector (Defence 2010). Since the introduction of the CSP during the early 1990s, which

sought to outsource many sustainment and administrative functions hitherto carried out in-house by uniformed personnel or public servants, Defence's industry policy has consistently emphasised the need for a national industry base capable of supporting and upgrading in-service the ADF's (mostly imported) defence equipment. Stimulating or supporting defence equipment manufacturing activities has not been seen as a priority except in certain strategically important and quite narrow niches.

This has created the perception within Australian industry of a Defence bias towards foreign-built equipment based on a sometimes-mistaken belief within Canberra that this is superior or more cost-effective or more interoperable with that of Australia's principal allies. Furthermore, sections of Australia's defence industry believe Defence's apparent indifference towards the SME sector, in particular, means local SMEs are regular victims of uncontrolled market forces or predatory behaviour by some prime contractors, to the ultimate disadvantage of all parties. By this argument, private sector Defence innovation activities have been stunted by the perceptions of a customer, Defence, which seems indifferent (and sometimes actually hostile) to Australian companies and Australian-developed products.

The author's research is not intended to form part of any debate over these subjective views except to the extent it can be shown that a particular characteristic of the customer, or some aspect of his behaviour, significantly shapes market conditions and therefore innovation success factors.

Australia's combination of small market size, strong alliances, relative wealth and scientific and industrial sophistication creates tensions and contradictions which Australia's defence policy has been unable to resolve. On the one hand the ADF can buy most of what it needs from its close allies; on the other hand, sovereign self-reliance demands Australia maintain sufficient research and industry capacity to be able to make critical strategic decisions – including the selection of equipment and the conduct of military operations - with as much autonomy as possible. And the Australian government's economically rationalist approach to industry policy across all sectors of the economy means that local companies are free to compete for ADF equipment and service contracts, but generally derive no advantage from the fact they are Australian.

If taken at face value Defence's explicit commitment in the 2010 Defence Industry Policy Statement (and its predecessors) to the AIC program, to value for money and

a level playing field suggests that a genuinely competitive Australian company should not be at an automatic disadvantage relative to a foreign rival. It must be assumed that the factors determining the success or failure of an Australian defence innovation project are those which affect the customer's assessment of performance, utility, risk and value for money. This is the underlying assumption on which my thesis is constructed.

Defence's disinterested approach to industry is reflected in DSTO's lack of interest in commercialising the IP flowing from its R&D activities. Mostly, the R&D required for Australian companies and products to compete successfully against foreign rivals, both in the Australian domestic market and overseas, is carried out in-house by the companies themselves, or in close collaboration with some relatively small but important research organisations such as RPDE, CRCs and CRC-like organisations and in the CTD program.

The Australian defence market is essentially a high-technology market requiring companies to be innovative and technologically proficient. The author's research aims to identify and if possible measure the relative importance of the factors which affect product innovation outcomes in the Australian defence industry. These include levels of R&D investment as well as other organisational and market environment factors, some of them generic in the high-technology marketplace and others specific to the defence sector.

Therefore, the purpose of this research is to identify and if possible measure those technical, business, cultural and market factors which determine the success or failure of the product innovation process at the highest level – where an Australian company attempts to develop a new product for a military end user. If these factors are a consistent feature of either successful or unsuccessful innovation programs, it may be possible to develop a model, or at least a more general set of pre-conditions, for innovation success in Australia's defence industry.

## Chapter 2 – Literature Review

### 2.1 Introduction

This chapter reviews the literature on existing innovation and commercialisation models and success factors, and their possible relevance to Australia's defence business environment.

This research seeks to identify factors enabling or impeding product innovation success in the Australian defence industry. So far as the author's research can determine no innovation success models exist for this industry sector. While a number of models have been developed around the world for successful innovation in both industrial and consumer markets, and in particular the commercialisation of Intellectual Property (IP) derived from R&D in specialist research establishments, and in high-technology industry sectors such as Information & Communications Technology (ICT) and Bio-technology, it would appear that none has been developed specifically for the defence sector.

It's not clear why this is so. It may be because defence R&D has historically existed in something akin to a command economy: defence forces have tended to specify equipment or capability needs (often expressed as emerging threats to which counters are required) and then fund the necessary R&D by a government research organisation or a private company. The result has then been commercialised – a private (or government-owned) company has been selected or simply instructed to design and build the resulting product: a radar, missile, aircraft or some other product or system, which is then fielded by the country's armed forces and possibly offered for export to allies and approved customers.

Generally, specialist defence companies invest a certain amount of their own money in R&D to position themselves to exploit these opportunities and to leverage the government's own R&D investment. Even when suitable equipment has been available off the shelf at relatively low risk and a competitive price from allies and foreign suppliers, the imperatives of 'sovereign self-reliance' have often driven defence forces and governments to conduct their own R&D and develop some (or many) of their own defence equipments in-country (Wylie, Markowski et al. 2006).

While defence forces have often exploited new technologies developed for non-defence applications, defence-related R&D has not always resulted in IP which can be exploited easily or profitably in the non-defence sector (Bellais and Guichard

2006), and this is rarely an explicit (or even implicit) goal of government-funded defence research (Trenberth 2004) (UKMoD 2007). Therefore, it can be argued defence R&D generally is not stimulated by commercial market drivers.

This research focuses on product innovation in the Australian defence industry. New products are generally innovations resulting from a systematic research, design and development process. A key component of the product innovation process is IP, either generated through in-house R&D or acquired from other industrial or research organisations such as DSTO. Regardless of the source of the original IP and its ultimate purpose, it is a reasonable proposition that the innovation process – the process of turning it into an effective, useable defence product - has features in common with the product innovation processes employed by private sector firms operating in commercial markets for industrial and scientific capital goods.

There are some convergent strands of defence and commercial product innovation: over the past two decades defence forces have begun exploiting high technology products and processes developed in the commercial ICT and biotechnology sectors. Whereas defence research once led civilian research in the ICT area, the opposite is now true (Sutton 2007). Therefore the defence community – defence forces, as well as specialist defence manufacturing and systems integration companies – is increasingly adopting products, systems and attendant processes that have already been commercialised from civilian-developed IP.

However, the demands of military operations – in particular for reliability under extremely stressful operating conditions, as well as for security, along with some unique applications and functions that have no civilian or commercial equivalent – mean there is still a sub-set of these and other high technology industry sectors that exists solely to develop products and processes for the military, and to support and enhance these once in service. And while much of the investment in defence-related Science & Technology (S&T) across the western world at present focuses on the NCW domain, there remains considerable S&T investment in ‘traditional’ defence-unique areas such as ordnance, sensor signal processing, ballistics, rocketry, high-speed aerodynamics and ballistic protection which have little or no direct relevance to the civil economy.

Industry innovation, and the commercialisation of IP developed for non-defence applications, has been examined widely. It is possible commercialisation and

innovation models developed for the non-defence market may be capable of being extended to address defence-related applications. However, the highly centralised nature of defence procurement, which in most countries results in a monopsony market, may limit the practical application of models designed for the more diverse and fragmented commercial and consumer markets. Sometimes the route to market for defence products and services doesn't follow road maps developed for the commercial sector, and companies face a different set of business and financial risks and challenges.

Notwithstanding, it's reasonable to hypothesise that any research into the factors contributing to defence product innovation success in Australia will benefit from an examination of successful innovation and commercialisation models developed for and adopted by non-defence research and industry players. And furthermore, given the essentially high-technology nature of the defence market generally, whether for ICT products or other technologies and capabilities, it could also be hypothesised that successful innovation and commercialisation models developed for the civil market can be modified to accommodate the unique features of the defence market.

The literature contains several examples of commercialisation models developed for high-technology markets for both consumer and industrial products. There is also a body of literature based on research into the distinguishing characteristics of successful technology innovators and factors determining, or at least strongly associated with, product innovation success. Only a tiny minority of this literature specifically addresses the defence domain.

It is reasonable to hypothesise that a defence industry survey based on a study of commercialisation models and success factors in the non-defence sector will identify certain factors unique to the defence sector which in turn will help define a model for defence product innovation success in Australia.

## **2.2 Categorisation of models**

Many of the innovation models described in the literature focus explicitly on commercialisation. But others tacitly acknowledge the OECD Oslo Manual's definition of innovation which is much broader and is the working definition of innovation which guides this research (OECD 2005); this is the definition used also by the Australian Bureau of Statistics (ABS) and other key sources of business and innovation statistics:

*“146. An **innovation** is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.*

147. This broad definition of an innovation encompasses a wide range of possible innovations. An innovation can be more narrowly categorised as the implementation of one or more types of innovations, for instance product and process innovations. This narrower definition of product and process innovations can be related to the definition of technological product and process innovation used in the second edition of the Oslo Manual.

148. The minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new (or significantly improved) to the firm. This includes products, processes and methods that firms are the first to develop and those that have been adopted from other firms or organisations.

149. **Innovation activities** are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation.

150. A common feature of an innovation is that it must have been implemented. A new or improved product is implemented when it is introduced on the market. New processes, marketing methods or organisational methods are implemented when they are brought into actual use in the firm's operations.

*“156. A **product innovation** is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.*

157. Product innovations can utilise new knowledge or technologies, or can be based on new uses or combinations of existing knowledge or technologies. The term “product” is used to cover both goods and services. Product innovations include both the introduction of new goods and services and significant

improvements in the functional or user characteristics of existing goods and services.”

It will be seen that, by this definition, Invention is not of itself Innovation; and nor are R&D and Commercialisation. But Innovation can and usually does embrace elements of both. Innovativeness is hard to measure directly: different measures of this organisational attribute and the activities it spawns exist within different organisations; comparisons can be problematic. But one useful surrogate measure of the innovativeness of an organisation and of how methodical it is in its approach to innovation generally (one of the factors studied in this research) is the amount it invests in R&D, and this is much easier to identify and measure.

This definition of innovation is extended by Rogers who argues that an innovation is something that is new in its context, not necessarily an entirely new invention or discovery (Rogers 2003). For example, the variable pitch airscrew, or propeller, was invented and adopted for civil airliners during the early 1930s. Despite the performance benefits it affords, this invention was not adopted for military use until the late 1930s, an innovation which (along with a new generation of more powerful engines) contributed to transformative change in the design and performance of high-speed fighter aircraft. Such an innovation (which may also be an enhancement of an existing product) may still require significant research and development effort and proficiency in many areas of business to make it a successful commercial reality when applied in a new or different way.

The innovation models in the open literature fall generally into two broad categories: the first is the ‘Linear Model’ (sometimes referred to also as a ‘Process Model’) which sets out a linear, step by step process. In some cases such models include parallel streams of complementary activities which should be undertaken concurrently in order to maximise the chances of innovation success.

The second category is the so-called ‘Functional Model’ which lists important activities and describes relationships between them, without necessarily prescribing steps to be taken down a particular path.

The Linear Models, with a few exceptions, generally set out a sequential process. Innovation is indeed a sequential process but typically one that integrates a number of diverse inputs and requires the innovator to repeat many iterative ‘loops’ before it is concluded successfully.



These models amount to 'check lists' (in different forms) of specific tasks to be completed, and technical, market and business conditions to be satisfied or goals to be met on the innovation path. They represent a distillation and fusion of expertise in the research, product development, marketing and business development domains. They highlight the importance of processes 'downstream' from the original invention or idea and the broad range of skills which must be deployed to create a successful venture based on a new piece of IP. Their common message for researchers is that having a good invention is not enough: successful innovation also requires a good business team and a good business plan which is implemented effectively.

Many of these models focus on the process of 'venturing' – that is, establishing an all-new business to commercialise a new piece of IP. Many such models have emerged from the academic world where a significant proportion of IP commercialisation involves venturing in some form by academic researchers, with or without the support of their parent organisation.

The pattern in established industry sectors, however, is for a more iterative approach based on the creation of a new product, process or service by an established company, either through 'importing' IP (for example, by licensing) or commercialisation of IP generated in-house or with a research partner. Subsequently, existing products, processes and services, and the IP underpinning them, are enhanced, upgraded, expanded and adapted incrementally to match evolving customer demands or new market opportunities. However, many of the technical, market and business factors identified and addressed in models designed for venturing purposes are still highly relevant here also.

While Linear Models list specific activities and tasks, they have no predictive power in themselves. But they almost all at various points require innovators and entrepreneurs to make honest and informed assessments of future market conditions, project schedules and cash flows, and product or organisational attributes which to some degree predict, or point to the likelihood of, innovation success or failure.

The literature also includes a body of research which has successfully identified key factors associated with successful innovation, whichever commercialisation process (IP licensing, venturing or in-house development) is adopted. These factors include the size and technology orientation of the innovating companies, the urgency of the

demand 'pulling' the IP down the commercialisation path and the Technology Readiness Level (TRL) of the IP being commercialised. This research, when applied to new product innovation projects, has a predictive function which can be applied to identify, shape and guide innovation opportunities.

A sub-set of the body of literature identifying commercialisation success factors consists of research to determine features of a national innovation system associated with high levels of commercialisation success. This seeks to establish whether a systematic approach at a national level can result in improved innovation outcomes by quantifying relationships between private and public sector investment in R&D and education and the numbers of people involved in R&D and commercialisation as a proportion of the workforce at large, and other similar relationships.

### **2.3 Linear Models**

One example of a Linear Model is that developed by Dr H. Randall Goldsmith (Goldsmith 1995). This integrates the technical, market and business elements of the commercialisation process into a matrix of concurrent and sequential activities and decision points.

The Goldsmith Model is one of three Linear Models studied and compared by Rosa and Rose in their 2007 report for the Science, Innovation and Electronic Information Division of Statistics Canada, "Report on Interviews on the Commercialisation of Innovation" (Rosa and Rose 2007).

The Goldsmith Model (see Fig.2.1) covers the entire process, from the first idea, through development, creation and start-up of a spin-off company and then the exit strategy for the inventor and investors. Formatted as a 'check list', it describes concurrent 'streams' of technical, market and business activity, each stream conforming to six sequential stages: Investigation; Feasibility; Development; Introduction; Growth; and Maturity. These streams, in addition, are broken into three sequential phases: the Concept Phase; Development Phase and Commercial Phase; in a slightly different version of this model adapted by the US Department of Energy (Lux and Rorke 1999) these phases are titled Innovation, Entrepreneurial and Managerial.

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© [H. Randall Goldsmith, Ph.D.](#)

### **Figure 2.1: The Goldsmith Model**

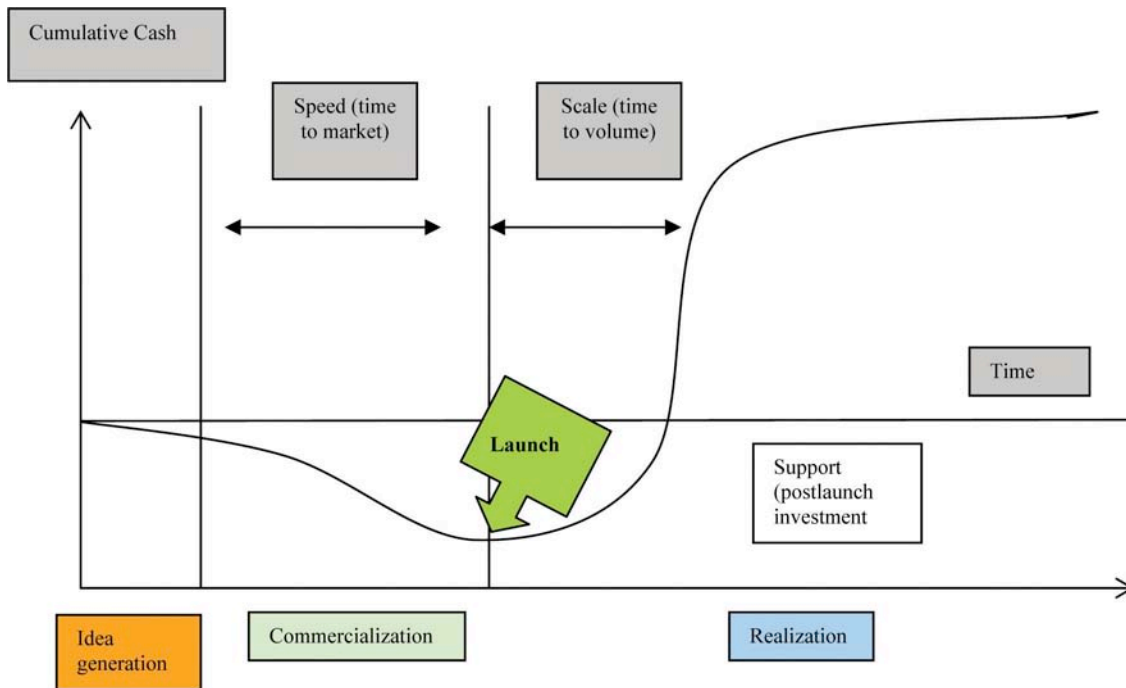
The model is intended to be followed as a series of sequential steps, working from left right and top to bottom; the process does not advance from one Stage to the next, or from one Phase to the next, until the technical, business and market issues dominating that stage have been sufficiently addressed and resolved. Goldsmith himself describes it as a ‘tactical model’ designed as “a framework to help... develop progress measures, identify information and technical assistance needs, project development costs, and forecast financing requirements,” (Goldsmith 2003). He does not characterise it, therefore, as a prescriptive set of instructions.

Rosa and Rose contend Goldsmith's model is more suitable for commercialising totally new ideas and not suited to incremental innovation, or the enhancement or upgrade of existing products, services and processes. They also contend the model isn't sufficiently flexible to accommodate feedback nor the re-ordering of steps where circumstances dictate this is necessary or desirable, especially in an incremental innovation program.

This seems to mis-interpret the Goldsmith model. There is no reason why the process cannot return to an earlier stage when some unexpected obstacle or development is encountered: commercialisation is very rarely an unbroken, linear process and most models acknowledge this fact. In returning to an earlier stage the innovator is forced to re-examine all of relevant and adjacent business, technical and market factors before starting again – this could prevent an error being repeated. And the Goldsmith model can be applied to incremental innovation by simply ignoring or modifying elements relating specifically to a new business start-up.

Goldsmith cautions that following the model slavishly is no guarantee of success. Any predictive power of this model derives entirely from the integrity of the work done by those following it.

The second Linear Model examined by Rosa and Rose was developed by Andrew & Sirkin (Andrew and Sirkin 2007) and presents a graph of a typical commercialisation project's cumulative cash position plotted against time (see Fig.2.2). Cash, on the vertical axis, is presented as a simple positive or negative value, changes in value resulting from changes in the cash flow of the business, from negative to positive. The horizontal axis represents the sequential stages of the innovation process, from idea generation, through commercialisation to market launch and full production.



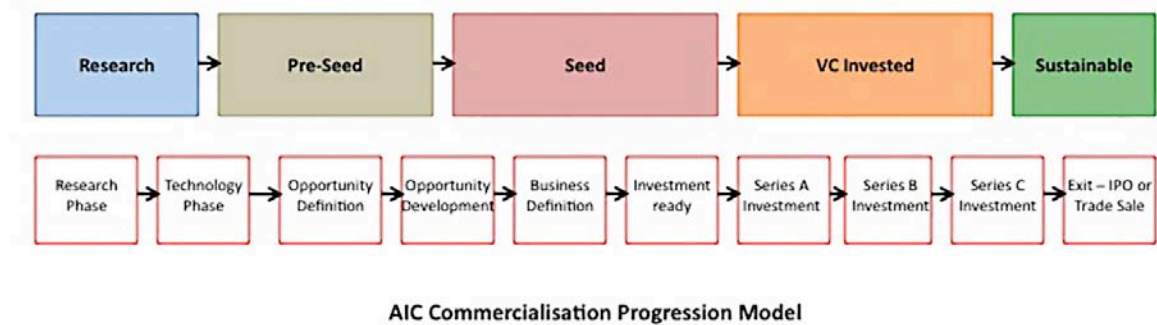
**Figure 2.2: The Andrew & Sirkin Model**

During the idea generation phase cash flow is negative; this negative flow increases sharply through the commercialisation process to the point of product or service launch, at which time the cash flow becomes positive. The project’s cumulative cash position doesn’t, however, become positive itself until sales have offset the initial investment.

The Andrew and Sirkin model does not describe commercialisation steps or activities and essential relationships between them. But it is very useful in demonstrating the importance of speed to market to minimise the cumulative cash loss prior to launch, and then the equal importance of speed in achieving volume sales in order to achieve a profitability threshold rapidly and recoup investment. It also highlights the importance of product support post-launch: advertising, marketing, technical support and product enhancements. This resonates with research described below which identifies business rather than technical factors contributing to successful product innovation.

While this model doesn’t set out prescribed steps, it does focus the innovator and investor on the economic risks and benefits of the project and forces them to answer the simple question: is it worth the time, money and effort?

This question is addressed also in the Commercialisation Progression Model (Smith 2002) developed for the Australian Institute for Commercialisation (AIC) whose principal stages reflect the needs of the investor and entrepreneur: Research; Pre-Seed; Seed; VC-Invested; Sustainable. The paper describing this model also notes what the author terms 'The Commercialisation Chasm' which lies between the Pre-Seed and Seed funding stages. He identifies this as the point at which the language, skills, values, interests and beliefs of the innovators on the 'upstream' side of the process yield to those of the 'entrepreneurs' on the downstream side.



**Figure 2.3: The AIC Commercialisation Progression Model**

Redrawn from original by AIC

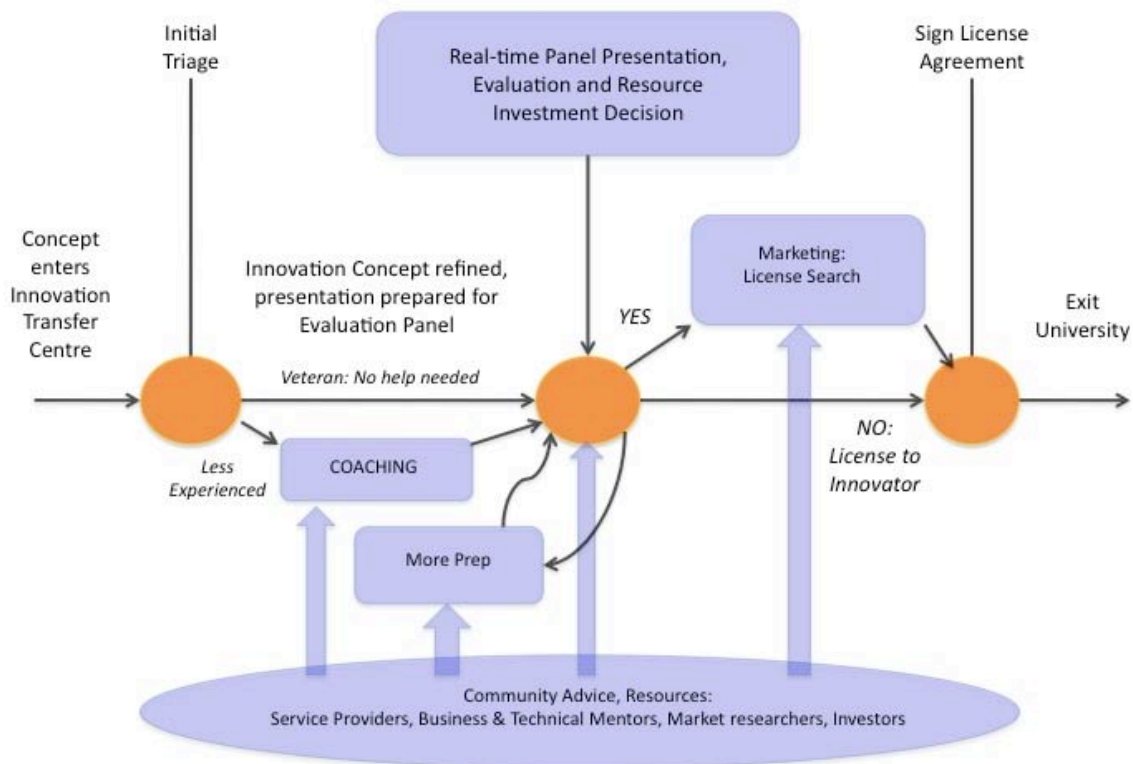
The AIC model (Fig.2.3) is based on data derived from a 1998 study of 266 companies in the United States by the Industrial Research Institute ([www.iriinc.org](http://www.iriinc.org)). This study found that a field of 3-4,000 promising ideas may for various technical and commercial reasons be whittled down to result in a single commercial success.

Smith's paper setting out the Commercialisation Progression Model emphasises also the need for a fairly fine screening process as part of the Pre-Seed stage. This in turn has several phases, beginning with the Technology Phase, in which ideas are assessed and possibly combined or re-shaped in a series of increasingly fine filters, and then passed through the Opportunity Definition and Opportunity Development Phases. As literature cited elsewhere in this chapter shows, the idea screening stage is a vital component in the IP commercialisation process.

The AIC model accommodates a critical shift in emphasis as the filtering process takes effect. In the early stages of the process, ideas are subjected to ruthless scrutiny and weeded out rapidly. Ideas which cross that Commercialisation Chasm to achieve Seed and VC (Venture Capital) funding are, by definition, good enough to be worth nurturing rather than culled. As survivors pass through the model the

emphasis progressively shifts from ‘filtering’ out weaklings to ‘failure avoidance’ and the protection and nurturing of promising ideas. This is the first model to identify explicitly the need for predictive tools to guide the efforts and resources of innovators and investors by helping identify the technical and market-related features of a promising idea which would help it across the chasm. It doesn’t incorporate any such tools, which would provide a useful predictive function for the model.

Carnegie-Mellon University describes this ruthless filter as ‘Initial Triage’ in its linear Innovation Transfer Process (Carnegie Mellon University 2002). This process is what the University terms an Interactive Model, designed to accommodate mentors and experts appropriate to the proposed commercialisation and is deceptively simple (Fig.2.4): it has three basic steps, and an iterative loop at the critical decision point. Its intent is to help a university researcher determine the commercial prospects for an idea by involving financial, technology and marketing experts at an early stage, developing the idea and then presenting it to potential licensees or investors.



**Figure 2.4: The Carnegie Mellon Innovation Transfer Process Model**

Re-drawn from original by Christina Gabriel, Vice-Provost for Corporate Partnerships and Technology Development, CMU, 2002

This model doesn't prescribe a sequence of commercialisation steps, focusing instead on assembling the right advisers and mentors for a given proposal and allowing them to generate the right commercialisation strategy. Again, the explicit emphasis is on spinning off a new venture, either by venturing or through IP licensing, rather than the iterative enhancement of an existing product or service. If the process doesn't result in a successful commercialisation the IP is then licensed to the innovator.

The University of Queensland's commercialisation arm, UniQuest Pty Ltd, has also developed an eight-stage model (Fig.2.5) describing a sequential process designed to take the inventor and entrepreneur from the basic idea to the eventual exit strategy from a successful start-up (UniQuest 2008).

### **The UniQuest Process**

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Source: UniQuest Pty Ltd - <http://www.uniquest.com.au/index.php?sectionID=106>

#### **Figure 2.5: The Uniquest Model**

Again, this is a Linear Model and UniQuest cautions, "While represented as a linear process, not all commercial ventures proceed from stage one to eight. For example, unexpected research outcomes may send a venture back to an earlier research stage or a change in market conditions may force a re-evaluation of the venture."

This model also places emphasis on the 'front end' R&D in a commercialisation program and less on the downstream elements of the process, whereas most of the



models examined earlier place relatively greater emphasis on the downstream processes.

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Source: Cooper et al. 'Defining the Stage Gate Process – What Best Practice Companies Are Doing – Part 2: The Product Development Institute, 2002.

### Figure 2.6: The Stage Gate Process

Cooper presents a Linear innovation model which addresses the challenge an established company faces in developing and introducing a new product. The Stage Gate process (Figure 2.6) isn't predicated on a 'venturing' approach and sets out clear business steps in the product innovation process (Cooper, Edgett et al. 2002). It is therefore arguably more relevant to the circumstances of most established defence companies.

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The Process of Technology Commercialisation. Source: Jolly, Vijay: "From Mind to Market", 1997

### Figure 2.7: Jolly's technology Commercialisation Model

Jolly's Technology Commercialisation model (Figure 2.7) presents a similar business process which explicitly acknowledges the iterative nature of the product innovation process (Jolly 1997). The only innovation model developed specifically for the Australian defence environment is that created by the Australian Department of Defence's Rapid Prototyping, Development & Evaluation (RPDE) organisation (Figure 2.8). This organisation's explicit task is to mobilise the resources of its members – both defence agencies such as the DSTO and defence companies – to tackle NCW-related problems identified by the ADF's war fighters.

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**Figure 2.8: The RPDE Model**  
(Copyright: RPDE)

The limitation on this model is that it identifies the elements of a solution to these problems and a methodology for introducing them, including where necessary a prototype or demonstrator and the necessary resource and organisational change implications, but it doesn't necessarily develop the solution itself. A solution consisting of a change of process, practice or organisational structure can be adopted readily by the war fighter, but anything which requires development of a new or improved product or item of equipment will be acquired using one of the normal DMO acquisition processes.

## 2.4 Functional Models

Rosa and Rose distinguish Linear Models from so-called Functional Models which don't prescribe a sequence of steps but, rather, describe a set of relationships which must be supported and conditions which must be satisfied in order to maximise the chances of a successful commercialisation.

The Rothwell & Zegfeld model (Rothwell and Zegfeld 1985) is described by Rosa and Rose as a Linear Model (see Figure 2.9), but it more closely resembles a Functional Model. It is set out as a block diagram, with the blocks describing the relationships between the components of the commercialisation process and how they interact with each other. It describes a sequential process with the technical 'stream' at the centre, its path to market influenced by emerging and evolving market needs on the one hand, and by the evolution of technology on the other. 'Business' issues are implied but not addressed specifically in this model, and the detailed 'check list' of technical, business and market factors is absent.

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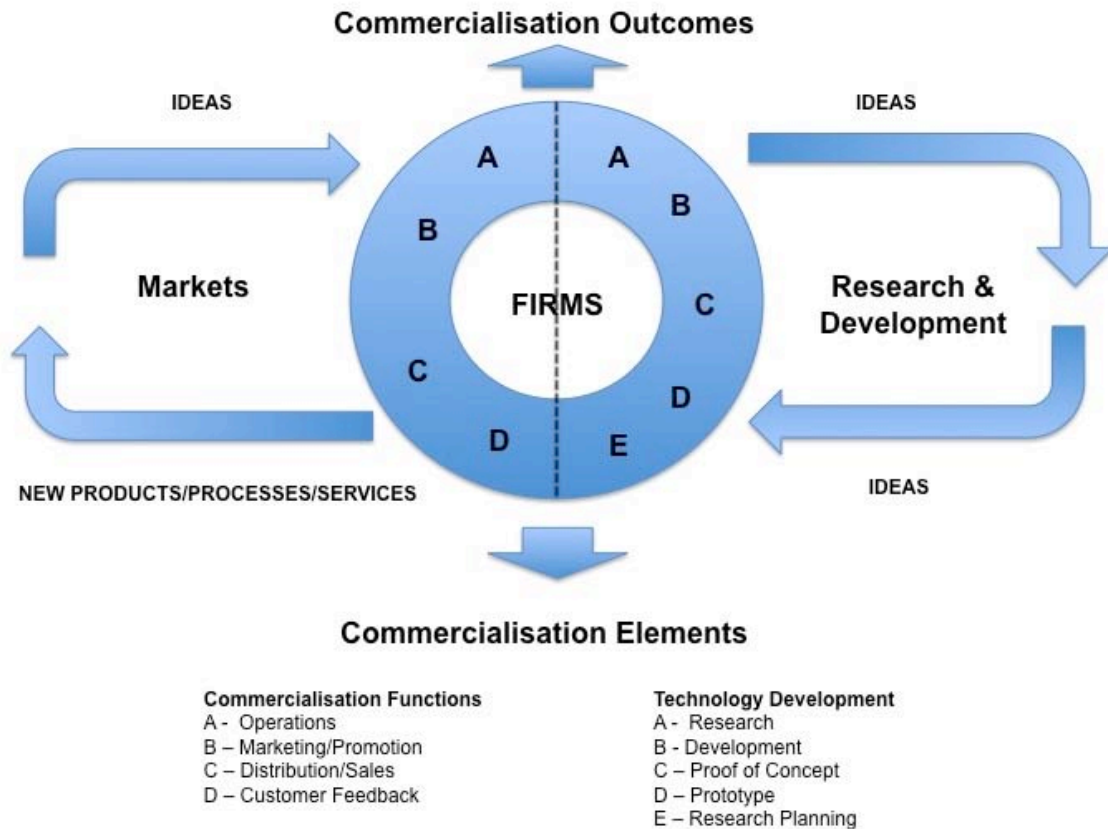
Source: Rothwell et Zegfeld 1985

### **Figure 2.9: The Rothwell & Zegfeld Model**

Again, this has no predictive capabilities but instead requires innovators to inform themselves and make their own judgements on which actions, or conditions, are most likely to result in success.

The Canadian Expert Panel on Commercialization developed a Functional Model and published it in 2006 (Industry Canada 2006); like the Rothwell and Zegfeld Model this describes the various components of the commercialisation process and their relationships to each other, but without overlaying them upon a linear, time-based process (see Fig.2.10). This model places ideas at the heart of the process in an iterative cycle which innovators, entrepreneurs and investors follow through the Technology ('R&D'), Business ('Firms') and Market elements of the process.

It acknowledges that ideas can emerge at any stage in the innovation process or product lifecycle; and also that several iterations of this cycle may be required in order to refine ideas and business models before innovation success is possible. Ideas can include all-new products or services, or incremental enhancements of existing ones, or new applications for existing products or services, and the steps necessary to adapt these to a new marketplace.



**Figure 2.10: The Canadian Functional Model**

Re-drawn from original graphic by Canadian Expert Panel on Commercialisation

The paper setting out this model, like the Goldsmith and Rothwell-Zegfeld examples, identifies and embraces some key commercialisation project elements, including: R&D; prototyping; finance; skills and human resources; Intellectual Property (IP); manufacturing; sales and marketing; and customer feedback.

## 2.5 Predictive Models

None of the models described thus far have any direct predictive power or offer any guarantee of success. They describe in various ways the key elements of the innovation process and their relationships to each other. They do not predict, still less guarantee, outcomes.

These models identify, to varying degrees, the need to create or seek out the conditions or combinations of circumstances most likely to result in a successful commercialisation; but they do not describe explicitly the conditions and circumstances most closely associated with successful commercialisation, nor the desired or essential qualities and attributes of the individuals and organisations

involved and their potential impact on the outcome. The burden of market knowledge and self knowledge falls on the innovator himself.

An analogy would be a pilot's manual for an aircraft. Theoretically, a complete novice with poor eyesight and motor skills could follow the instructions, step by step, and fly an aeroplane successfully but trained pilots would easily predict that attempting such a thing will almost certainly result in disaster. So it is with innovation and commercialisation: while in theory anybody could follow one of the models described above, history demonstrates that there are certain attributes of individuals and companies involved in the process of innovation, and the way they deal with the markets in which they operate, which make some more likely to succeed than others.

The value of an innovation success model would therefore undoubtedly be increased by the inclusion of techniques or knowledge which helps innovators, investors and entrepreneurs predict outcomes, or assess the likelihood of certain outcomes, with greater certainty.

## **2.6 Innovation and Commercialisation – the literature**

Data which could help create such a 'Predictive Model' has been gathered by researchers in a variety of studies across the world. However, only a few researchers have sought explicitly to develop a predictive tool from their research; the majority have focussed on identifying factors associated with commercialisation success and, in a relatively few cases, identifying factors associated with failure. To the extent that commercialisation is sometimes a key component of the product innovation process, commercialisation models are worth detailed examination in this literature review.

Sohn and Moon used a Structural Equation Model (SEM) to develop a predictive Technology Commercialisation Success Index (TCSI). This employs the American Customer Satisfaction Index (ACSI) to measure the success of the commercialisation projects examined in the research. Their objective was to develop a means of forecasting commercialisation success rates and so identify the optimum commercialisation strategy for various combinations of technology (or IP), IP transferor and IP transferee (Sohn and Moon 2003).

The success of the commercialisation process was measured across 284 commercialisation projects using the ACSI model to assess variables such as

customer expectations, customer perceptions of quality and value for money and customer dissatisfaction as measured in the number of complaints received.

The linkage of customer satisfaction, at one end of the innovation process, with the technology transfer mechanism close to the start of this process may appear tenuous. Other researchers generally argue that internal company processes following the initial technology transfer have the greatest effect on the commercialisation outcome. But it could also be argued that companies which are better equipped to execute these processes proficiently (allowing for differences between technology types and marketplaces) are inherently more likely to make the correct choice of IP and commercialisation opportunity.

Sohn and Moon identified a number of measurement and latent variables which they integrated using an SEM to develop the TCSI. These included the experience of the researcher, the management of the transferee, its marketing and production skills, its ability to make a product offering of superior price and quality, its export orientation, and external factors such as government policy and its broader effects on the R&D and business climate.

They found the most successful commercialisations involved established companies which spend over 2.5 per cent of sales on R&D. For software and systems development projects established companies were found to be more successful than start-ups; but for straight manufacturing projects (eg of semi-conductors) start-ups could also be successful.

Sohn and Moon subsequently developed a Decision Tree of Data Envelopment Analysis (DEA) of environmental variables representing the characteristics of technology providers, technology receivers and the technology itself (Sohn and Moon 2004). Their findings include a higher likelihood of successful commercialisation where a high technology product or process is developed by an independent researcher for commercialisation by a company employing 100 or more people which spends 2.5 per cent or more of its revenue on R&D.

Interestingly, the lowest chances of commercialisation success are associated with research by a university or research institute in order to develop a finished product. Similarly, if IP developed in a joint research program is transferred to a company with a low R&D expenditure (< 2.5 per cent of annual sales) the commercialisation has a low chance of success. This finding resonates with other research establishing

a link between the level of a company's R&D investment and its absorptive capacity – the very process of undertaking R&D equips the company better to absorb, understand and exploit another's IP successfully (Yencken and Gillin 2003).

Notwithstanding some acknowledged ambiguities in their results, Sohn and Moon independently demonstrate a high level of correlation between certain environmental factors and the likelihood of commercialisation success. These factors are the nature of the technology and the characteristics of the technology developer and technology receiver, including the size of the company doing the commercialisation, the amount of its revenue it devotes to internal R&D, whether or not the IP is derived from sole or joint research, whether the research partner is a university or another company, the level of technical sophistication of the product, and whether or not the project is government-run.

This serves to illustrate that, other things being equal, there are certain intrinsic factors in the attributes of and relationships between the partners in a high-technology commercialisation venture which have a determining effect on the outcome. If applied to a commercialisation or innovation model such as those discussed earlier in this chapter, these factors have a potentially very useful predictive and screening function.

Reflecting some of the factors identified in Sohn and Moon's work, much of the research into commercialisation success factors suggests that while a sound idea based on solid research and subjected to a rigorous screening process is an essential pre-condition, with very few exceptions success owes more to the business processes that follow, and the people implementing them, than it does to the invention itself.

To test this hypothesis, Cooper examined a number of project screening criteria as part of Project NewProd (Cooper 1980) and concluded that while careful project selection was an essential condition for success, undue attention was paid to this 'front end' aspect of a project and less to the execution and delivery aspects. Furthermore, he warns, too many screening models focus on relatively less important factors in successful innovation, such as the nature of the marketplace, the business environment and the venture. However, he states a screening process is a logical and important step in the process and sets out nine criteria for selecting a new product innovation project. In descending order of importance these are:

- Pick projects where the resulting product will yield significant and unique user benefits (avoid me too-ism)
- Seek projects where you already know the market well and where you're likely to execute the marketing activities competently
- Select projects with a high technical and production synergy between the product and company, and where the company has the necessary skills
- Avoid dynamic markets with frequent changes in user needs and where new products are introduced frequently
- Look for products aimed at large and growing markets and where a high level of need exists for this type of product
- Seek products which offer an economic advantage to the user: avoid costly products that offer no significant improvement in user benefits
- Seek projects with a high level of marketing and managerial synergy between the project and company – financial, marketing, sales, management, distribution
- Avoid highly competitive markets (many players, intense price and performance competition) where customers are already satisfied by competitors' products
- Avoid projects new to the firm: new customer class, new product class, new need served, new production process, new delivery mechanism/business model, new technology, new competitors

Although not all of these criteria apply to all cases, both Cooper in a separate study (Cooper 1984) and Rothwell (Rothwell 1977) emphasise the importance of an effective screening process. While not a totally reliable tool for predicting innovation success, the benefits of such a process are highlighted by one of Cooper's findings from a review of the product innovation strategies of 122 firms: overall, the mean success rate for developed products was 67 per cent – only 17 per cent of products failed commercially in the marketplace after they had been launched. He argues that this dispels the myth in some firms that R&D expenditure and product development are unaffordable luxuries yielding low returns and that "only a fortunate few succeed in the new product game". The opposite is true, in fact: once they get to the marketplace (and many of course are aborted before launch), the majority of new products actually succeed – some more than others, of course.

This reinforces Smith's argument, cited earlier in this chapter, that an effective screening process is essential to ensure that the right product ideas survive the essential 'culling' process.



Both Cooper and Rothwell argue that the outcome of a product innovation project is not determined by the technology, or the original idea, alone. This finding is borne out by several other studies carried out since the early 1970s. Most of these seek to identify factors contributing directly to or associated with successful innovations, or the characteristics of firms which have proven to be successful innovators.

This tends to validate the hypothesis that innovation success is really a function of the processes downstream from the original invention. Consequently, it is a reasonable hypothesis also that success depends to a significant degree upon factors such as the quality of a company's management, its internal processes, its understanding of the customer's needs, the technology it is dealing with and the market in which it is operating, and the competitive pressures it is facing.

For example Kleinschmidt and Cooper (Kleinschmidt and Cooper 1988) found that product innovation success is more likely when the company developing the product adopts an international outlook. That is, if the company designs the product for the world market and targets export markets deliberately (including carrying out market research overseas) it has a far higher chance of success both overseas and, significantly, at home in the domestic market. In Australia's very open defence market in which there are many foreign players, this may be a significant finding; it echoes the experience of a successful Australian radar and communications company, CEA Technologies Pty Ltd, whose strong commitment to the export market is based on the understanding that the Australian market is too small to support its R&D investment, while there is also "a perceived disinclination in the Australian marketplace to buy from local companies." (Gaul 2005)

One of the most detailed studies of success factors in technological innovation was Project SAPPHO (Scientific Activity Predictor from Patterns with Heuristic Origins), a two-phase project undertaken in the United Kingdom during the early 1970s. This was designed "as a systematic attempt to discover differences between successful and unsuccessful innovations." (Achilladelis, Robertson et al. 1971) (Rothwell, Freeman et al. 1974)

The technique employed in this project was that of Paired Comparisons in which a successful innovation was compared with an unsuccessful innovation competing for the same market. A successful innovation was defined as one that achieved a worthwhile market share and profit; failure, naturally, is defined as an inability to achieve this (a somewhat subjective judgement: case study candidates self-selected).

In all, some 43 pairs of successful and unsuccessful innovators were compared, 22 of them in the chemical process industry and 21 in the scientific instruments industry.

A total of 122 variables were measured and 41 were found to discriminate between success and failure, while the study also identified five key underlying factors which also discriminate between success and failure. The study also identified other factors associated with success as well as some inherent differences between the two industry sectors. These differences may be relevant in examining the prospects of large defence prime contractors and Small to Medium-sized Enterprises (SMEs) in the defence industry.

The five key underlying factors identified in project SAPPHO were, in descending order of importance:

1. Successful innovators were seen to have a much better understanding of user needs
2. Successful innovators pay more attention to marketing and publicity
3. Successful innovators perform their development work more efficiently than failures, but not necessarily more quickly
4. Successful innovators make more use of outside technology and scientific advice, not necessarily in general but in the specific area concerned
5. The responsible individuals (carefully defined by Rothwell, Freeman et al) in the successful attempts are usually more senior and have greater authority than their counterparts who fail.

These underlying success factors emerged from a multi-variate analysis of ten index variables constructed from the areas of competence identified as being associated with success or failure. These index variables (again defined carefully by Rothwell et al for the purposes of this analysis) are, in descending order of importance:

1. **Marketing** – a measure of the marketing effort deployed by the innovating organisation
2. **R&D Stretch** – a measure of the performance of the development work concerned with the innovation
3. **User needs** – a measure of the efficiency with which market research or other procedures have established the precise requirements of the customer
4. **Communications** – a measure of the effectiveness of the innovating organisation's communications network with the outside scientific and technical community
5. **Management strength** – a measure of the strength of the management of the innovating organisation
6. **Familiarity** – a measure of the extent to which the innovating organisation was familiar with technical problems posed by the innovation, and with the market
7. **Techniques** – a measure of the extent to which management explained the success/failure differences

8. **Pressure** – a measure of the competitive situation facing the innovating organisation
9. **Organic** – an attempt to classify the structure of the innovating organisation as organic or mechanistic
10. **Risk** – a measure of the degree of risk taken by the innovating organisation

This ranking represents an aggregate: for the chemical and scientific instrument sectors by themselves, the order of the first five variables differs quite significantly. The R&D Stretch occupies top position for the chemical industry, but fourth position for the scientific instruments, for example.

Rothwell et al also define the ‘key individuals’ in an innovating organisation: the Technical Innovator – the inventor or major technical contributor; Business Innovator – the individual actually responsible for the overall progress of the project; Chief Executive – the formal head of the innovating organisation; and Product Champion – who makes a decisive contribution by promoting the innovation’s progress through critical stages. In smaller firms a single individual may play some or all of these roles and make a far greater personal impact on the final outcome. In larger firms with formal, hierarchical structures and bureaucracy, each role is frequently played by a different person, highlighting the need for friction-free internal communications and processes.

Unlike Sohn & Moon, however, Project SAPPHO did not examine in detail the process of transferring IP from an outside R&D source to a firm, and the effect this process can have on project success.

A key difference between the chemical engineering and scientific instruments sectors identified in Project SAPPHO was that the former is dominated by large players with the resources to pursue what Rothwell et al describe as ‘radical innovation’, frequently requiring significant (and often sustained) levels of investment and relatively high levels of risk in pursuit of a significant reward. The scientific instrument-makers, by contrast, were generally low-capital small firms which, while agile and creative, also sought to minimise risk. The authors noted that whereas the major chemical companies derived a significant benefit from being ‘first to market’, among the scientific instrument makers the most successful were ‘second to market’, reflecting the risks borne by pioneering innovators.

Furthermore, Project SAPPHO identified another factor strongly associated with innovation and commercialisation success: autonomy. Successful scientific

instrument makers were found to be either independent or, if owned by a local or overseas parent, were largely autonomous in their financial management, decision-making and in selecting and managing specific R&D programs. In the chemicals sector, by contrast, where companies are generally bigger, autonomy was not found to be strongly associated with either success or failure.

To some degree these inter-sector differences are reflected in the experiences of what in the Australian defence industry are termed large prime contractors ('Primes') and Small-to-Medium-size Enterprises (SMEs) employing less than 200 people. By their very nature SMEs are generally dominated by tight cadres of individuals – innovators, entrepreneurs and engineers – and are generally regarded as being creative, flexible and adaptable organisations, though fragile and vulnerable to sudden, extreme shifts in market conditions.

Australia's primes are typically very large companies (by local standards) employing several thousands of people and are now with only a few exceptions wholly owned subsidiaries of European, British or American high technology aerospace and defence prime contractors such as Thales, EADS, Saab Systems, BAE Systems, Raytheon and Boeing. These are more bureaucratic and have formal management structures and hierarchies which mirror those of their overseas parents, and arguably of the large chemical companies studied in Project SAPPHO.

There is one important difference, however: in Australia's defence industry much of the product innovation, including innovations which could be described as 'disruptive', emerge from the small, creative, high-technology companies making up the SME sector. New product developments, including disruptive innovations, from within the ranks of the primes are relatively rare, given their size. Many of these companies, being foreign-owned, can 'reach back' to their parents for the products and technology sought by the ADF, some of which can be supplied 'Off the Shelf'.

## **2.7 A Wider Literature Review**

A review of the literature shows broad agreement with the findings of Project SAPPHO across many studies, albeit using different measures and approaches to different research questions. Importantly, however, few studies have attempted to emulate Project SAPPHO and compare successes and failures in order to identify the discriminating factors.

The literature highlights important variations in the impact of specific factors on commercialisation success arising from contextual differences such as industry sectors, geographical location and whether or not the market is an essentially high- or low-technology one.

Henard and Szymanski conducted a meta-analysis of the literature on new product performance and successful innovation (Henard and Szymanski 2001). Their review identified at least 60 empirical studies (including Project SAPHO) documenting the statistical relationship between new product performance (or innovation success) and its proposed antecedents. The authors investigated the 24 most frequently occurring predictors of new product performance identified in these studies. In order to classify them efficiently the authors adopted a taxonomy which defined these predictors and grouped them into four separate categories: Product Characteristics; Company Strategy Characteristics; Company Process Characteristics; and Marketplace Characteristics.

Product Characteristics include price, innovativeness and perceptions of how well the offering meets customers' needs; Strategy Characteristics refer to a firm's ability, through planned actions, to create for itself a competitive advantage in the marketplace; Process Characteristics refer specifically to the elements associated with the new product development process and its execution; Marketplace Characteristics describe the target market and its features.

From this list of 24 predictors, Henard and Szymanski identified the 11 most dominant drivers of product success. These are listed below in descending order of importance, along with their category:

1. **Market potential (Marketplace)** – anticipated growth in customers or customer demand in the marketplace
2. **Dedicated manpower (Strategy)** – commitment of personnel resources to a new product initiative
3. **Marketing task proficiency (Process)** – proficiency with which a firm conducts its marketing activities
4. **Product meets customer needs (Product)** – extent to which the product is perceived as satisfying the customer's desires/needs
5. **Product advantage (Product)** – superiority and/or differentiation of the product over competitive offerings
6. **Pre-development task proficiency (Process)** – proficiency with which a firm executes pre-launch activities: idea generation/screening, market research, financial analysis
7. **Dedicated R&D resources (Strategy)** – focussed commitment of R&D resources to a new product initiative

8. **Technological proficiency (Process)** – proficiency of a firm's use of technology in a new product initiative
9. **Launch proficiency (Process)** – proficiency with which a firm launches the product/service
10. **Order of entry (Strategy)** – timing of marketplace entry with a product/service
11. **Technological sophistication of the product (Product)** – perceived technological sophistication of the product (eg high-tech versus low-tech)

The others are also important, though their associations with successful innovation are less frequent in the literature examined by Henard and Szymanski :

- **Product price (Product)** – perceived value for money
- **Product innovativeness (Product)** – perceived newness/ originality/ radicalness of the product
- **Marketing synergy (Strategy)** – congruency between the firm's existing marketing skills and those required to execute a successful new product launch
- **Technological synergy (Strategy)** – congruency between the existing technological skills of the firm and those needed to execute a new product initiative successfully
- **Structured approach (Process)** – employment of formalised product development procedures
- **Reduced cycle time (Process)** – speed to market – i.e.: reduction in the concept-to-introduction time line
- **Market orientation (Process)** – degree of firm orientation to its internal, competitor and customer environments
- **Customer input (Process)** – incorporation of customer specifications into a new product initiative
- **Cross-functional integration (Process)** – degree of multiple-department participation in a new product initiative
- **Cross-functional communication (Process)** – level of communication between departments in a new product initiative
- **Senior management support (Process)** – degree of senior management support for a new product initiative
- **Likelihood of competitive response (Market)** – likelihood and degree of competitive response to a new product initiative
- **Competitive response intensity (Market)** – degree, intensity or level of competitive response to a new product introduction (also referred to in the literature as market turbulence)

Of those Top 11 predictors, it will be seen that the most numerous fall into the Process Characteristics category; three fall into each of the Strategy Characteristics and Product Characteristics categories; and only one falls into the Marketplace Characteristics category. Overall, 11 predictors fall into Process category; five each fall into the Strategy and Product categories, and three fall into the Marketplace category.

This reinforces the suggestion noted earlier that, other things being equal, the company's internal processes play a significant role in determining new product and commercialisation outcomes. Henard and Szymanski state these encompass department interactions, the firm's various proficiencies, management support, marketplace orientation, development, marketing and the launch of new products. In other words, the research points largely to factors within the direct control of the company's management.

This in turn suggests that their findings, if applied appropriately to an innovation model of the type described earlier, would provide a predictive capability these models currently lack. Taking into account factors such as the type and location of the market, the type of technology involved, the level of competition, and so on, it might be possible to predict the levels of risk and reward associated with a proposed product innovation, and decide whether or not the project is worth pursuing. This would be a helpful tool at the idea/product screening stage. Or seen from another angle, it may make it easier for commercialisation organisations (for example at universities and research institutes) to identify and broker better matches between specific product development opportunities and companies, and so increase the likelihood of commercialisation success.

Henard and Szymanski aggregated results across 60 separate studies; some of these studies, and others they did not include in their research for various reasons, draw out lessons and insights relating to specific circumstances or sets of conditions and are worth examining in more detail.

One of the studies they examined was conducted by Montoya-Weiss and Calantone (Montoya-Weiss and Calantone 1994). This too was a review of the literature on new product performance, examining 47 studies and noting their functional perspective: R&D, Management, Marketing and others ('Varied'). They noted that the range of factors studied by researchers is actually quite narrow, and yet some of them have not been included in studies as often as one might expect. They identified 18 factors from the literature which have an impact on new product performance, but noted that no single study has examined them all; they called, in future research, for broader-based studies that include all of these 18 factors, along with multiple factors from diverse categories, in order to jointly assess their impact on performance.

The 18 factors identified by Montoya-Weiss and Calantone echo quite faithfully the 24 identified by Henard and Szymanski, and underline the importance of the firm or company's organisational characteristics, skills and internal processes. These factors are also grouped in four distinct categories: Strategic Factors, Market Environment Factors, Development Process Factors and Organisation Factors. The 18 Factors and their categories are, in no particular order:

1. **Product advantage (Strategic)** – customer's perception of product quality, function and value for money compared with competitors
2. **Marketing synergy (Strategic)** – fit between company's marketing and sales resources and skills and the project's needs
3. **Technological synergy (Strategic)** – fit between project's needs and company's R&D and technology skills and resources
4. **Strategy (Strategic)** – strategic impetus
5. **Company resources (Strategic)** – compatibility of company resource base with needs of the project: capital, manufacturing facilities, manpower
6. **Market potential (Market Environment)** –market (and demand) size and growth
7. **Market competitiveness (Market Environment)** – intensity of competition within the market
8. **Protocol (Development Process)** – firm's knowledge and understanding of marketing and technical aspects prior to project start
9. **Proficiency of predevelopment activities (Development Process)** – idea screening, market and technical assessment, financial analysis
10. **Proficiency of market-related activities (Development Process)** – market research, customer testing, advertising and launch
11. **Proficiency of technological activities (Development Process)** – prototyping, testing, trial production
12. **Top management support, control and skills (Development Process)** – management commitment and day to day involvement; key individuals
13. **Speed to market (Development Process)** – speed of development, timing of launch, first or second to market effects
14. **Costs (Development Process)** – project development costs, including R&D, production and overruns
15. **Financial/business analysis (Development Process)** – proficiency of these during development and prior to launch, including go/no-go measures
16. **Internal/external communications (Organisation)** – coordination and cooperation internally and between partners
17. **Organisational factors (Organisation)** – structure of new product team

It will be noted that eight of these factors relate to the Development Process category; five to the Strategic category; three to the Market Environment; and just two to the Organisation. Again, this reinforces the suggestion that a company's internal processes play a major, even decisive, role in determining innovation project outcomes.



In a discussion of the limitations of innovation studies prior to 1977, Rothwell (Rothwell 1977) notes that most of the factors considered in the majority of research have dealt with project execution variables and have explained success or failure in those terms. But attributing failure to 'poor or incomplete development work' fails to distinguish between incompetence and lack of resources; if the latter is the underlying cause, then the project shouldn't have been attempted in the first place and so the real cause of failure is the inappropriate choice of project – putting the emphasis firmly on idea or project screening at the very start of the process, and by extension on the competence of the company's management. As a corollary to this Rothwell points to the need for robust project termination criteria so that flawed projects which 'leak' through the screening process get terminated before they cost the firm too much time and money.

He also notes the absence in much research of the study of exogenous factors such as government policy or legislation. This is an important factor in the defence industry, but most innovation studies focus instead on endogenous factors such as project execution, product development strategies and the attributes and capabilities of innovating firms.

Rothwell points out that many studies focus exclusively on major, or radical, innovations – essentially the development of all-new products – and ignore incremental or minor innovations. He suggests more research is needed to establish whether, in some industries minor innovations are as cumulatively important in their effect as the occasional major breakthrough; and he hypothesises that the circumstances surrounding the generation of successful minor innovations are significantly different from those surrounding the generation of major innovations.

This echoes the point made earlier about the utility of commercialisation models which focus on venturing to exploit new IP, and of Johne and Snelson's research cited below. But the meta-analyses by Montoya-Weiss & Calantone, and by Henard & Szymanski, cited above, do not show that recent research has addressed many of the omissions noted by Rothwell in 1977.

Johne and Snelson (Johne and Snelson 1990) examined product development strategies, leadership and management structures and styles, and team skills in a comparison of 40 successful and unsuccessful product innovators in the United Kingdom and the United States across four manufacturing industry sectors: chemicals, food, mechanical engineering, and electrical and electronic engineering.

Twenty companies from each country which operate in the same market sector were paired and compared using the McKinsey 7Ss framework for efficiency factors developed by the management consultancy McKinsey & Company (Peters and Waterman 1982).

The 7Ss are: Strategy, Structure and Systems (the so-called 'hard elements') and Shared Values, Skills, Style and Staff, the so-called 'soft elements'. Johnes and Snelson summarised the characteristics of successful and unsuccessful product innovators – importantly, they differentiate between the development of new products and the enhancement and upgrading of old products: these require different management styles and oversight of resources, but these different approaches can be accommodated successfully within a single organisation, they found.

While this study doesn't explicitly address the issue of customer knowledge and marketing, like Project SAPPHO it does find an association between the seniority and autonomy of key project personnel (the term 'intrapreneur' is used here) and sound internal processes, on the one hand, and a successful innovation on the other. Successful innovators have good internal and external communications and are organised to harness and exploit in-house R&D and absorb external IP; unsuccessful innovators are poor communicators in general, invest rather less in R&D and are not organised to harness and exploit in-house or external R&D; they tend to rely, in the main, on growth by acquisition, including the acquisition (rather than in-house development) of new product lines.

The critical issue of customer knowledge, of understanding the customer's needs and the dynamics of the marketplace in which a firm is operating, was addressed by Slater and Mohr (Slater and Mohr 2006). They identify three corporate archetypes: Prospectors, who seek to locate and exploit new product and market opportunities; Defenders, who attempt to seal off a portion of the total market to create a stable set of products and customers; and Analysers, who try to combine these two outlooks by maintaining a stable set of customers and products while cautiously following Prospectors into newly-established markets.

On the customer side of the transaction, Slater and Mohr found markets and customers mapped neatly onto the taxonomy developed by Everett Rogers in his studies of the diffusion of innovations (Rogers 2003). They identify two types of market: Early Market and Mainstream Market; and within these categories, five

types of customer. In the Early Market category are found Innovators – essentially technology enthusiasts motivated by the idea of being a change agent in their reference group – and Early Adopters who seek to harness innovation to achieve revolutionary improvements.

In the Mainstream Market are found the so-called Early Majority, pragmatists motivated by the revolutionary change they observe to pursue productivity enhancements and who seek relatively low-risk, proven, reliable solutions. These are probably the most numerous. Also in this category are Late Majority customers – conservative, risk-averse, price sensitive and technology-shy. The fifth customer type is the Laggard, a sceptic resistant to change, sceptical of claims that innovation can enhance productivity and deliver real benefits.

Slater and Mohr point out that customers often are unable accurately to articulate their needs and they set out a portfolio of research tools for innovators in high-technology markets who seek deep and detailed customer knowledge. These are designed to bridge the gap between what customers say and how they actually behave and include customer visits, empathic design, the lead-user process, research on customers' customers and the targeting of developing markets.

This taxonomy maps well onto defence department and defence force customers: in some areas the ADF is an Early Adopter, being forced to depend upon technology to offset its small size and massive geographical responsibilities (eg the JORN radar system); more frequently it could be described as a risk-averse organisation and to the extent that it uses a MOTS solution as its benchmark for assessing capability, risk and value for money, could therefore more often be characterised as an Early Majority customer. The New Zealand Defence Force, having considerably fewer resources than its Australian counterpart and a very strong aversion to cost and schedule risk, can be characterised as a Late Majority customer.

Slater and Mohr's research also identifies archetypes recognisable within the ranks of the defence industry: firms able to develop truly disruptive innovations have a customer orientation focused on emerging customer requirements, rather than on mainstream customer needs. In fact, a company orientation that focuses too closely on mainstream customer needs inhibits the development of disruptive innovations. However, they point out, a single company can exhibit both orientations simultaneously, a conclusion which resonates with the findings of Johne and

Snelson in relation to successful development of new products while simultaneously upgrading and enhancing existing products.

This is an issue which must be considered when setting criteria for a product screening process: too fine a filter can result in low-risk, low-reward projects, while too coarse a filter can expose the firm to unnecessary risks.

In Project NewProd, mentioned earlier, Cooper examined 195 new product cases, half of them successes, the others judged to be failures (Cooper 1980). He measured 77 variables which fell into six categories, three of them being controllable for a given project – The Commercial Entity; Information Acquired; and Proficiency of Process Activities – and three which were described as ‘environmental’, or non-controllable: Nature of the Marketplace; Resource Base of the Firm; Nature of the Project.

His analysis identified 15 specific properties of a project which distinguished successes from failures. In descending order of importance these were:

1. Proficiently executing the launch – sales, promotion, distribution
2. A new product that better meets customers’ needs than its competitors
3. A higher quality new product than competitors (quality, durability, reliability, etc)
4. Undertaking a good prototype test with the customer
5. Sales force and distribution well targeted on the right customers
6. Undertaking a proficient test marketing campaign
7. Proficient ramp-up to full-scale production
8. Knowledge of customers’ price sensitivities
9. Proficient execution of product development
10. Understanding buyer behaviour and customer purchase decision process
11. Product permits customer to reduce his own costs
12. Good company-product fit in sales/distribution
13. Good company-product fit in marketing skills
14. Good idea screening
15. Understanding customers’ needs, wants and specifications

It could be argued that number 15 is redundant, and that this detailed customer knowledge is implicit in Properties 2, 4, 5, 6, 8 and 10. Nevertheless, most of these factors could be described as ‘controllable’ in Cooper’s terms, rather than environmental.

Cooper also re-organised the data from the 77 variables to identify 18 Dimensions (also termed Underlying Factors) that characterise new product projects. When product outcomes were related to these 18 dimensions, 11 were immediately identifiable as determinants of product success, nine of them quite strongly. Of

these the three dominant dimensions were: product uniqueness and superiority; market knowledge and marketing proficiency; and technical and production synergy and proficiency, in that order.

Cooper found that the projects which scored highest in these three areas exhibited a 90 per cent success rate. Conversely, of the projects which scored lowest in these three areas, only 7 per cent were successful. However, he also made an important discovery: Product remains the critical variable. Even projects lacking both marketing and technical prowess achieved a 62 per cent success rate when they were based on what was classified as a unique, superior product.

More generally, says Cooper, Project NewProd showed that project success or failure were most directly impacted by controllable variables, while environmental variables had a relatively lower impact. It's not clear whether this is also the case in the defence market and others like it which are characterised by communities of expert practitioners; in the case of the defence market this community is a homogenous entity and the ADF tends to buy all of the equipment it needs to satisfy a specific need from a single supplier (albeit, in many cases, in a number of sequential phases). For example, while a medical equipment manufacturer may try to sell to individual hospitals or regional health authorities, and could pursue a minority or majority share of this market, warships and jet fighters are not sold one by one to individual captains or squadron commanders. They are ordered in bulk: the supplier's market share is either 100 per cent, or zero. The extreme binary nature of this type of market represents an environmental variable which presents high risks as well as significant rewards, and this could affect the behaviours of both customer and innovator.

This is congruent with Rogers' research (Rogers 2003) which highlights factors that are a feature of Australian defence acquisition: the DMO's processes follow strict probity rules, explicitly seek the best value for money and are extremely risk-averse. Rogers defines technology as "a means of uncertainty reduction that is made possible by information about the cause-effect relationships on which the technology is based." He states:

"The innovation-decision process [by the customer] is essentially an information-seeking and information-processing activity in which an individual [or an organisation, in the case of the DMO] is motivated to reduce uncertainty about the advantages and disadvantages of the innovation.

“The main questions that an individual typically asks about a new idea include “What is the innovation?”, “How does it work?”, “Why does it work?” “What are the innovation’s consequences?” and “What will its advantages and disadvantages be in my situation?” (Rogers 2003)

This strongly reinforces the suggestion that having a good idea isn’t enough – the innovator must be able to sell it and build it properly.

The importance to project success of controllable variables was also a conclusion of Tishler, Dvir and others from their multi-variate analysis of critical success factors in developmental defence projects (Tishler, Dvir et al. 1996). By definition, such projects are inherently risky and involve either the integration of existing and new products in a new way, for a new application, or the development of all-new products – and sometimes a combination of both.

Based on their analysis of 110 Israeli defence projects, the authors identified eight factors bearing heavily on the success of a developmental defence project. In descending order of importance these are:

1. A sense of urgency - the more urgent the need, the greater the chance of success
2. The professional qualifications, sense of responsibility for project outcome and continuity of personnel appointments within the customer ‘team’
3. Pre-project preparation, including proving technological feasibility and establishing the correct project structure
4. Quality of the project development team, and of its leader
5. Organisation culture within the project team, encouraging professional growth
6. Design policy of the developing organisation - a clear policy on decision-making procedures and communications
7. Design considerations in the early phases of the project – design to cost, reliability, ‘produceability’
8. Systematic use of schedule, budget and performance management tools.

Success and failure are also determined in part by the product innovation strategy selected by a firm, Cooper found in the study cited earlier (Cooper 1984); his findings largely echo those of others cited in this literature review. He studied the new product strategies of 122 firms in Canada, characterising these on each of 66 strategy elements which in turn fitted into four categories: Nature of the products developed; Nature of markets sought; Nature of technology employed; Orientation and nature of the new product process.

Cooper identified five separate new product strategy types:

- **Strategy A: The Technologically Driven Strategy (26.2 per cent of firms)** – innovative, high-technology, high-risk new products which don't 'fit' the developing company's existing product lines and have no relation to each other. Firms lack market orientation.
- **Strategy B: The Balanced Strategy (15.6 per cent of firms)** – similar high-technology product focus as Type A companies, but much stronger market orientation and product fit.
- **Strategy C: The Technologically Deficient Strategy (15.6 per cent of firms)** – total lack of technological sophistication, very low production and technological synergies, but strong market orientation
- **Strategy D: The Low-Budget, Conservative Strategy (23.8 per cent of firms)** – lowest R&D spending of all companies surveyed, products enjoy least differential advantage, but highest technological and production synergies of all firms surveyed
- **Strategy E: The High Budget, Diverse Strategy (18.9 per cent of firms)** – highest R&D spend (as a proportion of sales), but highly unfocused new product program – focus on radically new markets and new products; high risk, highly competitive sectors offering high rewards.

Perhaps unsurprisingly, the companies that performed best in this survey were those that adopted Strategy B: The Balanced Strategy – they had the highest success rate (72 per cent), the highest proportion of sales income derived from new products (47 per cent), and were equal-highest in terms of profitability. Strategy D was rated second, then A, C and E, in that order. Cooper rates the Strategies thus: "B: Top performers; best on every performance gauge. D: Good success rate, low impact program. A: High impact; low success rates; poor profitability. C: Very poor results. E: Very poor results."

An interesting finding of this research is the lack of connection between R&D expenditure and business success: the lowest-spending firms (Strategy D) performed second-best while the highest-spending firms (Strategy E) fared worst. This challenges the conventional wisdom that companies which spend more on R&D automatically achieve better results in product innovation. It has prompted the author to examine Australian defence industry R&D in order to determine whether a correlation exists between levels of R&D expenditure and product innovation success.

The strategies and orientations of firms were examined also by Paladino (Paladino 2007) who compared the performance of firms pursuing either a Market Orientation-based strategy or a Resource Orientation-based strategy. Resource

Oriented firms can be likened to Defenders in the Slater & Mohr taxonomy, while Market Oriented firms can be likened to Prospectors.

Paladino suggests that Resource Orientation enhances company performance by improving internal effectiveness and efficiency to achieve new product success, while the Market Oriented firm improves performance by enhancing customer value. This in turn suggests that managers seeking new product success should focus less on customer value and more on resource value, while those pursuing customer value should focus on market orientation.

This would seem to imply that Market versus Resource Orientation is an either/or proposition. But the research cited earlier suggests this is not the case and that successful innovators display signs of both types of orientation: they must be sensitive to market needs and also have efficient internal processes and a robust internal resources base. The fact remains, however, that most firms do have a dominant culture that tends towards one or other of these orientations, and Paladino suggests that Market Oriented firms may be better suited to service industries, in which customer-provider relationships have a relatively more immediate effect on company performance than in capital equipment manufacturing industries, for example. By contrast, Resource Oriented firms would seem to be better suited to high-technology, high-quality manufacturing.

Paladino's conclusions may have interesting implications for Australia's defence industry which derives the majority of its revenue from providing services rather than manufacturing new equipment. Many of Australia's prime contractors combine design and manufacture with service offerings, while smaller companies tend to be either specifically a service provider or a manufacturer. The larger firms tend to have several operating divisions focussing on different technology domains and market sectors – in many cases these divisions were independent companies until a fairly recent merger or acquisition. Anecdotally, it has been observed that a single, diverse company composed of several divisions can embrace a variety of cultures, more or less appropriate to the sectors in which those divisions operate. The challenge for the corporate leadership is to understand these differences and not stifle the divisions and their leaders by imposing an inappropriate cultural overlay on them.



## 2.8 Factors unique to the defence market

What about factors unique to the defence market? There is a paucity of literature in this area with Tishler, Dvir et al, mentioned above, standing out. However, research by Ben-Ari on the measurement of marketing performance in the defence electronics industry (Ben-Ari 2004) has identified 15 key indicators of marketing success. While Ben Ari's research did not encompass innovation per se, and focussed on export sales of proven technology rather than development by companies of new technologies for the domestic defence customer, Rogers's definition of innovation states that an innovation may be new to the user or adopter, even if it is not new in an absolute sense. And to the extent that innovation success is a by-product of marketing and communications proficiency, his findings contribute to the present research.

Ben-Ari's 'Marketing Compass' lists 15 factors, or 'indicators', which measure the performance and likelihood of success of defence industry marketing managers. These mirror many of the findings of Project SAPPHO, as well as those of Cooper (Cooper 1980), Montoya-Weiss and Calantone (Montoya-Weiss and Calantone 1994) and Slater and Mohr (Slater and Mohr 2006). They are, in no specific order:

- Understanding and knowing the customer
- Mutual trust and confidence
- Providing leading edge technology
- Competitiveness in price and in terms of payment
- Efficient representative and/or agent
- Good past performance of the company
- Past experience with similar projects
- Marketing intelligence
- Government support
- Global politics
- Efficient marketing and management
- Ability to demonstrate the product or system
- Transfer of technology or essential know-how
- Motivated marketing and technical team
- Senior management support

The issues of 'government support', 'global politics' and 'transfer of technology' are distinguishing features of the international defence market, and significant environmental variables in Cooper's taxonomy. The defence market is highly regulated for national security reasons and also to ensure general compliance with international treaties and agreements on the transfer and proliferation of different types of weapons and weapons-related technologies. The defence market in each

country is also controlled by the national government because it is so fundamental to the security and self-reliance of the nation and its armed forces, so there is a political complexion on defence equipment transfers of all kinds which are absent from almost every other market for industrial goods, with the possible exception of the nuclear energy sector. Government control and regulation of the defence market also has the purpose of protecting nationally important skills and capabilities.

The other factors mirror those identified by Rothwell and others in their studies of commercial markets for industrial goods: among other things, they focus on marketing proficiency and customer knowledge; the need for leading-edge (more accurately, for appropriately advanced) technology is a 'given'.

Notwithstanding the boundaries Ben Ari imposed on his own research, his findings resonate with the experience of defence manufacturers in the Australian market. As noted previously, this market is characterised by a conservative, risk-averse approach by the customer to capability development and acquisition, notwithstanding an oft-stated commitment to innovation as a means of delivering the advanced capabilities the ADF requires. Two significant reviews of Australian defence acquisition, published by Mortimer in 2008 and Pappas in 2009, note the cost, schedule and technical risks inherent in developmental projects. They both recommend that the ADF use the cost and capability of MOTS equipment as the benchmark for evaluating the need for a developmental solution to an operational need, and for assessing the value for money such a solution might represent. (Mortimer 2008; Pappas 2009)

Is the level of risk tolerance within the Department of Defence and the ADF a factor in stimulating or stifling innovation by the defence industry? Recent reports and studies carried out on behalf of the Department of Defence or by independent 'think tanks' have highlighted the costs and risks associated with developmental equipment acquisition programs (Mortimer 2008; Davies and Layton 2009; Pappas 2009). Highly publicised project delays and cost over-runs have resulted in an extremely risk-averse approach to capability development and acquisition by the ADF's Capability Development Group (CDG) and the DMO – Pappas points out, "Technical risk (in both the project itself and related projects) is the cause of more than 50% of post-approval [cost and schedule] slippage."

Davies & Layton note a gradual trend over the past two decades towards purchases of MOTS and COTS equipment to reduce cost and schedule risks (Davies and Layton 2009). Pappas recommends:

“The cost of local sourcing in comparison to other options must be determined prior to government approval, and presented to Government with the option set; Local sourcing should only be considered where it is a strategic priority or where it is competitive with other options, and if local sourcing is chosen outside this criteria, that the rationale be clearly articulated.” (Pappas 2009)

In November 2009, Australia’s defence minister, Senator John Faulkner, stated:

“The Government accepted the vast majority of the [Pappas] Audit recommendations and these will be implemented through the Strategic Reform Program.” (Faulkner 2009)

This has important consequences for local defence innovators: clearly, the reduced tolerance of risk advocated in the Mortimer and Pappas reports suggests the Department of Defence will in future seek more rigorous justification of the need for local development of innovative new equipment and solutions. This would seem to increase the relative importance in the Australian defence market of customer and environmental factors in innovation success.

## **2.9 The Customer’s Role**

While the literature reviewed above highlights the importance of customer and market knowledge in successful innovation, it fails to examine in detail the role played by customers in determining and defining the need for innovation. Von Hippel’s study of the innovation process in the scientific instruments industry (consciously extending the knowledge developed during Project SAPPHO) determined that innovation in this sector is overwhelmingly a user-dominated process (Von Hippel 1976). It was found that in 81 per cent of cases where a ‘major improvement innovation’ came to the market, the user had identified the need for a significant improvement in existing instrumentation, invented the improved instrument, and then built, tested and applied a prototype.

The user generally then publicised the invention and its value throughout the immediate and adjacent ‘cells’ in the scientific community. Only when this had been done, Von Hippel found, did instrument manufacturers become involved, carrying

out production engineering and development work to improve its reliability and ease of use and then market and sell the resulting product. He termed this the Customer-Active Paradigm (CAP).

Importantly, Von Hippel found this result was mirrored broadly across the sector: where a 'basic instrument' innovation was involved (that is, an all-new type of instrument never seen on the market before) the CAP applied in 100 per cent of cases; where a minor improvement innovation was undertaken (that is, a small or incremental improvement in an existing instrument) the CAP accounted for 70 per cent of the innovations. Some 30 per cent could be attributed to a Manufacturer-Active Paradigm (MAP), where the manufacturer initiates the innovation in response to a need that he has spotted and characterised. In some cases the MAP focussed on improving an existing type of instrument, making it easier to use or cheaper or more reliable, rather than developing an all-new one with a different set of functions to meet an unsatisfied need.

This suggests that some tasks are so specialised that developing new tools or methods to tackle them is difficult without the specialist knowledge of the user. In turn, that suggests a threshold of specialist knowledge embodied in the user community – the Community of Expert Practitioners mentioned earlier - above which manufacturers may be unable to understand, or at least anticipate, user needs.

Case studies recounted in Von Hippel's 1976 paper describe two examples of a 'major improvement innovation' and one of a 'minor improvement innovation'. One major and one minor innovation were CAP-driven while the third was MAP-driven. The first major improvement was driven by a dissatisfaction with the performance of nuclear magnetic resonance spectrometers within a laboratory at Stanford University; a solution was designed and tested by two students, and then commercialised by an external scientific instruments manufacturer – a CAP-driven innovation. The minor improvement innovation cited by Von Hippel was a self-cleaning aperture for electron microscopes; the need statement came from a laboratory at Harvard University, which also developed a quick, cheap solution. This was subsequently commercialised by an external manufacturer in a CAP-driven process.

The second major improvement innovation he cites was MAP-driven: the development by an American company, RCA, of a reliable, stable high-voltage

power source which transformed the cost and utility of transmission electron microscopes and therefore increased their availability and attractiveness to the scientific community.

This suggests that in markets where the CAP is dominant there may exist different strands of innovation: on the one hand the user and, eventually, manufacturer combine to develop a new product driven by a hitherto unfulfilled need; on the other hand, a manufacturer can innovate to improve an existing product in order either to increase its efficiency and/or performance or reduce its price.

Von Hippel's conclusion was that "the locus of almost the entire scientific instrument innovation process is centred in the user. Only "commercial diffusion" is carried out by the manufacturer." This, he noted, was a contrast to much of the existing literature of the time on innovation which attributes to the manufacturer the idea or proposal at the heart of an innovation. He developed this theme subsequently (Von Hippel 1978) and concluded that the CAP cannot apply where the user is ignorant of his needs, while the MAP cannot apply where the point of need is inaccessible by the manufacturer.

Rothwell agrees with these findings:

"The innovation literature strongly underlines the fact that a significant percentage of unsuccessful innovations fail because the innovator has not succeeded in satisfactorily establishing an appropriate set of user specifications and in interpreting these in the design of his new equipment. In many industrial sectors, user-need specification and product development involve more than simply a passive role for the user, and innovatory success is associated with active user involvement in product specification, design and development. Users also have an important role to play in the process of re-innovation. Moreover, it is users who are themselves technically progressive and innovation-demanding who have the greatest potential in this respect."  
(Rothwell 1986)

Von Hippel and Rothwell find an echo in the defence sector where companies might, for example, conduct R&D to improve the performance or lower the price of rocket motors or infra red seeker heads, but they wouldn't try to develop a new missile embodying these (and possibly other) improvements before the customer has identified and validated the need for a new weapon with specific performance

characteristics. Once the customer has done this the innovative manufacturer may be better placed, through his own R&D, to satisfy the need articulated by the user. Naturally, a customer- and market-aware company would try to shape the market by ensuring the customer is aware of his own research and so takes available performance improvements into account in identifying the elements of a solution to an emergent (or existing) problem.

Comparing his findings with proven and accepted models of the innovation process, Von Hippel argues that these models are not invalidated, merely that different models also exist. He also notes that his findings are consistent with those of Project SAPPHO in as much as large chemical companies are often the first customers for their own process innovations – in this case they embody the CAP process. Furthermore, the CAP model can represent a cost-saving to the manufacturer who is spared much of the investment in market research, field testing and selling a new product (Von Hippel 1982).

The applicability of this model, with appropriate variations, to other manufacturing industry sectors has been shown in subsequent studies across domains as different as semiconductor manufacturing, aerostructures manufacturing and sporting equipment (Rothwell 1986) (Foxall, Murphy et al. 1985) (Baldwin, Hienerth et al. 2006).

Von Hippel also demonstrates that in some industries, or industry sectors, the CAP model predominates while in others the MAP model predominates. He argues that this is due to the difference in the ability of the user and manufacturer to appropriate the benefit from the innovation, resulting from differences in the fundamental relationship between the innovator and the innovation (Von Hippel 1982). The argument he makes is that some users (particularly those in competitive markets) develop an innovative process which affords them a competitive advantage – this could be an improved manufacturing tool or process; the innovator retains his advantage by retaining control of his innovation, either by building it entirely in-house or by entering an exclusive agreement with an external manufacturer who is prevented from selling this innovation elsewhere. The opposite example would be a manufacturer who develops an improved machine tool which he can then sell to several users on a non-exclusive basis.

These examples resonate strongly in Australia's defence community where, to take a single example, during the 1980s the Royal Australian Navy and DSTO (we can

term them loosely ‘users’) developed a concept for a ‘smart’ decoy to protect surface ships against radar-guided anti-ship missiles. This was the start of the Nulka decoy program (Nulka is an aboriginal word meaning ‘be quick’); it saw an extended period of experimentation and development work, latterly in partnership with the US Navy, which resulted in an Australian company, AWA Defence Industries (now BAE Systems Australia), commercialising the concept.

This is a good example of a CAP-driven defence innovation; notwithstanding that the need for some means of ‘blinding’ or confusing missile radars was well understood, Nulka embodied an all-new innovation from DSTO – the application of vectored thrust missile steering technology to the development of a hovering, rocket-powered platform carrying a classified electronic payload which followed a carefully chosen flight path calculated to ‘seduce’ the incoming missile away from its intended target. The users – the RAN and US Navy – developed the innovation and validated the technical approach, an external manufacturer is producing it for them and for the Canadian Navy, and the users retain the benefit by forbidding the export of Nulka or disclosure of key data to any but a very few other navies.

This example is repeated throughout the Australian defence marketplace. While defence manufacturers have at the very least a general, and often very detailed, understanding of the user needs of the ADF and the wider Defence organisation, the statement of user need and therefore of any requirement for innovation in satisfying this normally comes from the user, and usually finds formal expression through the Defence Capability Plan (DCP).

This is because the expenditure of significant amounts of public money requires a robust and detailed justification of the capability sought and the funds required to pay for it (CDG 2006). This justification is made formally during the ADF’s capability development process which assesses the missions and the type and scale of threat the ADF is likely to face in any foreseeable future, and the capabilities it must field to deter or defeat these. This process also identifies and evaluates likely and emerging threats to both national security and ADF personnel in future operations, and canvases potential counters. Increasingly, over the past decade the ADF, its Capability Development Group and the DSTO (which functions as Defence’s scientific and technical authority) has identified, analysed and validated its user needs using sophisticated war gaming and modelling tools.

This experimentation process, generally carried out at a high level of classification, is designed to identify the capability and resulting force structure and equipment needs of the ADF, including weapons, platforms, communications and IT architectures, training and supporting physical infrastructure. This is where the CAP comes into play, and one of the mechanisms by which it generates its effect is the RPDE program which harnesses the ADF's unique knowledge of its user requirements with the research, analysis and prototyping capabilities of defence and industry players working as an integrated team.

It should be noted that this capability development process, and DSTO's participation in it, is not intended to trigger R&D by DSTO that will lead to the indigenous development of new equipment. This is in contrast to countries such as the UK, France, Israel and the USA where it is expected that government-owned (or supported) research establishments such as DSTL and QinetiQ (UK), DGA (France) and DARPA (USA) will play an intimate role in undertaking or at least funding the necessary R&D to develop new equipment.

In Australia it is possible to anticipate some of the outcomes of this experimentation and capability development process. But except where shortcomings in an already fielded item of equipment are evident, and can be redressed by an incremental improvement of some kind, it is hard for manufacturers to 'buck the system' by putting forward innovations which do not appear to have been subjected to detailed scrutiny and analysis within the operational context foreseen by the ADF. In the other countries mentioned in the previous paragraph,

The generally-stated need for 'customer knowledge' is moderated in this context by innovative manufacturers who introduce the idea of a new technology, or a new type of equipment, at a very early stage in the capability development process. Indeed, in the case of a very few disruptive innovations, such as the CEA Technologies CEA FAR and CEAMOUNT radars, the process of revealing these to the ADF has resulted in a new capability equipment project being launched specifically to acquire the capability they offer.

In a process which could be termed 'market shaping' manufacturers regularly brief ADF officers and defence officials on a 'commercial in confidence' basis on new innovations and new products their companies are developing or considering developing. The aim of this process is twofold: first, to inform the customer about the product or technology concerned and get him excited enough in its potential



that he will consider establishing a new project or re-configuring an existing one to embrace it. Secondly, the process informs the manufacturer about the customer's views of his own needs as well as of the technology or product on offer and any potential risks or other sensitivities he perceives. As well as being an exercise in market intelligence-gathering, this could be seen also as 'stimulating' some level of CAP activity.

Defence forces are traditionally regarded as conservative and risk-averse: it takes considerable effort to persuade them to embrace new technologies, especially if this involves significant changes to existing practices, procedures, battle tactics and the like. The challenge for manufacturers, then is to 'sell' the idea of a new technology well before the customer is in a position to define his detailed operational requirements. This process can be likened to Rogers's 'Diffusion of Innovation' (Rogers 2003) in the sense that acceptance of a new, unorthodox or disruptive innovation will eventually diffuse through an organisation and, manifesting in the CAP paradigm, shape that organisation's views of the options available to satisfy its needs.

History shows, however, that the cycle of technology development regularly confronts defence forces with rapidly evolving threats and operational challenges and dictates they must embrace innovation and at least some of the risk inherent in adopting new technology in order to gain a competitive advantage. This is the case with the ADF: the Australian Army, for example, now publishes an Army Continuous Modernisation Handbook (ACMP), first released in 2000 and updated in 2008, which sets out the practical steps for transforming the Army in Being (AIB) into the Army of the Future (AOF) and then the Army After Next (AAN). This development continuum constantly looks ahead to an aspirational force structure whose organisation and equipment needs are regularly updated to address the evolving strategic picture and emerging threats and opportunities presented by new defence and security players and technologies. (Army 2008)

The ACMP 2008 edition has its equivalents in the Royal Australian Navy and Royal Australian Air Force. They jointly support the theory of the Customer Active Paradigm (CAP) within Australian defence acquisition by validating the proposition that the ADF is inherently innovative, adopts a systematic approach to innovation and demands innovation from its equipment suppliers. This is shown in the ACMP 2008 list of objectives:

“The objectives of the ACMP are to:

- a. provide future warfighting concepts to guide the development of the Army Objective Force (AOF) and the Army-After-Next (AAN) in a joint, interagency and Whole of Government context;
- b. link future warfighting concepts to the capability development effort of key Army agencies;
- c. coordinate the transition of capabilities between the AOF and the Approved Future Force (AFF) and the AFF and the Army-in-Being (AIB);
- d. employ an experimental framework, tested in a joint framework, to develop and refine future warfighting concepts and force options;
- e. provide the basis for the Army to contribute positively to capability development and future capability planning in joint and wider Defence forums;
- f. integrate capability implementation in order to synchronise modernisation initiatives;
- g. integrate capability transition to ensure outputs required by Government are maintained at agreed levels; and
- h. identify Army’s capability development priorities, potential vulnerabilities and potential high pay-off areas to inform and focus information collection by staff and agencies from within Army, the ADO [Australian Defence Organisation], or elsewhere.” (Army 2008)

This demonstrates a willingness to innovate and to embrace change. To some extent this change process is reactive, where short-notice contingencies expose a need for equipment, training or processes which the ADF doesn’t currently command. But the ADF generally looks forward and seeks to balance the risks and rewards attendant on any technical and organisational change, and this provides opportunities for industry to meet its needs and address some of the risks.

However, Page argues that in Australia, at least, a willingness to innovate isn’t necessarily matched by the customer’s technical understanding – in particular of technology and technical risk (Page 2009). He highlights the importance of the customer’s professional and technical knowledge and understanding and how these can shape an innovation project and the way it is run.

Without consciously setting out to do so to, Page highlights the importance of customer knowledge and expertise in a market where the CAP applies. He establishes a link between Von Hippel’s theory and defence practice, and warns that where customer knowledge and expertise are lacking the result may be a risk-averse approach to capability development and acquisition which stifles innovation and actually impedes the desired outcome.

## 2.10 Structural issues: the National Innovation System

Defence industry innovation within Australia takes place within the construct of a much wider innovation system. At a higher level altogether Cornford (Cornford 2006), argues there are four main drivers of a country's innovative capacity: publicly-funded R&D, privately-funded R&D, availability of what he terms Highly Qualified Personnel (HQP) and access to risk capital. Based on research in Canada, Cornford argues the interaction between these factors results in a number of critical relationships: the ratio of investment in publicly funded R&D to that in developing HQP; the relationship of investment in privately funded R&D to that in developing HQP; the ratio of HQP to the total workforce; the ratio between investment in publicly and privately funded R&D; and the overall relationships between these factors.

To achieve optimal results, Cornford argues, the following key relationships must exist:

- Ratio of Privately funded R&D to publicly funded R&D must be greater than 3:1
- The ratio of HQP to the total workforce must exceed 10:1,000
- The ratio of privately funded R&D to investment in developing HQP must exceed 3:2

When these relationships are in the right balance, he concludes, there are two important results: a product opportunity emerges for each \$2 million of R&D spending; and for every four product opportunities, a venture investment occurs.

While these observations are based on research in Canada, the association between these relationships and commercialisation success suggests a predictive capability if they are overlaid on an existing commercialisation model. How far they can be applied specifically to defence-related R&D, and particularly to the Australian environment, remains to be established. With regard to the first two of Cornford's key relationships, it will be noted from the Australian Bureau of Statistics' figures that private sector R&D investment currently exceeds that of the public sector by nearly 5:1; however, in the defence sector public R&D investment exceeds private by nearly 2:1. Similarly, the DMO estimates the total workforce of the Australian defence industry to be 29,000; it's unclear how many of these are involved in R&D but it is unlikely to exceed the total workforce of DSTO, which is 2,300. (DMO 2010;

DSTO 2010) This in turn suggests that Australia's defence industry lacks some of the critical mass in both R&D manpower and investment to create and exploit market opportunities.

There are a number of other external factors which also affect innovation outcomes, factors which shape the business environment and which companies can identify and to some degree exploit for themselves.

This is suggested by Porter whose research on clusters (Porter 1998) supports the view that the immediate business environment outside the company has an important influence on its prospects. Noting the existence of industry clusters across North America and Europe (financial services in Boston, fashion companies in Italy, textile firms in North and South Carolina, IT firms and wineries in California), he argues that clusters of "interconnected companies and institutions" provide a mutually reinforcing network of players whose physical proximity to each other provides its members with a comparative advantage over rivals located elsewhere. It's possible these clusters provide conditions similar to those proposed by Cornford. Porter's argument is supported by Johnson (Johnson 2010) who coins Christopher Langton's phrase 'Liquid Networks' (Langton, Taylor et al. 1992) and cited the potential for 'Information Spillover' among people in a physical community – a 'cluster' in other words – as a necessary condition for innovation.

Clusters promote both competition and cooperation, says Porter; without vigorous competition between its members, typically in the horizontal plane, the cluster will fail. Yet the very existence of the cluster also enables cooperation, typically in the vertical plane, to capture mutual benefits. Clusters, he argues, increase the productivity of their members, drive the direction and pace of innovation in the business sector concerned, and stimulate the formation of new businesses which continually refresh and regenerate the cluster. While the core of most clusters tends to emerge spontaneously, their growth is driven by deliberate decisions on the part of constituent companies to locate all or part of their operations within the cluster's area of influence.

This idea resonates strongly in Australia where the Defence Teaming Centre (DTC), for example, grew from a proposal during the late-1990s to promote a defence industry cluster in Adelaide's northern suburbs close to the DSTO research centre there (DTC 2009). This centre's principal focus is on systems engineering, sensors

and electronics, including electronic warfare, and not surprisingly the main focus of the emergent DTC 'cluster' is defence electronics, defined broadly.

To the extent that Adelaide has emerged as a defence industry 'hot spot' with a relatively high number of high-technology defence companies based in and around the city, this could be the localised effect of an industry cluster which creates the conditions and relationships suggested by Porter, Cornford and Johnson.

## **2.11 Discussion**

The general conclusion from the research cited here is that the success of product innovation programs is determined by a number of factors: firstly, the careful selection of commercialisation or product innovation opportunities, via an appropriate screening process which takes into account technological, business and market synergies; secondly, the market knowledge of the innovator or entrepreneur undertaking the project; and thirdly, the proficiency with which he undertakes the development and launch process.

There is a divergence between the models described earlier in this literature review and the research examined later on. Most of the models describe a process that's relatively rare within the defence industry: the development of a new piece of IP by a research organisation such as a university or publicly-funded research establishment, and its transfer and subsequent commercialisation by a start-up company. Much more common is the process described and examined in much of the literature cited above: the development by existing companies of new products or services, or the incremental enhancement of existing ones. Some research identifies the variations in the processes required for new product development and incremental product development and much of the research sets out to identify inherent attributes of the firms involved which are determinants of new product innovation success in different types of market.

It seems a reasonable hypothesis that this research could be applied to some of the commercialisation models discussed earlier. Where these models seek to set out a roadmap for a new venture based on a new piece of IP, the predictive value of the research examined here could help shape these new ventures according to the types of technology and market involved and the sorts of new product development strategies firms should follow.

However, in the context of product innovation by Australia's defence industry, the vast majority of effort is expended by existing companies, either developing new products from original IP or enhancing existing products. Therefore innovation success factors identified from studies of industrial (rather than consumer) product development may be more appropriate, and adaptable, to the unique circumstances of the defence industry.

Many of the studies cited here focus on a process downstream from the original research, whether this was carried out in-house or by a research partner or provider. They do not link marketing efforts and essential customer knowledge with levels of R&D expenditure, and they don't address explicitly the difficulties for innovators of taking a new product (or a new venture) across the commercialisation chasm described by Smith in the AIC's Commercialisation Progression Model – this is also frequently referred to as the 'Valley of Death'. In some cases established companies are able to fund new product developments internally, or through access to loans or other regular sources of finance; but many high-technology companies, especially SMEs, rely on external funding from venture capitalists, other investors or government grants to get them across the Valley of Death, even when undertaking an incremental innovation project.

Sources of finance naturally seek assurances of different types from and about the firms they lend to or invest in; the predictive value of this research may help in the identification of solid prospects and, indeed, may help companies make necessary changes to improve their chances of success and, therefore, their attractiveness to lenders and investors.

## **2.12 Conclusion**

This Literature Review has identified a number of models for product innovation success in markets which resemble the defence market. Given the essentially high-technology nature of modern warfare and defence equipment it is reasonable to hypothesise that innovation success factors identified in markets for ICT, scientific and industrial equipment, and the resulting models and processes, can be applied, extended and adapted to serve the high-technology elements of the defence industry. The Review has also identified literature describing the customer's own role in triggering and shaping innovation outcomes in certain markets. And it has identified a small body of literature describing features of successful high-technology defence export marketing activities.

While fusion of different types of model can be problematic, it may be possible to develop a Predictive Model incorporating some of the features of the models described above as well as findings from the other research cited in this literature review.

## Chapter 3 - Research Methodology

### 3.1 Introduction

This Chapter describes the methodology used to identify the data required to answer the Key Research Questions and prove or disprove the hypotheses arising from them. It sets out a Dependent Variable, how a number of hypothetical Independent Variables are identified and refined, and the methodology for conducting the Case Study survey that gathers the data for this research.

### 3.2 Aim of the Research

The research sets out to answer three Key Research Questions:

- What are the factors which determine the success or failure of product innovation projects by companies in Australia's defence industry?
- Can these factors be measured and used to create a model, or a more general set of pre-conditions, for successful product innovation within Australia's defence industry?
- To what extent is R&D investment an indicator of product innovation success in the Australian defence industry?

The contributions to knowledge this research seeks to make are summarised in these research questions. The first question goes to the heart of this research: the Literature Review in the previous Chapter shows that to the extent that all successful innovators and all successful innovations have certain features in common, there are certain generic factors associated with innovation success. This research aims first to discover which, if any, generic success factors apply also in the defence market; and secondly, to discover any additional factors unique to the defence sector which are associated with innovation success, or failure. If such factors exist and can be measured their effect on innovation outcomes and their relative importance may be incorporated into a model or methodology which, if applied, provides an increased chance of success. Such a model may also have some value in helping inform and shape the development of defence industry policy in the future.

Why is this contribution to knowledge important?

There are two reasons why this contribution to knowledge is important: the first is that, as discussed elsewhere, the Australian market for specialist defence equipment



and services is worth over \$10 billion a year, or close to 1% of Gross Domestic Product (Gumley 2009). Notwithstanding the significant proportion of its equipment which the ADF acquires from allies such as the US, the UK and European nations, this represents an important market for local firms who compete with each other and with foreign companies to win this business. A significant increase in the innovation and commercialisation performance of local companies could have a significant beneficial effect on both the operational capability of the ADF and the national economy.

Secondly, despite this very significant expenditure of public funds there has been very little research into the innovation and commercialisation activities and performance of the Australian defence industry. Therefore, there is a general lack of knowledge about the factors affecting them and the mechanisms by which they operate. Identifying and measuring these factors and the range and scale of their effects on companies' innovation performance will help create tools enabling companies to improve their performance: to grow, to expand into other markets and to increase profits.

### **3.3 Research Paradigm**

This exploratory research aims to identify factors associated with defence product innovation success in the Australian defence industry. Because it is exploratory (to the author's knowledge little or no research of this kind has been carried out before in Australia) it would seem therefore to conform with an Interpretivist, qualitative research paradigm.

However, identifying success factors requires a definition of product innovation success, and therefore some examination of the opposite case – of product innovation failure. The need to compare and contrast success and failure, even in exploratory research, of necessity requires an unbiased, methodical approach that is more grounded in a Positivist, Quantitative paradigm. But the sample of case studies was too small for meaningful statistical analysis using recognised methods such as a Chi-Square or T-Test, so Qualitative analysis proved extremely important.

The end result has been a Qualitative study informed by Quantitative methods: a quantitative examination of completed projects whose outcomes are known, even if they have not been documented in detail. These can therefore be examined using a common methodology designed to identify important similarities associated with

either success or failure, and important differences between successful and unsuccessful projects. As well as allowing some quantitative analysis of the resulting data this methodology also solicits interpretive comment from participants which make possible an Interpretivist, Qualitative analysis that enriches considerably the information derived from the raw quantitative data.

### **3.4 Research Methodology**

The aim of this research is to identify factors that have a significant direct or indirect effect on *Product Innovation Success*. This can be defined as the sale and delivery of a product that worked as the customer wished. While it may have been possible to refine this definition somewhat, the relatively small sample size and the criteria for selecting case study candidates (see below) would have added an extra layer of complication to the research. In this case the simplest definition of Product Innovation Success was the best.

It is hypothesised that some generic product innovation success factors apply also in the defence market; and similarly, that there are some success factors that are unique to the defence market. Many of these factors have been identified in research cited in Chapter 2. In order to establish whether or not they have any effect on defence product innovation success it is necessary to test this hypothesis against the known facts of a project's outcome.

Therefore, it is possible to treat *Product Innovation Success* as a Dependent Variable, and the various factors which, it is hypothesised, may have some effect on innovation outcomes, as Independent Variables. The method used to identify and refine the Independent Variables is set out below in section 3.6 – Data Collection Method.

To test and measure the effect of the Independent Variables on the Dependent Variable a quantitative approach was adopted, based on case studies of a number of Australian defence innovation projects. This approach was chosen because using historical data leaves no room for doubt about the outcomes and provides an opportunity to test data, opinion and assertions provided by interviewees against the known facts of a project's history.

Furthermore, this approach lends itself to a 'Paired Comparison' methodology in which a successful project is compared directly with an unsuccessful project, as was done in Project SAPPHO (see p.63). This requires careful selection and pairing of

projects in order to ensure that so far as possible they are a close match in terms of scale, complexity, technical domain and customer, or end user.

### 3.5 Sampling

There have been hundreds, if not thousands, of defence product innovation projects in Australia over the century to 2009. These cover a range of technical domains, from guided missiles and radars to armoured vehicles and submarines. In order to provide a realistic basis for comparison it was decided that the case studies should be drawn from projects undertaken over the previous 15-20 years, and therefore within largely the same defence industry policy and capability development and acquisition framework.

However, it was impossible to follow exactly the same methodology as Project SAPPHO, which sought to compare very similar products competing for the same market (Rothwell, Freeman et al. 1974; Rothwell 1985). Australia's relatively small defence market and pool of defence industry players means that direct competition between two all-new Australian products developed solely for the ADF is very rare.

Furthermore, finding suitable examples of unsuccessful innovations is surprisingly difficult. Reflecting Cooper's findings that "Industrial product development programmes have a much better performance than has previously been assumed", and that "only 17 per cent of launched products failed commercially in the marketplace" (Cooper 1984), Australia's defence market has thrown up relatively few new product innovations which could be described as failures in either a technical or a commercial sense. By their very nature new products developed for the ADF are designed around the ADF's stated needs and tend to meet them more or less satisfactorily. While the complexity and technical difficulties encountered during their development may result in significant delays and cost increases, generally speaking new Australian defence products tend to be regarded as a technical and operational success.

So the selection of case study candidates has been driven by the definition of failure and the need to ensure sufficient diversity of innovating company, technical domain and project scale. Failure is defined by the Dependent Variable: the sale and delivery of a product which worked as the customer wished. Failure can be defined as the opposite of this: a product which either didn't work as the customer desired, or fell well short of the innovator's sales target. Once a suitable 'failure' had been

identified this was matched with a successful product of similar scale, complexity and technical domain. This made possible a modified form of the 'Paired Comparison' methodology used in Project SAPPHO.

The criteria for inclusion in the case study program were that the innovation:

- Must have been developed in Australia either by Australian firms or by the local subsidiaries of overseas parent companies
- Must have been offered to, or entered service with, a paying customer
- Must have been designed originally for a defence application

The projects were also at a stage of maturity which allowed an accurate judgement to be made of their success, and this was the basis for their selection as a case study candidate: they were chosen from an initial long list of 45 Australian defence innovations, of which 13 were acknowledged market and/or technical failures. Obvious candidates would include successful projects like the Nulka anti-missile decoy and Bushmaster Protected Mobility Vehicle (PMV). But the case studies also included many less-prominent or lower-value products. Several major projects were deliberately not included, eg: the Jindalee Operational Radar Network (JORN) and Collins-class submarine. Neither of these could be matched with a project of equivalent value, complexity and technical domain. Furthermore, JORN and Collins were projects of national significance, shaped as much by contemporary political and strategic considerations as by the industry centric factors determining innovation success or failure in the projects examined in this research.

The projects included in the case studies were carried out by prime contractors, Small to Medium Enterprises (SME) and companies in-between; they include innovations developed from in-house IP as well as from IP developed externally by organisations such as DSTO; they include products offered directly to the Department of Defence and to export customers; and they cover a range of technology domains.

Due to the smaller number of unsuccessful projects these were used as the basis for selecting the matched pairs; the choice was complicated by the fact that a disproportionate number of Australian defence innovations were produced by a relatively small number of companies: ADI Ltd, AWA Defence Industries, BAE Systems, Tenix Defence, Thales Australia, Thales Underwater Systems and Saab Systems. Industry mergers and acquisitions have seen these coalesce to just three companies – BAE Systems, Saab Systems and Thales Australia – and in order to

prevent the sample being dominated by one or other of these companies a number of otherwise suitable case study candidates were rejected.

Once a shortlist of candidates had been drawn up each of the companies on it were approached personally by the author and asked if they wished to take part in the case study program. A number declined for various reasons.

The final list of 16 case studies consisted of eight matched pairs of successful and unsuccessful product innovation projects and was drawn up according to the following criteria: technical domain; size of the innovating company; innovation impetus; source of the original IP; scale and complexity of the product and its development process. One of the participating companies demanded higher levels of confidentiality

The Technical Domain criteria saw products paired in the Electronic Warfare (EW) Command and Control (C2), Sensor and Systems, Unmanned Air Vehicle (UAV), Communications and Military Vehicle domains.

One pairing compared products developed initially in Defence's Capability and Technology Demonstrator (CTD) program and sought to discover what discriminates between a CTD that is developed into a product and then ordered by the ADF and a CTD that successfully demonstrates worthwhile operational potential but is not subsequently developed.

In only one case was it possible to compare two products developed in Australia to compete directly for a specific ADF contract. The winner in this contest has proved highly successful in operational service and has started to achieve export sales to Australia's allies; the loser won no orders from the ADF but has been sold in small numbers to a single export customer.

The 'size of the innovating company' criteria were reflected in pairings which in two cases compared products developed by the same company; and in another deliberately sought to compare similar products developed by SMEs employing less than 200 people. In all, five pairs compared products manufactured by prime contractors or substantial firms with technical reach-back to an overseas parent or partner. While Australia's defence community distinguishes simply between 'Primes' and 'SMEs', the Australian Bureau of Statistics (ABS) definition is helpful here: *small* businesses employ fewer than 20 people, *medium* businesses 20 to 199 people, and *large* businesses 200 or more. These are the definitions which will be

applied to the case studies. However, within the classification *large* there is a big difference between a firm employing 200 people and a firm employing 5,000, so the definition *medium-large* will be used in this research to classify companies employing 200-300 people.

Table 3.2 lists the criteria for selection, assigns a number to each project and a letter to each separate innovator and identifies the size of the innovator. It will be seen that in addition to the eight paired comparisons (comprising 16 case studies), a further four case studies were conducted. Because interviewees were available and willing to participate in the research, the decision was taken also to conduct case studies of a further four successful defence industry innovations using the same technique in order to establish whether success factors identified in the eight paired comparisons were also present in an extended sample.

**TABLE 3.1: Case Study Projects**

<b>MATCHING CRITERIA</b>	<b>FAILURE (F)</b>	<b>SUCCESS (S)</b>
Same company; electronic warfare; all a response to a specific ADF operational need; both derived from original S&T work by DSTO	<b>1 A Large</b>	<b>2 A Large</b>
Same company; complex command and control system; strong customer pull; significant systems integration and software development	<b>3 B Medium-Large</b>	<b>4 B Medium-Large</b>
Sensor / systems technologies; developed from original S&T work done by DSTO	<b>5 C Medium</b>	<b>6 D Large</b>
Sensor / systems technologies; developed in-house; significant software development and systems integration work required	<b>7 A Large</b>	<b>8 E Medium-Large</b>
Capability & Technology Demonstrator (CTD) projects; both were a technical success	<b>9 F Medium</b>	<b>10 G Medium</b>
UAVs, SMEs. export successes all developed entirely by manufacturer	<b>11 H Small</b>	<b>12 I Medium</b>
SMEs; significant software development and systems integration; both were a technical success	<b>13 J Small</b>	<b>14 K Small</b>
Land environment; military vehicle; significant development and integration task	<b>15 A Large</b>	<b>16 D Large</b>
<b>EXTENDED STUDY SUCCESS (ESS)</b>		
Tactical communications product, developed for export market only		<b>17 L Medium</b>
Sensor signal processing technology developed in-house for the ADF and exported subsequently		<b>18 M Medium</b>
Equipment developed under a Defence Rapid Acquisition Project (RAP) contract		<b>19 N Medium</b>
Operations planning and management tool developed originally for ADF and subsequently exported widely		<b>20 O Medium</b>

### 3.6 Data Collection Method

The Data Collection method chosen was to conduct case studies of each project based on an identical survey questionnaire. The questionnaire would be filled out during an interview with a senior member of the company responsible for the innovation. The interviews were structured around a detailed questionnaire consisting of 112 questions measuring a total of 400 data points and requiring a mixture of simple yes-no, multiple choice and scaled responses (see Chapter 4). The questions themselves were framed to address the 14 Independent Variables (see below) and determine what effect these had on the Dependent Variable. This makes it possible to seek out factors associated with success or failure which relate to specific Variables. By careful framing of the questions it was possible in several cases to repeat a number of them in different ways throughout the survey which helped check the consistency of the responses. Interviewees were asked to respond to the individual questions and then add whatever interpretive comment they felt was necessary and provide clarification where it wasn't clear to the interviewer why they had made certain responses.

The end result was a structured approach to exploratory research: participants in the projects in question were asked what happened, and why, and their responses compared and interpreted within a framework created by the survey questionnaire.

Because companies were willing to take part in the case study program, even where their innovation was unsuccessful, there is no reason to believe there was any systematic or even ad hoc attempt to mis-represent the project's history. Offering the interviewees complete confidentiality encouraged levels of candour (particularly in comments about the customer's behaviour or capabilities) that might not otherwise have emerged. Nevertheless, it is acknowledged that each case study interview provided a subjective account of the project by the company concerned.

It would have been helpful to include the customer's perspective in these case studies but after initial discussions with officials from the Department of Defence and DSTO it was decided that the case studies should concentrate on the experiences of the companies alone. It was by no means certain that the author would obtain approval to interview defence officials intimately associated with each of these projects. For the sake of consistency it was decided that if it wasn't possible

to get Defence's input into all of them, then it was better not to pursue it for any of them.

### **3.7 The role of Defence-related R&D**

Noting Cooper's findings about the relative amounts of R&D expenditure by companies following different product strategies (Cooper 1984) the case studies also sought information on the R&D investment of the companies concerned in order to determine whether or not specific levels of R&D investment had an impact on innovation outcomes. A separate R&D survey of Australian defence companies was also undertaken in late-2009 to determine their R&D investment and the focus of their R&D activities. The purpose of this survey was to try to resolve some of the ambiguities and contradictions in other bodies of statistical data. The survey questionnaire asked, so far as possible, the same questions posed by Wylie in his 2004 study of the Australian defence industry (Wylie 2004) in order to provide a stable comparison between sets of data gathered six years apart. This would enable changes in behaviour or outlook to be identified and would also provide an R&D expenditure figure which would either vindicate or cast further doubt on the ABS figures.

It was unrealistic to expect that every company generating all or most of its revenue from defence activity would respond, and therefore gross expenditure on defence-related industry R&D would be impossible to obtain. Therefore no attempt was made to classify companies according to product innovation strategies identified by Cooper. But it was hoped sufficient data would be gathered to enable a realistic assessment of the proportion of revenue Australian defence companies devote to R&D. The survey was publicised through a number of Australian industry associations, through Australian Defence Magazine (ADM) and through the Defence Materials Technology Centre (DMTC). The survey was conducted 'blind' and participants were assured total discretion. However, participation rates were disappointingly low with only 19 companies responding. The consolidated survey results are presented and discussed in Chapter 4.

### **3.8 Data Analysis**

While Qualitative exploratory research doesn't necessarily lend itself to (and isn't necessarily enlightened by) the rigour of statistical analysis, in any case this sample size is too small for statistically significant analysis using tools such as SPSS. Hence



the decision to undertake a Qualitative analysis using the interviewees' explanatory comments to expand on the raw data provided by their questionnaire responses.

As will be seen in Chapter 4, the data analysis process was quite simple: each survey question asked for a simple response: a yes/no; a numerical value (number of employees, size of company turnover etc); a scaled response (typically on a scale of 0 to 5); and an ordering of preferences. These made it relatively easy to compare one project with another, and then to aggregate responses so that general differences between successful and unsuccessful projects could be identified. Differences weren't apparent in the responses to all of these questions, but in cases where noticeable or significant differences did emerge, the interpretive comment provided by the interviewees explained why these contrasts existed and made it possible to re-interpret and re-define the Independent Variables.

### 3.9 Linking to the Literature - Independent Variables

The Independent Variables are a hypothetical construct due to the exploratory nature of this research. They are the factors which are believed to have some effect on the Dependent Variable, *Product Innovation Success*. While the basic measure of Product Innovation Success is sales of the product concerned, all other things being equal (which of course is rarely the case) the determinants of sales success boil down to three factors which to a large degree are measures of the innovator's own business and technical proficiency:

1. **Function** - whether or not the product actually worked and met the user's needs.
2. **Timeliness** - whether or not the product reached the market (or the launch customer) at the right time.
3. **Cost** - a measure of the efficiency of both business planning and technical execution.

A fourth, but underlying, factor which has a significant bearing on these is:

4. **R&D Investment** – a measure of the extent to which the innovator invests in R&D and adopts a systematic and methodical approach to the innovation process generally, and also of his capacity to absorb technology and IP sourced externally.

However, in a market shaped by the Customer-Active Paradigm (CAP), each of these is moderated to a sometimes-significant degree by the customer's characteristics, behaviours and environment.

For the purposes of this research it is hypothesised that the various Independent Variables fall into these four categories, and also that they are derived from factors identified in the literature cited in Chapter 2.

*Function* is a measure primarily of the innovator's marketing and technical expertise: did the innovator understand the user's needs properly, and did he design and develop a product that met them? This factor is a measure of the innovator's marketing, R&D, technical and business proficiency and of his ability and willingness to seek external expertise, where necessary. It is also to a lesser degree a measure of his innovation impetus and the customer's attributes and behaviour (in the sense that the customer needs to be able to identify and articulate his own needs properly).

*Timeliness* is a measure of technical and business proficiency and, to the extent that delays inevitably cost money, is related to *Cost*. Timeliness (including both setting and meeting schedule goals) is a measure of the efficiency and speed of the product development process and therefore a measure of communications, R&D and technical proficiency and also of business proficiency – including, crucially, the ability to estimate schedule and cost accurately. In Australia, due to the CAP and the monopsony nature of the local defence market, innovators are to some degree at the mercy of customer attributes and other customer-controlled factors. Therefore the actual time taken to bring an innovation to market may also be affected significantly by the speed of customer decision-making, along with unusual requirements or unexpected changes in requirements.

Being first to market carries important advantages but in the CAP-dominated Defence market the expression 'first to market' doesn't necessarily mean the same thing as in a more traditional market where the CAP doesn't apply. In the defence market, or other markets where it is impossible (or unwise) to anticipate the outcome of the customer's own capability development process, it is arguable these advantages derive more from the innovator's technical and production readiness than from product availability – that is, the innovator may have the technology and resources available to develop a timely, successful response to an opportunity presented by the customer. Those resources may include IP or early prototypes

developed to help position the innovator without necessarily anticipating the customer's precise requirement. *Timeliness* is therefore a measure to some degree of the company's Technical and Business Proficiency – his familiarity with both the technical domain and the specific conditions of the defence market, as well as the internal management skills necessary to develop and husband the required technical and material resources, and then bring these to bear efficiently once the project gets under way.

Where the customer is more inclined to buy a Commercial or Military Off The Shelf (COTS or MOTS) item, however, having a developed and proven product available either for immediate sale or as the basis for further development may afford the innovator an advantage. This is especially the case in some export markets where customers lack the technology or resources to develop new and complex equipment by themselves, or where the user need is so urgent that the rapid procurement of a COTS or MOTS solution is essential.

*Cost* is not a measure of price, per se, as this and the expected profit margin will be determined as part of the business case for the project. Price expectations may be set by the customer in his tender or market solicitation process - this will have a significant shaping effect on the entire project and its business case, and the innovator's ability to determine the customer's price sensitivity is an important measure of Marketing Proficiency. So the quality of the business case, and therefore the product cost component of this, is a function of the innovator's Marketing and Business Proficiency, building on his R&D and Technical Proficiency as well as his familiarity with the market sector and technology domain. Other things being equal (in particular, predictable and efficient Customer Processes) efficient business and technical processes on the part of the innovator will ensure the product can be delivered profitably at the intended price.

This factor is a measure of the company's Proficiency: in Marketing (in determining the customer's needs and price sensitivity and the level of competition in the market); in Business (in determining whether an incremental or disruptive innovation is required, estimating development and production costs and determining an appropriate price and margin); in R&D and Technical (in designing, developing and manufacturing the product efficiently, and on time); Communications, in developing and sustaining productive relationships with the customer, partners and suppliers and bodies such as DSTO, and also in establishing

efficient, cross-functional project teams, is a factor also in achieving *Cost*, *Timeliness* and *Functionality* goals.

*R&D Investment* is an important component of innovation in technology-rich or technology-driven industry sectors. In the defence sector companies conduct a certain amount of self-funded R&D which supplements the government-funded R&D carried out by public sector research establishments such as DSTO and academic and private sector researchers. Self-funded industry R&D is generally directed towards new products or more efficient industrial or business processes. The very process of conducting R&D, whether or not it results in new products or processes, strengthens the company by improving its absorptive capacity – its ability to interact with research partners and IP sources and exploit the IP and expertise they share and to seek out appropriate IP sources.

The Variables which, it is hypothesised, impact on *Product Innovation Success* collectively make up these determinants of sales success and are derived from a combination of well-understood generic innovation success factors and factors specific to the Australian defence market.

To some extent innovation success factors are generic: that is, non-defence companies with a record of successful innovation and commercialisation in the markets for scientific and industrial equipment (which have many features in common with the defence market - see Chapter 2) have been shown to have certain features in common. These have been identified and listed by a number of researchers (Rothwell, Freeman et al. 1974; Von Hippel 1976; Rothwell 1977; Cooper 1980; Rothwell 1985; John and Snelson 1990; Henard and Szymanski 2001; Slater and Mohr 2006; Paladino 2007). Successful non-defence innovation and commercialisation projects also tend to have certain features in common. It is reasonable to hypothesise that these factors also apply in the defence market.

It is also reasonable to hypothesise that there are factors unique to the defence market which are independent of and additional to any generic success factors. These factors reflect the unique circumstances of the marketplace: its size, the monopsony nature of the market, the effect of the Customer-Active Paradigm (CAP), the number of firms competing for Defence's business, the technology domains involved, the levels of technology involved, the levels of R&D required to meet project and customer requirements, the scale of the projects, the finance and

other resource requirements for both vendor and customer, and the government policies and other forces shaping the market and the way in which it operates.

Such factors may have a mitigating or amplifying effect on the more generic features common to successful projects and companies which innovate and commercialise successfully. So it is important to examine both types in order to determine what effect, if any, they have in the defence market and how important relative to each other these effects might be.

Research cited in Chapter 2 has identified a range of more or less generic factors associated with successful product innovation projects and companies which are successful innovators. (Rothwell, Freeman et al. 1974; Rothwell 1977; Cooper 1980; Montoya-Weiss and Calantone 1994; Henard and Szymanski 2001)

Henard & Szymanski, Montoya-Weiss & Calantone, Cooper and Rothwell between them identified 66 factors associated with product innovation success or successful firms. To determine which factors were most dominant, an analysis was conducted to determine which were cited in all four studies, or in just three. Factors cited in two studies or fewer were considered less likely to be determinants of company or project success.

Some 17 factors were common to all four studies. A further 25 factors were cited in three of the four studies (Table 3.1).

**Table 3.2: Aggregated Success Factors**

<b>FACTOR</b>	<b>Rothwell (Project SAPPHO)</b>	<b>Henard &amp; Szymanski</b>	<b>Montoya- Weiss &amp; Calantone</b>	<b>Cooper (Project NewProd)</b>	<b>TOTALS</b>
Marketing	1	1	1	1	4
R&D stretch	1	1	1	1	4
Meeting user needs	1	1	1	1	4
Communications	1	1	1		3
Management strength	1	1	1		3
Familiarity	1	1	1	1	4
Techniques	1				1
Pressure	1	1	1		3
Organic	1				1
Risk	1	1	1		3
Launch execution		1	1	1	3
Understanding customer needs, wants & specs	1	1	1	1	4
Product quality		1	1	1	3

prototype test with customer				1	1
targeted sales and distribution force				1	1
proficient test marketing			1	1	2
proficient production ramp-up		1	1	1	3
knowledge of customer price sensitivities		1	1	1	3
proficient product development	1	1	1	1	4
understanding buyer behaviour				1	1
product helps customer reduce costs				1	1
product/company fit - sales/distribution	1		1	1	3
company/product fit in marketing	1	1	1	1	4
good idea screening		1		1	2
Product better meets user needs	1	1	1		3
Product advantage		1	1	1	3
marketing synergy	1	1	1	1	4
technological synergy	1	1	1		3
strategy	1		1		2
company resources			1		1
market potential		1	1		2
market competitiveness	1	1	1		3
protocol	1	1	1	1	4
proficiency of pre-development activities	1	1	1	1	4
proficiency of market-related activities	1	1	1	1	4
proficiency of technological activities	1	1	1	1	4
Top management support, control & skills	1	1	1		3
speed to market			1		1
costs			1		1
financial/business analysis		1	1		2
internal/external Comms	1	1	1		3
organisation factors - team structure		1	1		2
market potential		1	1		2
dedicated manpower		1			1
marketing task proficiency	1	1	1	1	4
meeting customer needs	1	1		1	3
product advantage		1	1	1	3
pre-development task proficiency		1	1	1	3
dedicated R&D resources		1			1
technological proficiency	1	1	1	1	4
launch proficiency		1		1	4
order of entry		1	1		2
technological sophistication		1			1
product price		1	1	1	3
product innovativeness		1			1

marketing synergy	1	1	1	1	4
technological synergy	1	1	1		3
structured approach	1	1	1		3
reduced cycle time		1	1		2
market orientation	1	1	1	1	4
customer input		1	1	1	3
cross-functional integration		1	1		2
cross-functional communications		1	1		2
senior management support	1	1	1		3
likelihood of competitive response	1	1	1		3
competitive response intensity	1	1	1		3
<b>TOTALS</b>	<b>35</b>	<b>54</b>	<b>53</b>	<b>34</b>	

Not surprisingly, there were some obvious duplications; once these had been eliminated, some 26 factors remained. This was considered too many factors around which to create a survey questionnaire. To assess and measure these factors properly would have required a questionnaire of daunting and ultimately self-defeating complexity, demanding far too much time and research effort on the part of the respondents, especially as, the questionnaire must also deal with company characteristics and the companies' perceptions of the market and defence business environment, which would increase its size.

It was decided, therefore, to further reduce the number of factors by a two-stage process: generalising those factors specifically relating to innovation project success, and equating them to the characteristics and internal processes of successful companies; and then aggregating and refining factors which address similar issues. This resulted in a list of 14 principal success factors. These are listed and explained below, in no particular order:

1. **Market competitiveness** - size of market; intensity of competition within the market; degree, intensity or level of competitive response to a new product introduction (also referred to in the literature as market turbulence)
2. **Top management support, control and skills** - degree of senior management support for a new product initiative; also a measure of the strength of the management of the innovating organisation, management commitment and day to day involvement; role and involvement of key individuals
3. **Customer knowledge** - Understanding customers' needs, wants and specifications; knowledge of customers' price sensitivities; understanding buyer behaviour and customer purchase decision processes
4. **Dedicated R&D resources** - Focussed commitment of R&D resources to a new product initiative; general investment in R&D and in commercialisation of externally developed IP

5. **Market orientation** - degree of firm orientation to its internal, competitor and customer environments
6. **Internal/external communications** - coordination and cooperation internally and between partners; level of communication between departments in a new product initiative; communication with actual and potential customers; communication with external IP sources
7. **Technological synergy** - congruency between the firm's existing R&D and technological skills and resources and those required to execute a successful new product launch
8. **Marketing synergy** - congruency between the firm's existing marketing skills and resources and those required to execute a successful new product launch
9. **Resource base** - congruency between the company's other resources and the requirements of a successful new product initiative: capital; workforce; manufacturing facilities; sales/distribution
10. **Risk** - a measure of the degree of risk the innovating organisation is willing to bear; major risk factors impacting on specific market sectors
11. **Structured approach** - employment of formalised product development procedures
12. **Proficiency in pre-development activities** - proficiency with which a firm executes pre-launch activities: idea generation/screening, market research, financial analysis
13. **Proficiency in market-related activities** - proficiency with which a firm conducts its marketing activities; market research, customer testing, advertising and launch
14. **Proficiency in technological activities** - proficiency of a firm's use of technology in a new product initiative; prototyping, testing, trial production

In addition to these generic factors, of course, it is hypothesised that there are also factors unique to the defence market – principally the customer himself and the unique market in which he operates. The influence of the defence customer's characteristics and behaviours is amplified by the monopsony nature of the defence market. Therefore, it is hypothesised that in the Australian market for high-technology defence equipment the characteristics, policies and processes of the customer have a shaping effect both on industry innovation processes and the likelihood of success.

A concurrent hypothesis is that the defence market is also shaped by the Customer-Active Paradigm (CAP) identified by Von Hippel and others (Von Hippel 1976; Rothwell 1986). Like the fields of medicine and scientific research, defence is characterised by a community of expert practitioners who, at the highest level, have unique insight into their own (or their professional community's) needs and the likely elements of a solution, and therefore initiate and to some degree shape the



product innovation process. This research aims to determine whether these hypotheses are accurate, and if so to attempt to measure these effects and create a model for product innovation success based on them.

The combination of a Monopsony market and the Customer-Active Paradigm means the Australian defence market is shaped and to a great extent controlled by the behaviour of the customer. This in turn is the result of the customer's own intrinsic attributes, deliberate policy decisions (many made externally by the Federal government of the day, with or without reference to Defence) and external factors acting on the customer himself. So the customer's effect on the defence market and on the outcome of product innovation projects can be viewed through the prisms of Customer Characteristics, Customer Processes and Customer Environment.

Specific, Defence-unique factors that emerge from these prisms include the threat environment the customer faces; his operational, technical and scientific knowledge; risk tolerance; market regulation and security; and his capability development and acquisition processes. It is important in the Australian context to distinguish between Capability Development and Acquisition as these are separate but complementary, and often closely integrated, activities for whom quite separate individuals are responsible.

Briefly, Capability Development is Defence's internal process for identifying existing and emergent defence capability needs, establishing priorities, examining options for meeting those needs, determining appropriate budgets, managing an ongoing investment program, and doing so within financial guidance and with high levels of accountability. The responsibility of the ADF's Capability Development Group, this is necessarily a complex, rigorous, time-consuming and resource-intensive process (CDG 2006).

The Acquisition process has its genesis during Capability Development. Ideally the two processes should inform each other through some degree of concurrency and a feedback loop. In the Acquisition process Defence, via the DMO, formally solicits industry quotations and estimates based on the Government-endorsed operational requirement developed during the Capability Development process. This typically (though not always) involves a competitive tendering process. Once a contract has been signed the DMO manages the acquisition process and delivery of the equipment to the user. So these two Customer Processes, and the way they are

applied, and the innate organisational characteristics and deliberate policy decisions behind them, have a significant effect on product innovation projects and their outcomes. This is consistent with the findings of Tishler and Dvir, Ben-Ari and Davies and Layton (Tishler, Dvir et al. 1996; Ben-Ari 2004; Davies and Layton 2009).

However, the Defence-specific factors examined in this research are hypothetical: their definitions, for the purpose of this research, are developed from the Literature sources cited above, and from the more subjective opinions and views of defence industry and Defence (including DSTO) personnel. Collectively, these views amount to a form of “received wisdom” which has evolved over decades and has not been tested or validated in any formal way.

The differences that set the defence sector apart from Australia’s broader high-technology market for goods and services include: the apparent anomaly of DSTO accounting for a very high proportion of Australia’s defence R&D investment, and yet having no mandate to commercialise the fruits of its labour; Australia’s small domestic market for dedicated (i.e. with no civilian application) defence products and services; the monopsonistic nature of the market in which, ultimately, there is only one single customer – the Federal government; Defence’s very deliberate processes; Defence’s reliance on competitive tension to determine value for money; Defence’s risk-aversion; Defence’s generally disinterested stance towards Australia’s domestic manufacturing industry; the high costs of developing and testing modern defence equipment; Australia’s privileged access to the US and British arsenals, which provides the ADF with extremely capable defence equipment at a price it could not otherwise afford, and so relieves Defence of the need to fund the development of much high-technology equipment in-country; the consequent low barriers to market entry in Australia facing defence firms from these and other countries; and the high technical, financial and cultural barriers to entry in most export markets.

These differences are identified and discussed in journal and magazine articles, academic papers and books, and in speeches, interviews, and publications by senior industry and defence department personnel (past and present). They were also examined in the author’s own interviews with senior defence personnel and industry executives in the course of this research. Much of this raw material refers directly and indirectly to successful and unsuccessful defence innovation projects carried out by different companies over the past 10-15 years (Ferguson 2005).

The existence, or importance, of a defence-unique factor cannot be considered a fact unless it can be identified specifically and its effect on the Dependent Variable can also be identified and measured. So one purpose of this research is to determine whether in fact these hypothetical Defence-unique factors shape the defence industry's innovation activities and their outcomes and, if so, to measure their effects and importance.

As described above, the chosen methodology was to ask industry respondents what effect (if any) specific factors had on the Dependent Variable, and then compare responses across a sample of respondents to determine whether these effects were unique to a specific project or occurred frequently enough to be statistically significant. There was therefore a risk that the survey form could become extremely long, complex and unwieldy and demand more time than an industry respondent was prepared to give to this activity. So the decision was taken to aggregate still further some of the 14 generic factors listed above and add to them a number of defence-unique factors identified in the author's own research, arriving at a final list of 14 Independent Variables. This process was guided by the systematic construction (and if necessary abandonment) of hypotheses linking the Independent and Dependent Variables.

The final list of 14 Independent Variables is:

1. **Marketing Proficiency** (Market research, understanding user needs, price and risk sensitivity, customer testing, promotion etc)
2. **R&D Proficiency** (level of R&D investment, R&D skills, R&D management)
3. **Technical Proficiency** (design, development, prototyping, testing, manufacturing)
4. **Business proficiency** (management, financial and business analysis, project management)
5. **External Expertise** (willingness and ability to source essential knowledge and expertise from partners and other sources; terms of access to that expertise)
6. **Innovation Impetus** (The factors driving the need to innovate: customer need for increased capability, lower purchase and operating costs; Manufacturer's need for reduced cost, increased profit)
7. **Market Size and Growth** (Size of market, multiple customers, market access/barriers to market entry)
8. **Market Competitiveness** (number of competitors, intensity of competition)
9. **Time to Market** (urgency of customer need, competitive pressure, innovator proficiency, customer processes, cost)
10. **Customer Characteristics** (Customer's willingness to innovate, operational (or domain) knowledge, technical knowledge, risk tolerance, key appointments)

11. **Customer Processes** (capability development, risk management, acquisition, project management)
12. **Customer Environment** (strength of customer need (including threat environment), evolving customer operating environment (including threat and technology evolution))
13. **Communications** (internal and external communications/collaborative arrangements with DSTO, stakeholders, customer and partners)
14. **Market Regulation** (Security, export controls, ITARs)

Defence-specific factors are addressed through Variables 7-14. Variables 7 and 8 – *Market Size and Growth* and *Market Competitiveness* introduce the effects of Defence's industry and acquisition policies on the function of the Australian defence market, alongside more generic aspects of competition and market turbulence; Variable 9 – *Time to Market* introduces aspects of the Customer's environment and processes and their effect (if any) on project timescales, alongside generic aspects of speed to market; Variables 10-12 and 14 focus specifically on *Customer Characteristics*, *Processes* and *Environment* and the effects of very tight Market Regulation on innovation outcomes. Variable 13 – *Communications* addresses the generic issue of communications (and therefore the creation and management of relationships) within and between players in the innovation project and introduces the effects on communications and the ability to build effective working relationships.

### **3.10 Method of Drawing Conclusions and Implications**

The case studies generated a significant amount of raw numerical data which made it possible to compare individual projects with each other, and groups of projects with each other in a simple Quantitative analysis. This data described, but did not in many cases explain, the differences between successful and unsuccessful defence product innovation projects.

Greater insights emerged from analysis of the explanatory comment provided by the interviewees. This Qualitative analysis made it possible to draw conclusions, based on and backed up by numerical data, on the factors which influence defence product innovation outcomes. The limitations on this method are those of much exploratory research: the conclusions are to some degree subjective, though informed as far as possible by hard evidence. For that reason, this research acts in part as a signpost to others attempting to explore and map this territory in greater detail.

### **3.11 Confidentiality and Privacy**

In order to ensure that interviewees had no reason to withhold or conceal data, they were assured privacy and confidentiality: specific information about the company, the project concerned, the questionnaire responses and the explanatory comment provide during the interview would not be published. Instead, only aggregated data would be published, thus concealing the details of individual companies and projects.

One of the participating companies also insisted the author sign a Non-Disclosure Agreement (NDA) making it impossible to identify its products and the case study results publicly. As the other case study participants had also been promised that only generalised results would be published, it was decided that none of the individual products and participating companies should be identified by name in this Thesis. The identities of the companies and the products have been disclosed to the author's principal supervisor on a 'commercial-in-confidence' basis. The case study data and explanatory comment (some in audio form, most in the form of written notes) has been kept on the author's own desktop computer, backed-up on an external hard drive and also saved to a secure external file server for added redundancy. It has not been shared with or shown to anybody else except the supervisor.

### **3.12 Conclusion**

This Chapter sets out the process by which the research methodology was developed: a qualitative approach was selected, based on case studies of successful and unsuccessful defence product innovations. The factors believed to determine the success or otherwise of a defence product innovation project were derived from the literature described in Chapter 2 as well as the author's own research. Their contribution (or lack of it) to the projects' success was explored through the mechanism of the questionnaire lying at the heart of the case studies.

## Chapter 4 – Research Findings

### 4.1 Introduction

This chapter sets out the results of case studies that were conducted in late-2009 and early 2010 of 20 Australian defence innovation projects. These results emerged from responses to a questionnaire designed to determine which, if any, of 14 separate Independent Variables discriminated for or against Product Innovation Success in these case studies. This chapter sets out the influence exerted by the Independent Variables and also an association between R&D investment by the companies concerned and Product Innovation Success.

The original intention was to follow the approach used in Project SAPPHO (Scientific Activity Predictor from Patterns with Heuristic Origins): comparisons between matched pairs of successful and unsuccessful innovations in the same industry sectors - either industrial chemicals or scientific instruments (Rothwell, Freeman et al. 1974). Due to the smaller population and resulting smaller sample size within Australia's defence industry it proved impossible to follow the SAPPHO methodology exactly. Instead, as described more fully in Chapter 3, 16 Australian defence innovation projects were grouped in pairs, matching a successful innovation with an unsuccessful one that was comparable in scope, value, defence market sector and technology domain. In only one case were two matching innovations developed to compete for the same market opportunity.

The intent was to conduct an analysis of the survey results from the matched pairs in order to identify significant differences between the successful and unsuccessful innovation projects. Case studies were also conducted of a further four successful product innovation projects in order to determine whether success factors identified in the matched pairs were present in a larger sample of successful innovation projects.

The Dependent Variable in this analysis is, quite simply, *Product Innovation Success* – the sale in the anticipated quantities of a product that worked as the customer wished. As noted in Chapter 3, given the relatively small sample size and the criteria for selecting case studies, refining this definition would have added an extra layer of complication. In this case the simplest definition of Product Innovation Success was the best.

While the basic measure of Product Innovation Success is sales of the product concerned, all other things being equal (which of course is rarely the case) the determinants of sales success boil down to three factors which to a large degree are measures of the innovator's own business and technical proficiency:

1. **Function** - whether or not the product actually worked and met the user's needs.
2. **Timeliness** - whether or not the product reached the market (or the launch customer) on time.
3. **Cost** - a measure of the efficiency of both business planning and technical execution.

The innovator's ability to meet those Function, Timeliness and Cost goals is determined by a mix of intrinsic organisational *attributes* – its culture, leadership and competencies – and organisational *behaviours*. The latter are shaped, of course, by the former, as well as by external factors, but are capable of being changed relatively quickly as a result of internal policy decisions or in response to external changes, challenges and opportunities.

However, in a market shaped by the Customer-Active Paradigm (CAP), regardless of the innovator's characteristics and behaviours, the prospect of achieving *Product Innovation Success* is moderated to a sometimes-significant degree by the customer's characteristics and behaviours and his shaping effect on the market environment.

The 14 Independent Variables examined in the case studies are a mix of factors intrinsic to the defence market place (including customer characteristics and behaviour and regulation) and to the innovating company (including technical and marketing skills and general management proficiency), along with innovator behaviours. They are derived from the literature on Product Innovation Success factors in other industry sectors which was reviewed in Chapter 2 (Sohn and Moon 2003; Sohn and Moon 2004) (Von Hippel 1976; Rothwell 1977; Cooper 1980; Cooper 1984; Rothwell 1985; Rothwell 1986; Johne and Snelson 1990; Montoya-Weiss and Calantone 1994; Goldsmith 1995; Henard and Szymanski 2001) as well as from research and interviews with Defence and industry officials conducted by the author in 2004-05 (Ferguson 2005).

These Independent Variables are themselves made up of components contributing to the overall effect of the Independent Variable in question. In aggregate, these components amount to 58 separate factors impacting to some degree on the

prospects for Product Innovation Success. The survey results are set out in Tables 1 and 2 below. These tables summarise the responses from the 20 interviewees to the 8 questions in the introductory part of the Survey Questionnaire, and the 104 questions making up the main Questionnaire. The Independent Variables themselves, and the survey questions which address them, are:

1. **Marketing Proficiency** (familiarity with the market, market research, understanding user needs, price and risk sensitivity, customer testing, promotion etc) – Addressed in Questions F, G, H and 1 to 11
2. **R&D Proficiency** (level of R&D investment, R&D skills, R&D management) - Addressed in Questions B, D, D, F, and 12 to 20
3. **Technical Proficiency** (familiarity with the technology domain, design, development, prototyping, testing, manufacturing) - Addressed in Questions 21 to 28
4. **Business proficiency** (leadership of key executives, general management, financial and business analysis, project management) - Addressed in Questions 29 to 41
5. **External expertise** (willingness to source essential knowledge and expertise from partners and other sources; terms of access to that expertise) - Addressed in Questions 42 to 51
6. **Innovation Impetus** (Customer need for increased capability, lower purchase and operating costs; manufacturer's need for reduced cost, increased profit) - Addressed in Questions 52 to 54
7. **Market size and growth** (Size of market, diversity of customer base, market access) - Addressed in Questions 55 to 59
8. **Market competitiveness** (number of competitors) - Addressed in Questions 60 to 63
9. **Time to market** (urgency of customer need, competitive pressure, cost) - Addressed in Questions 64 to 74
10. **Customer characteristics** (Customer's willingness to innovate, professional domain knowledge, technical knowledge, risk tolerance, key appointments) - Addressed in Questions 75 to 83
11. **Customer processes** (needs analysis, risk management, acquisition, project management) - Addressed in Questions 84 to 91
12. **Customer environment** (strength of customer need (including operational tempo and threat environment), evolving customer operating environment, including threat and technology evolution) - Addressed in Questions 92 to 94
13. **Communications** (internal and external communications/collaborative arrangements with DSTO, stakeholders, customer and partners) - Addressed in Questions 95 to 99
14. **Market Regulation** (Security, export controls, ITARs) - Addressed in Questions 100 to 104

The responses by interviewees in the eight matched pairs of projects were analysed very simply and labelled 'F' for *Unsuccessful Projects* and 'S' for *Successful Projects*.



Case Studies were conducted also of four additional successful projects to determine whether or not success factors identified in the matched pairs were still present in an extended study. The aggregated results for the eight successful projects making up the matched pairs and the four additional successful projects – that is, the 12 successful projects in this study - are labelled '**ESS**' for *Extended Study Successful Projects*.

#### **4.2 Data Issues**

It was decided that, due to the small sample size, a small difference in results between successful and unsuccessful projects should not be considered significant. For example, where successful projects show a 4:4 split between yes/no responses, and unsuccessful projects show a 5:3 split between responses to the same question, it could be argued there is no significant difference between the two: just one respondent answering the question differently would have changed the result entirely. In the case of questions where respondents could state a value on a scale from 0 to 5, an average was calculated so that the responses from unsuccessful innovators could be compared with responses from the Extended Study of successful innovators. Even this needed interpretation, however, as simple averages can be misleading, several high scores being offset significantly by a single very unrepresentative low score, and vice versa, or clusters of similar scores being distorted by a significant 'outlier'.

Respondents were asked in some questions to rank certain factors in order of importance; the majority tended to nominate a single factor, so the decision was taken to count only those factors nominated as the most important – this made analysis simpler without affecting the validity of the survey itself.

An attempt was also made to conduct a statistical analysis of the questionnaire responses results using SPSS. As expected, the sample size was too small to show statistically significant differences in all cases, so the statistical analysis results have been omitted from the final thesis. Instead, bar charts have been drawn up to highlight the differences between successful and unsuccessful projects where responses to the questions concerned supported strongly the hypothesis that this specific variable discriminated between success and failure.

The two tables are presented below. In the column headed 'Result' typically three sets of numbers are included: 'S', denoting responses from the eight successful

innovation projects in the matched pairs; 'ESS' denoting responses from these eight projects as well as the four additional successful projects included in the Extended Study; and 'F' denoting responses from the eight unsuccessful projects in the matched pairs. In the column headed 'Comment' it is stated whether the responses to the question supported the hypothesis that the Independent Variable concerned discriminated between success and failure, and how strongly – 'Strong Support', 'Weak Support', 'Not Supported'.

# Factors affecting innovation performance in the Australian defence industry

S = Successful; F = Unsuccessful; ESS = Extended Study Successful

TABLE 4.1: CASE STUDY INTRODUCTION

Question Number	Question	Response Options	Result	Comment
A	What sector(s) of the defence industry does your organisation operate in? (NB: 'Platform' includes propulsion systems; 'Equipment' includes sensors, weapons and munitions)	What percentage of your turnover is represented by these or other sectors? A.1 - Platform/equipment design, manufacturing & upgrading A.2 - Software A.3 - Systems integration A.4 - Platform/equipment maintenance and support A.5 - Garrison support and 'hotel'-type services A.6 - Others (please list):		See P.142
B	What is your organisation's annual turnover?	<b>In Australian dollars per year: (circle one)</b> <\$5M   \$5-10M   \$10-20M   \$20-50M   \$50-100M   >\$100M 1            2            3            4            5            6		See Chapter 4
C	How many full-time employees does your organisation have?	<20   20-50   50-100   100-250   250-500   >500 1        2        3        4        5        6 (circle one)		See Chapter 4
D	How much did you invest last year in R&D/S&T?			See Chapter 4
E	Is your company Australian-owned or owned by a foreign company or individual?	<b>Australian-owned</b> <b>(circle one)</b> <b>Foreign-owned</b> 1                                  2	S – 7 x 1 F – 4 x 1	Not Supported - Ownership not a significant determinant
F	In what technical area was your innovation?	1 Platform 2 Electronic Systems (including sensors and weapons) 3 Decision Support	ESS – 3x1, 7x2, 2x3 F – 2x1, 5x2, 1x3	Not Supported – most projects focused on electronic systems
G	Who was your intended primary customer?	1 Australian defence 2 Export defence 3 Australian industry supply chain 4 Export industry supply chain 5 Internal process/product improvement	ESS – 10x1, 2x2 F – 7x1, 1x2	Not Supported – general focus on domestic customer
H	Did your product/system enter production for any customer group?	1 Primary customer only 2 Primary and other customers 3 Other customer(s) than primary 4 Didn't enter production	ESS – 12 x 2 F – 1 x 1, 2 x 2, 1 x 3, 4 x 4	Strong Support – all successful innovators responded '2', only 4 of 8 unsuccessful innovators responded the same way.

**TABLE 4.2: CASE STUDY QUESTIONS AND RESULTS**

**S = Successful; ESS = Extended Study Successful; F = Unsuccessful**

Question Number	Case Study Questions	Response Options	Result	Graphical Analysis	Comment																		
1.	How did you become aware of the opportunity?	1 – public solicitation (inc. DCP and/or RFT) 2 – networking/market intelligence 3 – direct approach by customer 4 – Other (please state).....	S – 2 x1, 2x2, 4x3 ESS – 2x1, 5x2, 5x3  F – 1x1, 5x2, 1x3, 1x4	<table border="1"> <caption>Data for Question 1 Graphical Analysis</caption> <thead> <tr> <th>Response Option</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2</td> <td>1</td> </tr> <tr> <td>2</td> <td>5</td> <td>5</td> </tr> <tr> <td>3</td> <td>4</td> <td>1</td> </tr> <tr> <td>4</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Response Option	Successful	Unsuccessful	1	2	1	2	5	5	3	4	1	4	0	1	Strong Support – 5 of 12 Successful innovators recorded '3', indicating they were more likely to see a direct approach by customer			
Response Option	Successful	Unsuccessful																					
1	2	1																					
2	5	5																					
3	4	1																					
4	0	1																					
2.	How did you determine user needs?	1 – public solicitation (inc. DCP and/or RFT) 2 – direct approach to customer 3 – direct approach from customer 4 – networking/market intelligence 5 – Other (please state).....	S – 3x2, 4x3, 1x4 ESS - 1x1, 4x2, 4x3, 3x4  F – 1x1, 3x2, 1x3, 1x4 2x5	<table border="1"> <caption>Data for Question 2 Graphical Analysis</caption> <thead> <tr> <th>Response Option</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> <tr> <td>2</td> <td>4</td> <td>3</td> </tr> <tr> <td>3</td> <td>4</td> <td>1</td> </tr> <tr> <td>4</td> <td>3</td> <td>1</td> </tr> <tr> <td>5</td> <td>0</td> <td>2</td> </tr> </tbody> </table>	Response Option	Successful	Unsuccessful	1	1	1	2	4	3	3	4	1	4	3	1	5	0	2	Strong Support – successful innovators clustered on 2 and 3; the unsuccessful innovators recording 5s had no launch customer. Suggests successful innovators had closer relationship with customer
Response Option	Successful	Unsuccessful																					
1	1	1																					
2	4	3																					
3	4	1																					
4	3	1																					
5	0	2																					

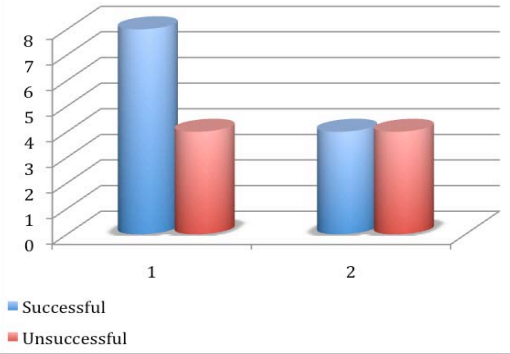
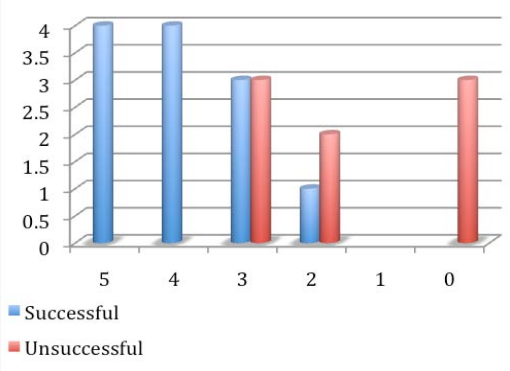
Product innovation success in the Australian defence industry – an exploratory study

3.	Were you able to verify and clarify customer needs in a timely way?	1 – yes – customer was accessible and open 2 – yes – minor difficulties due to geography/access 3 – slow/difficult – customer very reticent 4 – slow/difficult - customer didn't clearly understand own needs 5 – Didn't try to verify needs	S – 5x1, 1x2, 2x4 ESS – 7x1, 2x2, 3x4  F – 3x1, 4x4, 1x5	<table border="1"> <caption>Data for Question 3 Bar Chart</caption> <thead> <tr> <th>Response Level</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>6</td> <td>3</td> </tr> <tr> <td>2</td> <td>2</td> <td>0</td> </tr> <tr> <td>3</td> <td>0</td> <td>0</td> </tr> <tr> <td>4</td> <td>3</td> <td>4</td> </tr> <tr> <td>5</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Response Level	Successful	Unsuccessful	1	6	3	2	2	0	3	0	0	4	3	4	5	0	1	<p><b>Strong Support – successful innovators more likely to record 1s suggesting quality of customer relationship is a factor in success.</b></p> <p>Customer's knowledge of own needs is also a factor – possibly alleviated by quality of relationship with innovator</p>			
Response Level	Successful	Unsuccessful																								
1	6	3																								
2	2	0																								
3	0	0																								
4	3	4																								
5	0	1																								
4.	Who developed the functional specification for the product or system?	1 – Australian Defence 2 - Export Defence 3 – Industry customer 4 - Internal product development process based on market knowledge 5 – Other –please state	S – 5x1, 3x4 ESS – 7x1, 5x4  F – 3x1, 4x4, 1x5		<p><b>Not Supported - though responses suggest that if functional spec is developed by ADF customer there's a higher chance of success</b></p>																					
5.	To what extent did you promote your own technology / capabilities / emerging products to shape your customer's view of his needs?	Very Strongly (circle one)      Not At All 5      4      3      2      1      0	S – average 4.13 5x5, 1x4, 2x2 ESS – average 3.73 7x5, 1x4, 1x3, 2x2, 1x0 F – average 3.38 2x5, 2x4, 2x3, 1x2 1x1	<table border="1"> <caption>Data for Question 5 Bar Chart</caption> <thead> <tr> <th>Response Level</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>7</td> <td>2</td> </tr> <tr> <td>4</td> <td>1</td> <td>2</td> </tr> <tr> <td>3</td> <td>1</td> <td>2</td> </tr> <tr> <td>2</td> <td>2</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	Response Level	Successful	Unsuccessful	5	7	2	4	1	2	3	1	2	2	2	1	1	0	1	0	1	0	<p><b>Strong Support - 8 of 12 successful innovators responded '4' or '5' while 4 of 8 unsuccessful innovators responded less than '4'. Suggests an association between pro-active marketing and promotion and success</b></p>
Response Level	Successful	Unsuccessful																								
5	7	2																								
4	1	2																								
3	1	2																								
2	2	1																								
1	0	1																								
0	1	0																								

Product innovation success in the Australian defence industry – an exploratory study

6.	Did the product or system work effectively in its intended role?	<p>Very Effective (circle one)      Not At All</p> <p>5      4      3      2      1      0</p>	<p>S – average 4.75 7x5, 1x3 ESS – average 4.73 9x5, 2x4, 1x3 F - average 3.75 2x5,3x4,2x3,1x2</p>	<table border="1"> <caption>Data for Question 6 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr><td>5</td><td>9</td><td>2</td></tr> <tr><td>4</td><td>2</td><td>3</td></tr> <tr><td>3</td><td>1</td><td>2</td></tr> <tr><td>2</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>0</td><td>0</td></tr> </tbody> </table>	Rating	Successful	Unsuccessful	5	9	2	4	2	3	3	1	2	2	0	1	1	0	0	0	0	0	<p><b>Strong Support – ESS clusters around 4-5; F more evenly spread</b></p>
Rating	Successful	Unsuccessful																								
5	9	2																								
4	2	3																								
3	1	2																								
2	0	1																								
1	0	0																								
0	0	0																								
7.	Did it meet the user's needs?	<p>Met/Exceeded (circle one)      Not At All</p> <p>5      4      3      2      1      0</p>	<p>S – average 4.63 6x5, 1x4, 1x3 ESS - average 4.45 6x5, 5x4, 1x3 F - average 3.38 4x4,3x3, 1x2</p>	<table border="1"> <caption>Data for Question 7 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr><td>5</td><td>6</td><td>0</td></tr> <tr><td>4</td><td>5</td><td>4</td></tr> <tr><td>3</td><td>1</td><td>3</td></tr> <tr><td>2</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>0</td><td>0</td></tr> </tbody> </table>	Rating	Successful	Unsuccessful	5	6	0	4	5	4	3	1	3	2	0	1	1	0	0	0	0	0	<p><b>Strong Support – 11 of 12 successful innovators responded '4' or '5' while 4 of 8 unsuccessful innovators responded '3' or less and none scored 5;</b></p>
Rating	Successful	Unsuccessful																								
5	6	0																								
4	5	4																								
3	1	3																								
2	0	1																								
1	0	0																								
0	0	0																								
8.	Did it offer superior or inferior value for money than currently available solutions?	<p>Superior (circle one)      Inferior</p> <p>5      4      3      2      1</p>	<p>S – average 4.50 4x5, 4x4 ESS - average 4.55 7x5, 5x4 F - average 3.75 1x5, 4x4, 3x3</p>	<table border="1"> <caption>Data for Question 8 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr><td>5</td><td>7</td><td>1</td></tr> <tr><td>4</td><td>5</td><td>4</td></tr> <tr><td>3</td><td>0</td><td>3</td></tr> <tr><td>2</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> </tbody> </table>	Rating	Successful	Unsuccessful	5	7	1	4	5	4	3	0	3	2	0	0	1	0	0	<p><b>Strong Support – ESS clusters on 4 and 5, F cluster on 3 and 4</b></p>			
Rating	Successful	Unsuccessful																								
5	7	1																								
4	5	4																								
3	0	3																								
2	0	0																								
1	0	0																								

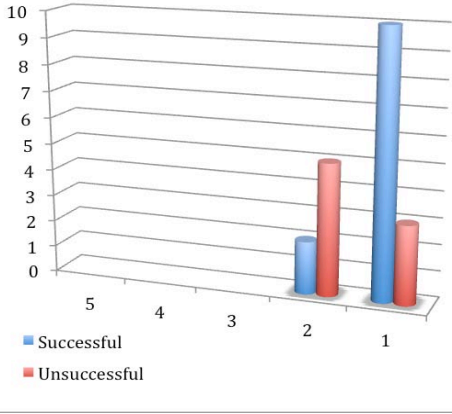
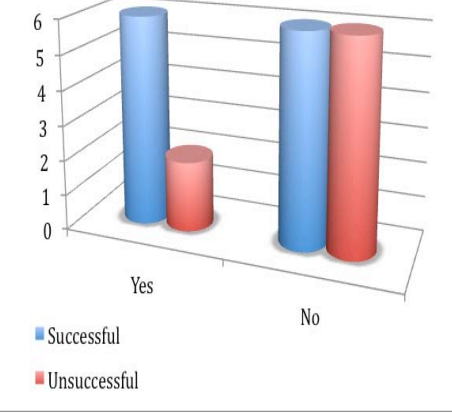
Product innovation success in the Australian defence industry – an exploratory study

9.	Does your company employ a dedicated marketing officer or team in the market sector(s) in which you operate?	1 – Yes 2 - No	S - 6x1, 2x2 ESS - 8x1, 4x2  F - 4x1 4x2		<b>Strong Support – 8 of 12 successful innovators responded '1' while 4 of 8 unsuccessful innovators responded '2'</b>
10.	To what extent did you promote your product and more general credentials to the customer?	Very Strongly (circle one) Not At All 5 4 3 2 1 0	S - average 3.75 4x5,5x4,1x3,1x1,1x0 ESS – average 3.55 4x5, 5x4, 1x3, 1x1,1x0 F – average 4.00 3x5, 3x4, 1x3, 1x2		<b>Not Supported</b>
11.	Did you achieve the sales volume you predicted?	Exceeded Predictions (circle one) No Sales At All 5 4 3 2 1 0	S – average 3.88 3x5, 2x4, 2x3, 1x2 ESS – average 4.0 4x5, 4x4, 3x3, 1x2 F – average 1.63 3x3, 2x2, 3x0		<b>Strong Support – 8 of 12 successful innovators responded '4' or '5' while all unsuccessful innovators responded '3' or less.</b>

<p>11.5.</p>	<p>Did you halt development of this product?</p>	<p>1 – Yes 2 – No</p>	<p>S - 8 x 2 ESS - 12 x 2 F - 6 x 1, 2 x 2</p>	<table border="1"> <caption>Data for 3D Bar Chart</caption> <thead> <tr> <th>Response</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>1</td> <td>6</td> </tr> <tr> <td>No</td> <td>12</td> <td>2</td> </tr> </tbody> </table>	Response	Successful	Unsuccessful	Yes	1	6	No	12	2	<p><b>Strong Support – all successful innovators responded '2', 6 of eight unsuccessful innovators responded '1'.</b></p>
Response	Successful	Unsuccessful												
Yes	1	6												
No	12	2												
<p>12.</p>	<p>If you halted development of this product/system, why was this?</p>	<p>1 - It didn't work well enough to be worth persisting with 2 - Too many existing competitors in this market sector 3 - Anticipated development costs too high 4 - Lack of customer interest 5 - customer chose a rival solution 6 - Overtaken by technology developments 7 - Didn't offer sufficient user benefits 8 - Technology too immature for low-risk development 9 - Market saturation 10 - Other (please state).....</p>	<p>F – 1x3, 2x4, 1x5, 2x6, 1x10</p>		<p><b>All were unsuccessful projects. In one case customer delays led to technological stagnation resulting in the customer choosing a rival solution</b></p>									



Product innovation success in the Australian defence industry – an exploratory study

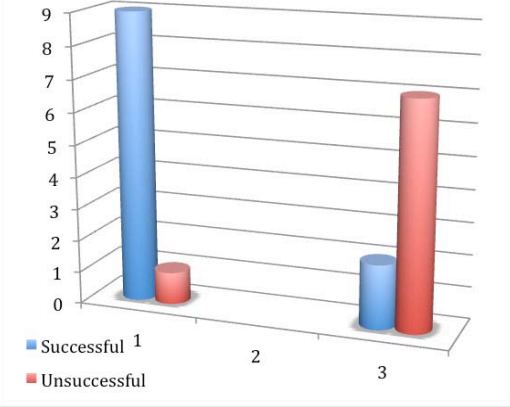
13.	Why does your company invest in R&D?	1 – develop new IP/products 2 - technical knowledge 3 - market knowledge 4 - absorptive capacity 5 - Other (please state).....	S – 6x1, 2 x 2 ESS – 10x1, 2 x2 F – 3x1, 5x2	 <table border="1"> <caption>Data for R&amp;D Investment Reasons</caption> <thead> <tr> <th>Reason</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>0</td> <td>0</td> </tr> <tr> <td>4</td> <td>0</td> <td>0</td> </tr> <tr> <td>3</td> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>1</td> <td>4</td> </tr> <tr> <td>1</td> <td>9</td> <td>2</td> </tr> </tbody> </table>	Reason	Successful	Unsuccessful	5	0	0	4	0	0	3	0	0	2	1	4	1	9	2	<b>Strong Support – 10 of 12 successful innovators responded '1', 5 of 8 unsuccessful innovators responded '2'.</b>
Reason	Successful	Unsuccessful																					
5	0	0																					
4	0	0																					
3	0	0																					
2	1	4																					
1	9	2																					
14.	Does your company/business unit have a dedicated R&D department?	1 – Yes 2 – No	S - 4x1 4x2 ESS – 6x1, 6x2 F - 2x1 6x2	 <table border="1"> <caption>Data for Dedicated R&amp;D Department</caption> <thead> <tr> <th>Response</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>6</td> <td>2</td> </tr> <tr> <td>No</td> <td>6</td> <td>6</td> </tr> </tbody> </table>	Response	Successful	Unsuccessful	Yes	6	2	No	6	6	<b>Strong Support – 6 of 12 successful innovators responded '1' while 6 of 8 unsuccessful innovators responded '2'.</b>									
Response	Successful	Unsuccessful																					
Yes	6	2																					
No	6	6																					
15.	Did you need to increase your R&D/S&T investment and effort for this project?	1 – Yes 2 – No	S - 7x1, 1x2 ESS – 10x1, 2x2 F - 6x1, 2x2		<b>Not Supported – both increased R&amp;D spend</b>																		
16.	Did you need a technology	1 – Yes 2 – No	S – 4x1, 4x2 ESS – 5x1, 7x2		<b>Not Supported</b>																		

	partner to carry out this development work?		F - 4x1 4x2											
17.	To meet customer's requirements:	1 - required an all-new product/system 2 - required further development of an existing product	S - 6x1, 2x2 ESS - 8x1, 4x2  F - 8x1	<table border="1"> <caption>Data for Bar Chart</caption> <thead> <tr> <th>Category</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>8</td> <td>8</td> </tr> <tr> <td>2</td> <td>5</td> <td>0</td> </tr> </tbody> </table>	Category	Successful	Unsuccessful	1	8	8	2	5	0	<b>Strong Support - Extended Study</b> confirmed successful innovators are more likely to adapt an existing product to meet the customer's needs
Category	Successful	Unsuccessful												
1	8	8												
2	5	0												
18.	Did you have IP of your own appropriate to the opportunity?	1 - Yes 2 - No	S - 8x1 ESS - 12x1 F - 8x1		<b>Not Supported</b>									
19.	Did you need IP or expertise from DSTO?	1 - Yes 2 - No	S - 3x1 5x2 ESS - 3x1, 9x2 F - 3x1, 5x2		<b>Weak Support</b> – 9 of 12 successful innovators and 5 of 8 unsuccessful innovators responded '2'									
20.	If so, was this of a sufficiently high TRL?	1 - Yes 2 - No	S - 3x1 ESS - 3x1  F - 3x2		<b>Strong Support</b> – successful and unsuccessful innovators unanimously disagreed									
21.	How long had your company	1 - started up specifically for this project 2 - Had been active for ..... years (insert	S - 13yrs ESS - 11.6yrs		<b>Not Supported</b> – none were started									

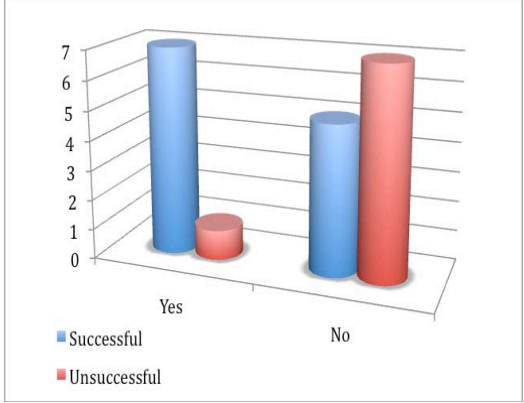
Product innovation success in the Australian defence industry – an exploratory study

	been involved in this sector of the defence industry?	figure)	F - 11.13yrs		specifically for this opportunity.
22.	Is your company owned by a local or overseas defence prime contractor with expertise in this area?	1 – overseas parent 2 – local parent 3 – neither	S - 4x1 4x3 ESS - 4x1, 8x3 F – 4x1, 4x3		<b>Strong Support - Overseas ownership makes no difference; but successful innovations more likely to come from companies not owned by a parent</b>
23.	Did you need an industry partner to provide additional resources?	1 – Yes 2 – No	S - 3x1 5x2 ESS 4x1, 8x2 F – 3x1, 5x2		<b>Not Supported - strong aversion to industry partners</b>
24.	If so, in which area(s)?	1 – design/software/technical 2 – project management 3 - manufacturing skills 4 – manufacturing capacity 5 – finance 6 - Other	S – 2x1, 1x3, 1x4 ESS – 3x1, 1x3, 1x4 F – 1x1, 2x3, 1x4, 1x6		<b>Weak Support – F required industry partners across a wider spectrum of capability; ESS required partners with design, software, technical and manufacturing skills and capacity</b>
25.	Where did the majority of software come from?	1 - in-house 2 – partner 3 - contractor	S - 6x1, 1x3, 1x0 ESS - 10x1, 1x3, 1x0  F - 2x0, 6x1		<b>Not Supported – most innovators keep software development in-house.</b>  <b>0 denotes no software involved</b>

Product innovation success in the Australian defence industry – an exploratory study

26.	Where did the majority of hardware come from?	1 - in-house 2 - partner 3 - contractor	S - 6x1 2x3 ESS - 9x1, 2x3  F - 1x1 7x3	 <table border="1"> <caption>Hardware Sourcing Data</caption> <thead> <tr> <th>Category</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1 (in-house)</td> <td>9</td> <td>1</td> </tr> <tr> <td>2 (partner)</td> <td>0</td> <td>0</td> </tr> <tr> <td>3 (contractor)</td> <td>1</td> <td>7</td> </tr> </tbody> </table>	Category	Successful	Unsuccessful	1 (in-house)	9	1	2 (partner)	0	0	3 (contractor)	1	7	<b>Strong Support</b> – 7 out of 8 unsuccessful innovators sourced hardware from contractors, 9 out of 12 successful innovators sourced hardware in-house.
Category	Successful	Unsuccessful															
1 (in-house)	9	1															
2 (partner)	0	0															
3 (contractor)	1	7															
27.	Were you able to test ideas and hypotheses on the customer during the development process?	1 – Yes 2 – No	S - 8x1 ESS - 12x1  F - 5x1, 3x2		<b>Strong Support</b> – all successful innovators responded ‘1’, 3 of 8 unsuccessful replied ‘no’.												
28.	Did you build a prototype (inc. beta version or integration/ test site) for customer testing?	1 – Yes 2 – No	S - 8x1 ESS - 12x1  F - 7x1, 1x2		<b>Not Supported</b> – almost all innovators built prototypes for customer testing/evaluation												
29.	Did your CEO support the project?	1 – Yes 2 – No	S - 8x1 ESS - 12x1 F – 8x1		<b>Not Supported</b> – all reported a supportive CEO												
30.	Did he/ she take a personal interest in it?	1 – Yes 2 – No	S - 8x1 ESS - 12x1 F – 8x1		<b>Not Supported</b> – all reported strong CEO engagement												

Product innovation success in the Australian defence industry – an exploratory study

31.	Did your financial and business analysis accurately predict cost, schedule and technical challenges?	1 – yes – no major surprises 2 – somewhat – minor surprises 3 – no – badly underestimated some or all of these	S - 4x1, 3x2, 1x3 ESS – 4x1, 5x2, 2x3 F - 4x1, 3x2, 1x3		<b>Not Supported – most innovators claimed to be relatively successful in predicting business and technical challenges.</b>									
32.	Did you establish a dedicated business analysis team to study the financial and business case?	1 – used existing management team and resources 2 – recruited/appointed specialist(s), including consultants 3 – already employ specialist business analysis team	S - 7x1, 1x2 ESS – 10x1, 2x2 F - 8x1		<b>Not Supported – most innovators used internal resources for business and project analysis</b>									
33.	Was accurate customer and budget information available (eg through the DCP or similar documents) to build a robust business case?	1 – Yes 2 – No	S - 4x1, 4x2 ESS - 7x1, 5x2 F - 1x1, 7x2	 <table border="1"> <caption>Data for 3D Bar Chart</caption> <thead> <tr> <th>Response</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>7</td> <td>1</td> </tr> <tr> <td>No</td> <td>5</td> <td>7</td> </tr> </tbody> </table>	Response	Successful	Unsuccessful	Yes	7	1	No	5	7	<b>Strong Support – 7 of 12 successful innovators responded '1' while 7 of 8 unsuccessful innovators replied 'no'.</b>
Response	Successful	Unsuccessful												
Yes	7	1												
No	5	7												
34.	If you have an overseas parent company, did it allow you freedom of action?	1 – controlled project closely from overseas 2 – loose rein, retained power of veto 3 – entirely hands-off	S - 2x2, 2x3 ESS – same F - 3x2, 1x3		<b>Not Supported – overseas ownership had little or no effect on innovation project outcomes</b>									

Product innovation success in the Australian defence industry – an exploratory study

35.	Did you receive grant support – eg a COMET grant?	1 – Yes 2 – No	S - 1x1, 7x2 ESS - 1x1, 11x2 F - 1x1, 7x2		<b>Not Supported – and little reliance on grant support across the sample</b>												
36.	What sort of grant?	Insert here.....			<b>1 Federal GIRD grant  1 State-level export development grant</b>												
37.	Did you appoint one or more business or technical ‘champions’ to run aspects of the project?	1 – Yes 2 – No	S - 8x1 ESS – 12x1  F - 7x1, 1x2		<b>Not Supported – almost all appointed a ‘leader’ or ‘champion’. The exception was an unsuccessful innovator whose project was controlled and managed entirely by the customer.</b>												
38.	How senior were they?	1 – solely responsible for a single project team function, eg marketing, engineering; subordinate to functional head 2 – cross-functional responsibility as head of project team, subordinate to heads of marketing, engineering, etc 3 – cross-functional responsibility for project, equal or senior to heads of marketing, engineering, etc	S - 1x1, 2x2, 5x3 ESS – 1x1, 2x2, 9x3  F - 2x1, 1x2, 4x3	<table border="1"> <caption>Data for Seniority Level vs. Outcome</caption> <thead> <tr> <th>Seniority Level</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>2</td> <td>2</td> <td>1</td> </tr> <tr> <td>3</td> <td>9</td> <td>3</td> </tr> </tbody> </table>	Seniority Level	Successful	Unsuccessful	1	1	2	2	2	1	3	9	3	<b>Strong Support, – 9 of 12 successful innovators responded ‘3’; only 4 of 8 unsuccessful innovators responded the same way.</b>
Seniority Level	Successful	Unsuccessful															
1	1	2															
2	2	1															
3	9	3															
39.	Did you set up a dedicated project team to develop this product/system	1 – used existing management/technical team and resources 2 – set up new team with separate reporting line to CEO/business unit head 3 – spun-off new business unit/company to	S - 3x1, 5x2 ESS – 5x1, 6x2, 1x3  F - 2x1, 6x2		<b>Not Supported - companies generally attempt to set up a new project team to develop a new</b>												

Product innovation success in the Australian defence industry – an exploratory study

	?	develop product/system			innovation.
40.	Did you meet your own project schedule?	1 – yes 2 – slight delays 3 – significant delays 4 – severe delays	S - 5x1, 2x2, 1x3 ESS - 5x1, 5x2, 2x3 F - 5x1, 2x2, 1x3		<b>Not Supported – significant internal delays didn't affect most projects</b>
41.	Why – can you give reasons?				<b>Various reasons: cash flow; under-estimating complexity; slow customer processes; slow company processes</b>
42.	Do you have formal collaboration agreements of any kind with DSTO or other Australian government owned defence R&D agency?	1 – Yes 2 - No	S - 6x1, 2x2 ESS - 7x1, 5x2 F - 5x1, 3x2		<b>Not Supported between successful and unsuccessful innovators – in both cases slightly more did than didn't</b>
43.	Did you engage with any of them during the project?	1 – Yes 2 - No	S - 7x1, 1x2 ESS – 9x1, 3x2 F - 6x1, 2x2		<b>Not Supported – all innovators sought to engage with government R&amp;D agencies to some degree</b>
44.	Did you require IP, expertise or R&D facilities from your parent company or another external technology partner, including DSTO or other defence	1 – Yes 2 - No	S - 5x1, 3x2 ESS – 5x1, 7x2 F - 5x1, 3x2		<b>Not Supported – no evidence that access to external IP, expertise or R&amp;D facilities made a significant difference to project success</b>

Product innovation success in the Australian defence industry – an exploratory study

	agencies?													
45.	If so, in which area?	1 – Core technology 2 – separate technology area of integrated solution	S - 4x1, 1x2 F - 3x1, 2x2		<b>Not Supported – principal need relates to core technology.</b>									
46.	What was the source of your product's original IP?	1 - Own R&D 2 - DSTO 3 - Other R&D organisation 4 - Industry partner 5 - collaborative R&D 6 – Other (please specify).....	S - 7x1, 1x2 ESS - 11x1, 1x2  F - 5x1, 1x2, 1x4, 1x6		<b>Weak Support - DSTO is NOT a key IP source for either successful or unsuccessful innovators. 11 of 12 successful innovators selected '1' - unsuccessful innovators appear less likely to develop essential IP in-house</b>									
47.	Did you require access to Defence-owned test and certification assets and facilities?	1 – Yes 2 - No	S - 7x1, 1x2 ESS – 9x1, 3x2  F - 4x1, 4x2	<table border="1"> <caption>Data for 3D Bar Chart</caption> <thead> <tr> <th>Category</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>9</td> <td>4</td> </tr> <tr> <td>2</td> <td>3</td> <td>4</td> </tr> </tbody> </table>	Category	Successful	Unsuccessful	1	9	4	2	3	4	<b>Strong Support - 9 of 12 successful innovators planned to use Defence-owned facilities; only 4 of 8 unsuccessful innovators planned to use these</b>
Category	Successful	Unsuccessful												
1	9	4												
2	3	4												
48.	If you adopted any DSTO or other Defence IP, was the license for the IP available on an exclusive or non-exclusive	1 – Exclusive 2 – Non-Exclusive	S - 2x1 F - 2x1, 1x2		<b>Not Supported – Defence-owned IP was available mostly under an exclusive license</b>									

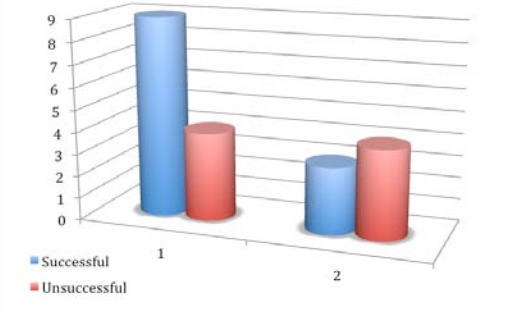


Product innovation success in the Australian defence industry – an exploratory study

	basis?				
49.	If the Defence/DSTO license was non-exclusive how did this affect the business case for the project?	1 – non-exclusive arrangement no deterrent to licensing and product/system development 2 – non-exclusive arrangement introduced minor commercial risk 3 - non-exclusive arrangement introduced significant commercial risk	Unsuccessful: 1x1		<b>Not Supported - the non-exclusive arrangement was no deterrent to licensing and product/system development</b>
50.	If adopted from any other source, was the license for the IP exclusive or not?	1 – Exclusive 2 – Non-Exclusive	S - 1x1 F - 2x1, 2x2		<b>Weak Support - Unsuccessful innovators are less likely to have exclusive IP license...</b>
51.	If the license was non-exclusive how did this affect the business case for the project?	1 – non-exclusive arrangement no deterrent to licensing and product/system development 2 – non-exclusive arrangement introduced minor commercial risk 3 - non-exclusive arrangement introduced significant commercial risk	Unsuccessful: 2x1		<b>...But it doesn't seem to make any difference to the business case or project outcome.</b>
52.	What were the customer's primary needs?	1 – significant leap in existing operational capability 2 – significantly different task/mission, requiring new equipment/technology 3 – improved performance from existing equipment types 4 – reduced operating costs 5 - Other (please state).....	S – 5x1, 1x2, 2x3 ESS – 7x1, 2x2, 2x3, 1x4  F – 5x1, 1x2, 2x3		<b>Not Supported</b>

Product innovation success in the Australian defence industry – an exploratory study

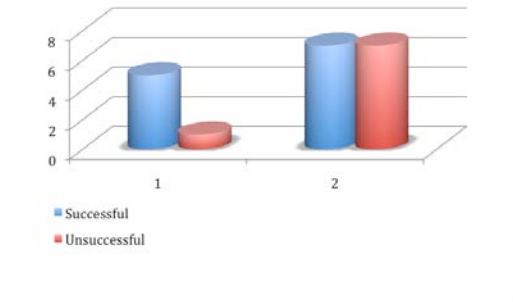
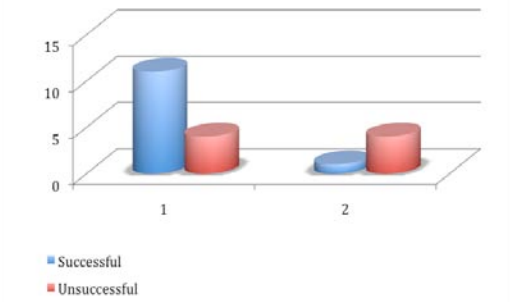
<p>53.</p>	<p>What level of innovation was required to meet your primary customer's needs?</p>	<p>1 – none: COTS/MOTS product was sufficient                  2 – incremental innovation to adapt/improve existing product/system for customer needs                  3 - disruptive innovation required to develop new product/system to meet customer's needs</p>	<p>S - 2x2, 6x3                  ESS – 5x2, 7x3                  F - 1x2 7x3</p>	<table border="1"> <caption>Data for Question 53 Bar Chart</caption> <thead> <tr> <th>Innovation Level</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>2</td> </tr> <tr> <td>2</td> <td>5</td> <td>1.5</td> </tr> <tr> <td>3</td> <td>7</td> <td>7.5</td> </tr> </tbody> </table>	Innovation Level	Successful	Unsuccessful	1	0	2	2	5	1.5	3	7	7.5	<p><b>Strong Support – 5 of 12 successful innovators responded '2' while only 1 of 8 unsuccessful innovators did the same; 7 of 8 unsuccessful innovators responded '3' compared with only 7 of 12 successful innovators.</b></p>																		
Innovation Level	Successful	Unsuccessful																																	
1	0	2																																	
2	5	1.5																																	
3	7	7.5																																	
<p>54.</p>	<p>What were your primary motivations?</p>	<p>1 – needed to reduce manufacturing costs                  2 – needed to increase profitability                  3 - reacting to encroaching competitors                  4 - following a competitor's lead                  5 - seizing market leadership                  6 - developing a new product line                  7 - extending an existing product line                  8 - exploiting new technology                  9 - Other (please state).....</p>	<p>S – 3x5, 3x6, 2x7                  ESS – 5x5, 4x6, 2x7, 1x8                  F – 2x5, 4x6, 2x8, 1x9</p>	<table border="1"> <caption>Data for Question 54 Bar Chart</caption> <thead> <tr> <th>Motivation</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>0</td> <td>0</td> </tr> <tr> <td>3</td> <td>0</td> <td>0</td> </tr> <tr> <td>4</td> <td>0</td> <td>0</td> </tr> <tr> <td>5</td> <td>4.5</td> <td>1.5</td> </tr> <tr> <td>6</td> <td>3.5</td> <td>3.5</td> </tr> <tr> <td>7</td> <td>1.5</td> <td>0.5</td> </tr> <tr> <td>8</td> <td>0.5</td> <td>1.5</td> </tr> <tr> <td>9</td> <td>0</td> <td>0.5</td> </tr> </tbody> </table>	Motivation	Successful	Unsuccessful	1	0	0	2	0	0	3	0	0	4	0	0	5	4.5	1.5	6	3.5	3.5	7	1.5	0.5	8	0.5	1.5	9	0	0.5	<p><b>Weak Support - 5 of 12 successful innovators responded '5' but only 2 of 8 unsuccessful innovators; 2 of 12 successful innovators responded '7' but none of the unsuccessful ones did.</b></p>
Motivation	Successful	Unsuccessful																																	
1	0	0																																	
2	0	0																																	
3	0	0																																	
4	0	0																																	
5	4.5	1.5																																	
6	3.5	3.5																																	
7	1.5	0.5																																	
8	0.5	1.5																																	
9	0	0.5																																	
<p>55.</p>	<p>Was the initial market opportunity a single sale, or was there potential for subsequent sales of the same or similar products to the same or other customers?</p>	<p>1 – single opportunity                  2 – potential for repeat sales to same or other customer                  3 – potential for follow-on sales to other customers</p>	<p>S - 8x2                  ESS – 12x2                  F - 1x1, 4x2, 3x3</p>	<table border="1"> <caption>Data for Question 55 Bar Chart</caption> <thead> <tr> <th>Market Opportunity Level</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>1.5</td> </tr> <tr> <td>2</td> <td>12</td> <td>4</td> </tr> <tr> <td>3</td> <td>0</td> <td>2</td> </tr> </tbody> </table>	Market Opportunity Level	Successful	Unsuccessful	1	0	1.5	2	12	4	3	0	2	<p><b>Strong Support - successful innovators unanimous in selecting 2, while 3 of 8 unsuccessful innovators selected 3</b></p>																		
Market Opportunity Level	Successful	Unsuccessful																																	
1	0	1.5																																	
2	12	4																																	
3	0	2																																	

56.	Did you develop the product from the outset with export needs in mind?	1 – Yes 2 - No	S - 4x1, 4x2 ESS - 6x1, 6x2  F - 5x1, 3x2		<b>Not Supported – export orientation not a determinant of success</b>
57.	If there were no potential for export or follow-on sales would you have continued development of the product/system?	1 – Yes 2 - No	S - 7x1, 1x2 ESS – 9x1, 3x2  F - 4x1 4x2		<b>Strong Support – 9 of 12 successful innovators justified the project on the most conservative domestic market projections while half of unsuccessful innovators did not – reflects differences in customer focus and stimulation to innovate</b>
58.	Was the market growing, mature/static or declining?	1 - emerging market, growing demand 2 – mature market, steady demand 3 – declining market, falling demand as customers anticipate emerging technologies or threats	S - 7x1, 1x2 ESS – 10x1, 2x2 F - 7x1, 1x2		<b>Not Supported - Innovators almost always target emerging markets</b>
59.	Did Defence help you to access potential export customers for this product/system?	Very Helpful (circle one) Not Helpful At All 5 4 3 2 1 0	S – average 2.25 2x5, 3x2, 2x1, 1x0 ESS – average 1.75 2x5, 1x3, 3x2, 2x1, 4x0 F – average 1.00 1x3, 1x2, 3x1, 3x0,		<b>Weak Support – Unsuccessful innovators cluster on '0' and '1', successful innovators are spread from '2' to '5'. However, Defence generally regarded as unhelpful</b>
60.	How would you rate the intensity of competition in the domestic market?	Very Intense (circle one) No Competition 5 4 3 2 1 0	S – average 3.0 2x5, 2x4, 1x3, 1x2, 1x1, 1x0 ESS - average 2.75 2x5, 4x4, 1x3, 1x2, 2x1, 2x0 F – average 2.5		<b>Not Supported – half of all innovators believed they faced very intense competition in the domestic market.</b>

Product innovation success in the Australian defence industry – an exploratory study

			2x5, 2x4, 2x1, 2x0																				
61.	How would you rate the intensity of competition in this sector in the export market?	Very Intense (circle one) No Competition 5 4 3 2 1 0	S – average 4.25 4x5, 3x4, 1x2 ESS – average 4.0 6x5, 4x4, 1x2, 1x0 F – average 3.88 4x5, 1x4, 1x3, 2x2		<b>Not Supported - competition is significantly more intense in export markets than domestic ones.</b>																		
62.	Did your primary customer encourage competitors to enter this market?	1 – Yes 2 - No	S – 5x1, 3x2 ESS - 8x1, 4x2  F - 5x1, 3x2		<b>Not Supported - Defence encourages competitors to enter the market to provide choice as well as price leverage</b>																		
63.	How did you respond to competitive pressure on your project?	1 – focussed on the price/value for money of the product 2 – focussed on rapid delivery 3 – focussed on ensuring we understood customer needs properly 4 – no competition – focussed on customer’s stated needs 5 - Other (please state).....	S – 2x1, 0x2, 4x3, 1x4, 1x5 ESS – 3x1, 1x2, 5x3, 2x4, 1x5  F – 3x1, 0x2, 1x3, 2x4, 2x5	<table border="1"> <caption>Data for Bar Chart: Response to Competitive Pressure</caption> <thead> <tr> <th>Response Category</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>3</td> <td>3</td> </tr> <tr> <td>2</td> <td>1</td> <td>0</td> </tr> <tr> <td>3</td> <td>5</td> <td>1</td> </tr> <tr> <td>4</td> <td>2</td> <td>2</td> </tr> <tr> <td>5</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	Response Category	Successful	Unsuccessful	1	3	3	2	1	0	3	5	1	4	2	2	5	1	2	<b>Strong Support – 5 of 12 successful innovators responded ‘3’ but only 1 of 8 unsuccessful innovators.</b>
Response Category	Successful	Unsuccessful																					
1	3	3																					
2	1	0																					
3	5	1																					
4	2	2																					
5	1	2																					
64.	Was there an urgent customer requirement for this product?	1 – Yes 2 - No	S - 3x1, 5x2 ESS – 6x1, 6x2  F - 4x1, 4x2		<b>Not Supported - urgency of demand is not a factor discriminating between success and failure</b>																		

Product innovation success in the Australian defence industry – an exploratory study

65.	Was urgency a factor in determining the acquisition process?	1 – Yes 2 - No	S - 2x1, 6x2 ESS – 5x1, 7x2  F - 1x1, 7x2	 <table border="1"> <caption>Data for Question 65 Bar Chart</caption> <thead> <tr> <th>Response</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>5</td> <td>1</td> </tr> <tr> <td>2</td> <td>7</td> <td>7</td> </tr> </tbody> </table>	Response	Successful	Unsuccessful	1	5	1	2	7	7	<b>Strong Support - 5 of 12 successful innovators responded '1', but only 1 of 8 unsuccessful innovators responded the same way.</b>
Response	Successful	Unsuccessful												
1	5	1												
2	7	7												
66.	Did project timescale:	1 – allow time for an all-new or incremental product development program 2 – demand a MOTS/COTS solution	S - 8x1 ESS - 11x1, 1x2 F - 8x1		<b>No Practical Difference</b>									
67.	Was being first, or early, to market a factor in the commercial success of this product?	1 – Yes 2 – No	S - 7x1 1x2 ESS – 11x1, 1x2  F - 4x1 4x2	 <table border="1"> <caption>Data for Question 67 Bar Chart</caption> <thead> <tr> <th>Response</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>11</td> <td>6</td> </tr> <tr> <td>2</td> <td>1</td> <td>4</td> </tr> </tbody> </table>	Response	Successful	Unsuccessful	1	11	6	2	1	4	<b>Strong Support – 11 of 12 successful innovators responded '1' and only 4 of 8 unsuccessful innovators. Cause or effect?</b>
Response	Successful	Unsuccessful												
1	11	6												
2	1	4												

Product innovation success in the Australian defence industry – an exploratory study

68.	If so, why?	1 – single market and single opportunity 2 – leverage for follow-on sales 3 – establishing/consolidating strong competitive position 4 – Other – please specify.....	S – 2x1, 1x2, 3x3,1x4 ESS – 2x1, 4x2, 4x3, 1x4  F - 0x1, 1x2, 2x3,1x4	<table border="1"> <caption>Data for Question 68 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2</td> <td>0</td> </tr> <tr> <td>2</td> <td>4</td> <td>1</td> </tr> <tr> <td>3</td> <td>4</td> <td>2</td> </tr> <tr> <td>4</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	Rating	Successful	Unsuccessful	1	2	0	2	4	1	3	4	2	4	1	1	<p><b>Strong Support - of companies responding '1' above, 4 of 12 successful innovators selected '2', but only 1 of 8 unsuccessful innovators did.</b></p>
Rating	Successful	Unsuccessful																		
1	2	0																		
2	4	1																		
3	4	2																		
4	1	1																		
69.	Did you achieve the first sale as quickly as you had planned?	1 – slower than anticipated 2 – on anticipated schedule 3 – faster than expected	S - 3x1, 4x2, 1x3 ESS – 5x1, 6x2, 1x3  F - 4x1, 2x2, 1x3	<table border="1"> <caption>Data for Question 69 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>5</td> <td>4</td> </tr> <tr> <td>2</td> <td>6</td> <td>2</td> </tr> <tr> <td>3</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	Rating	Successful	Unsuccessful	1	5	4	2	6	2	3	1	1	<p><b>Strong Support - 6 of 11 successful innovators responded '2' but only 2 of 7 unsuccessful innovators. One unsuccessful innovation didn't reach the market at all so no score was recorded.</b></p>			
Rating	Successful	Unsuccessful																		
1	5	4																		
2	6	2																		
3	1	1																		
70.	Were you first, or early, to market?	1 – no competition 2 – first to market, benefited from beating competition 3 - early enough to benefit 4 – late to market, weaker competitive position as a result	S - 1x1, 4x2, 2x3 ESS – 2x1, 7x2, 3x3  F - 3x1 3x3 1x4	<table border="1"> <caption>Data for Question 70 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>2</td> <td>7</td> <td>0</td> </tr> <tr> <td>3</td> <td>3</td> <td>3</td> </tr> <tr> <td>4</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Rating	Successful	Unsuccessful	1	2	3	2	7	0	3	3	3	4	0	1	<p><b>Strong Support – 7 of 12 successful innovators selected '2' but none of the unsuccessful ones did. No unsuccessful innovator was first to market</b></p>
Rating	Successful	Unsuccessful																		
1	2	3																		
2	7	0																		
3	3	3																		
4	0	1																		

Product innovation success in the Australian defence industry – an exploratory study

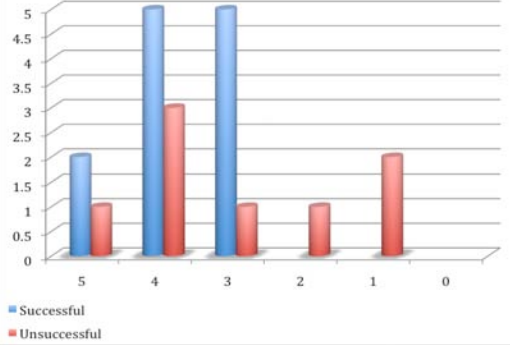
71.	Did competitive pressure affect your schedule?	1 – yes – we focussed strongly on schedule 2 – moderately – schedule wasn't the principal determinant of competitiveness 3 – no competition – customer's schedule requirements were key driver	S - 1x1, 3x2, 4x3 ESS – 2x1, 6x2, 4x3  F - 2x1, 4x2, 2x3		<b>Not Supported – but Extended Study highlights the fact schedule wasn't the sole determinant of competitiveness in the customer's view</b>															
72.	If your customer was Defence, did its acquisition process and schedule take into account potential market benefits for an Australian manufacturer if its product was selected in a timely fashion?	1 – yes – Defence tried to help 2 – no – Defence was indifferent to effects of its decisions on our other market prospects	S - 4x1, 3x2 ESS – 4x1,6x2  F - 1x1, 6x2		<b>Weak Support – unsuccessful innovators cluster on '2', while nearly half of successful innovators responded '1'.</b>  <b>NB - three companies, one unsuccessful, did not target Defence as a customer</b>															
73.	Was availability of Defence T&E assets, or the speed of their testing/certification processes, a factor in the project schedule?	1 – yes – process was slower than anticipated 2 – no – schedule allowed for this 3 – no - finished ahead of schedule 4 – not applicable in this project	S - 7x2 1x4 ESS – 1x1, 9x2, 2x4  F - 1x1 3x2 4x4	<table border="1"> <caption>Data for Bar Chart: Successful vs Unsuccessful Innovators by Response</caption> <thead> <tr> <th>Response</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> <tr> <td>2</td> <td>9</td> <td>3</td> </tr> <tr> <td>3</td> <td>2</td> <td>0</td> </tr> <tr> <td>4</td> <td>0</td> <td>4</td> </tr> </tbody> </table>	Response	Successful	Unsuccessful	1	1	1	2	9	3	3	2	0	4	0	4	<b>Strong Support – 9 of 12 successful innovators responded '2', but only 3 of 8 unsuccessful innovators did.</b>
Response	Successful	Unsuccessful																		
1	1	1																		
2	9	3																		
3	2	0																		
4	0	4																		

Product innovation success in the Australian defence industry – an exploratory study

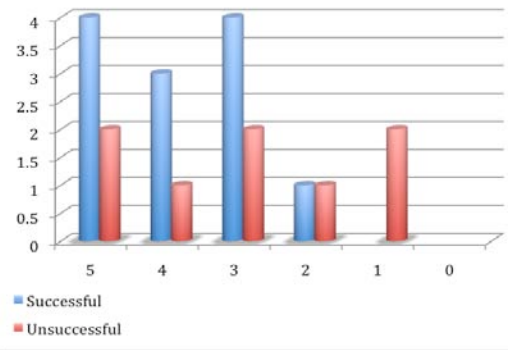
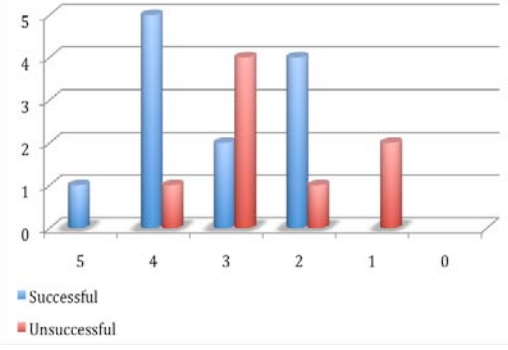
74.	How important was schedule to your project costs?	<p>Critical (circle one)      Unimportant</p> <p>5    4    3    2    1    0</p>	<p>S – average 3.75 1x5, 4x4, 3x3 ESS – average 3.92 3x5, 5x4, 4x3 F – average 3.25 1x5, 4x4, 1x3, 2x1</p>	<table border="1"> <caption>Bar Chart Data</caption> <thead> <tr> <th>Score</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>3</td> <td>1</td> </tr> <tr> <td>4</td> <td>5</td> <td>4</td> </tr> <tr> <td>3</td> <td>4</td> <td>1</td> </tr> <tr> <td>2</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>2</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Score	Successful	Unsuccessful	5	3	1	4	5	4	3	4	1	2	0	0	1	0	2	0	0	0	<p><b>Weak Support. Higher proportion of successful innovators responded '3' and all successful scores were 3 or above.</b></p>
Score	Successful	Unsuccessful																								
5	3	1																								
4	5	4																								
3	4	1																								
2	0	0																								
1	0	2																								
0	0	0																								
75.	Had the customer ever previously acquired such a product/system?	<p>1 – Yes 2 - No</p>	<p>S - 5x1, 3x2 ESS – 7x1, 5x2  F - 3x1, 5x2</p>		<p><b>Not Supported – in roughly half of all cases the customer had previously acquired a similar product/system</b></p>																					
76.	Had DSTO or another Australian defence agency previously done any R&D/S&T work in relation to this capability?	<p>1 – Yes 2 - No</p>	<p>S - 5x1, 3x2 ESS – 8x1, 4x2  F - 6x1, 2x2</p>		<p><b>Not Supported – Previous DSTO R&amp;D is not an indicator of success or failure.</b></p>																					
77.	Did the customer do any modelling or experimentation to verify and refine his needs?	<p>Extensive Investigation (circle one)      None At All</p> <p>5    4    3    2    1    0</p>	<p>S – average 3.5 2x5, 2x4, 2x3, 2x4 ESS – average 3.00 3x5, 2x4, 3x3, 2x2, 2x0 F – average 3.13 1x5, 3x4, 2x3, 1x2, 1x0</p>		<p><b>Not Supported - The amount of modelling and experimentation carried out by the customer doesn't seem to be an indicator of project success or failure.</b></p>																					



Product innovation success in the Australian defence industry – an exploratory study

78.	In your opinion, did your primary customer understand his real operational needs?	Deep Understanding (circle one) or None 5    4    3    2    1    0	S – average 3.88 2x5, 4x4, 1x3, 1x2 ESS – average 3.75 3x5, 6x4, 2x3, 1x2 F – average 3.25 2x5, 3x4, 1x2, 2x1		<b>Weak Support – 3 of 8 unsuccessful innovators responded &lt;3 compared with just 1 of 12 successful innovators, suggesting customer ignorance of his own needs more likely to be a feature of unsuccessful projects.</b>																					
79.	In your opinion, to what extent did the customer seek to innovate in his processes and practices in order to meet the challenges he faced?	Very Innovative (circle one) or Very Conservative 5    4    3    2    1    0	S – average 4.00 2x5, 4x4, 2x3 ESS – average 3.75 2x5, 5x4, 5x3 F – average 3.00 1x5, 3x4, 1x3, 1x2, 2x1	 <table border="1"> <caption>Bar Chart Data</caption> <thead> <tr> <th>Response Category</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>2</td> <td>1</td> </tr> <tr> <td>4</td> <td>5</td> <td>3</td> </tr> <tr> <td>3</td> <td>5</td> <td>1</td> </tr> <tr> <td>2</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>2</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Successful	Unsuccessful	5	2	1	4	5	3	3	5	1	2	0	1	1	0	2	0	0	0	<b>Strong Support – all successful innovators responded '3' or higher, seven of them responding '4' or '5', while 3 of 8 unsuccessful innovators scored less than '3'.</b>
Response Category	Successful	Unsuccessful																								
5	2	1																								
4	5	3																								
3	5	1																								
2	0	1																								
1	0	2																								
0	0	0																								
80.	In your opinion, did your primary customer understand the technical aspects of this project?	Deep Understanding (circle one) or None 5    4    3    2    1    0	S – average 3.88 2x5, 3x4, 3x3 ESS – average 3.83 2x5, 6x4, 4x3 F – average 3.38 2x5, 3x4, 1x3, 3x2		<b>Weak Support - similar averages conceal the fact that customer ignorance of technical aspects is more likely to be a feature of unsuccessful projects – 3 of 8 unsuccessful innovators responded '2' but no successful innovators did so.</b>																					

Product innovation success in the Australian defence industry – an exploratory study

<p>81.</p>	<p>In your opinion, to what extent did the customer seek innovative technical solutions to the challenges he faced?</p>	<p>Actively sought innovation (circle one) Didn't seek innovation</p> <p>5    4    3    2    1    0</p>	<p>S – average 3.63 2x5, 2x4, 3x3, 1x2 ESS – average 3.83 4x5, 3x4, 4x3, 1x2 F – average 3.00 2x5, 1x4, 2x3, 1x2, 2x1</p>	 <table border="1"> <caption>Data for Question 81 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>4</td> <td>2</td> </tr> <tr> <td>4</td> <td>3</td> <td>1</td> </tr> <tr> <td>3</td> <td>4</td> <td>2</td> </tr> <tr> <td>2</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>2</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Rating	Successful	Unsuccessful	5	4	2	4	3	1	3	4	2	2	1	1	1	0	2	0	0	0	<p><b>Strong Support - 7 of 12 successful innovators responded '4' or '5', only three of 8 unsuccessful innovators did the same; 2 of 8 unsuccessful innovators selected '1', no successful innovator did. Success associated with the customer's search for innovative technical solutions.</b></p>
Rating	Successful	Unsuccessful																								
5	4	2																								
4	3	1																								
3	4	2																								
2	1	1																								
1	0	2																								
0	0	0																								
<p>82.</p>	<p>What level of technical, schedule or cost risk was the customer willing to bear?</p>	<p>Very Risk Tolerant (circle one)    Very Risk-Averse</p> <p>5    4    3    2    1    0</p>	<p>S – average 3.50 5x4, 2x3, 1x2 ESS – average 3.25 1x5, 5x4, 2x3, 4x2 F – average 2.50 1x4, 4x3, 1x2, 2x1</p>	 <table border="1"> <caption>Data for Question 82 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>1</td> <td>0</td> </tr> <tr> <td>4</td> <td>5</td> <td>1</td> </tr> <tr> <td>3</td> <td>2</td> <td>4</td> </tr> <tr> <td>2</td> <td>4</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>2</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Rating	Successful	Unsuccessful	5	1	0	4	5	1	3	2	4	2	4	1	1	0	2	0	0	0	<p><b>Strong Support – only 1 of 8 unsuccessful innovators responded '4', but 6 of 12 successful innovators responded '4' or '5'. Suggests the greater the customer's risk tolerance, the greater the chances of innovation success.</b></p>
Rating	Successful	Unsuccessful																								
5	1	0																								
4	5	1																								
3	2	4																								
2	4	1																								
1	0	2																								
0	0	0																								

Product innovation success in the Australian defence industry – an exploratory study

83.	In your opinion, how much difference did the customer's professional or technical understanding make to his level of risk tolerance?	<p>Significant Difference (circle one) No Difference</p> <p>5    4    3    2    1    0</p>	<p>S – average 4.00 2x5, 5x4, 1x2 ESS – average 4.00 3x5, 7x4, 1x3, 1x2 F – average 3.13 4x4, 2x3, 1x2, 1x1</p>		<p><b>Strong Support – 10 of 12 successful innovators responded '4' or '5', while only 4 of 8 unsuccessful innovators responded '4' – the rest were '3' or below.</b></p>
84.	Aside from the customer's acquisition project manager, was the presence or otherwise of a project 'champion' or 'sponsor' representing the user a factor in project success?	<p>Very Important (circle one) Made no Difference</p> <p>5    4    3    2    1    0</p>	<p>S – average 4.25 2x5, 6x4 ESS – average 4.42 5x5, 7x4 F – average 4.50 4x5, 4x4</p>		<p><b>Not Supported – no innovator responded with a value below '4'. Responses either praised the contribution of a 'champion', or lamented the lack of one.</b></p>
85.	What acquisition method did the customer use?	<p>1 – competitive tender 2 – sole-source acquisition after market survey/ITR/RFP 3 – collaborative development program with the contractor and other, eg DSTO</p>	<p>S - 3x1, 3x2, 2x3 ESS – 5x1, 4x2, 3x3 F - 1x0, 2x1, 2x2, 3x3</p>		<p><b>Not Supported - no insights from this result. The unsuccessful innovator recording a '0' didn't make a sale at all</b></p>
86.	In your opinion, to what extent did the customer's capability development and acquisition	<p>Strongly Affected (circle one) Didn't Take Into Account</p> <p>5    4    3    2    1    0</p>	<p>S – average 3.50 1x5, 3x4, 3x3, 1x2 ESS – average 3.42 1x5, 5x4, 4x3, 2x2 F – average 3.14 1x5, 3x4, 2x2, 1x1</p>		<p><b>Not Supported – one unsuccessful project wasn't counted because it was developed without a launch customer and never made a sale so</b></p>

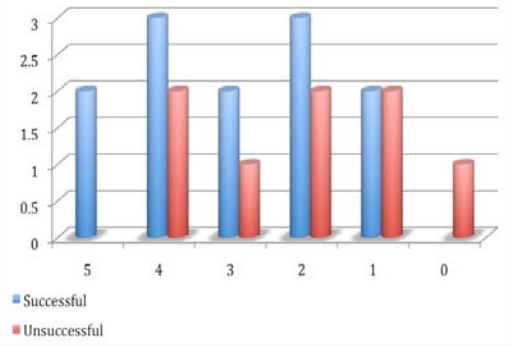
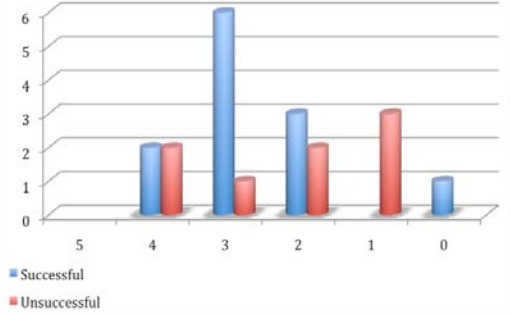
Product innovation success in the Australian defence industry – an exploratory study

	processes take into account the risk factors in this project?				no values were recorded																					
87.	In your opinion, to what extent did the customer's acquisition strategy encourage or discourage innovation by manufacturers?	Strongly Encouraged (circle one) Strongly Discouraged  5    4    3    2    1	S – average 3.50 6x4, 2x2 ESS – average 3.50 1x5, 7x4, 1x3, 3x2 F – average 3.14 1x5, 3x4, 2x2, 1x1	<table border="1"> <caption>Data for Question 87 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>2</td> <td>3</td> <td>2</td> </tr> <tr> <td>3</td> <td>1</td> <td>0</td> </tr> <tr> <td>4</td> <td>7</td> <td>3</td> </tr> <tr> <td>5</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	Rating	Successful	Unsuccessful	1	0	1	2	3	2	3	1	0	4	7	3	5	1	1	Strong Support - 8 of 12 successful innovators responded '4' or '5' while only 4 of 8 unsuccessful innovators responded the same way. One unsuccessful project wasn't counted because it was developed without a launch customer and never made a sale so no values were recorded			
Rating	Successful	Unsuccessful																								
1	0	1																								
2	3	2																								
3	1	0																								
4	7	3																								
5	1	1																								
88.	In your opinion, how faithfully did the customer's acquisition process reflect user needs?	Very Faithfully (circle one)    Very Poorly  5    4    3    2    1.....0	S – average 3.88 3x5, 2x4, 2x3, 1x2 ESS – average 3.83 3x5, 5x4, 3x3, 1x2 F – average 2.50 1x5, 3x4, 3x1, 1x0	<table border="1"> <caption>Data for Question 88 Bar Chart</caption> <thead> <tr> <th>Rating</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>3</td> <td>1</td> </tr> <tr> <td>4</td> <td>5</td> <td>3</td> </tr> <tr> <td>3</td> <td>3</td> <td>0</td> </tr> <tr> <td>2</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>3</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Rating	Successful	Unsuccessful	5	3	1	4	5	3	3	3	0	2	1	0	1	0	3	0	0	1	Strong Support – 8 of 12 successful innovators responded '4' or '5'; 4 of 8 unsuccessful innovators responded '1' or '0'
Rating	Successful	Unsuccessful																								
5	3	1																								
4	5	3																								
3	3	0																								
2	1	0																								
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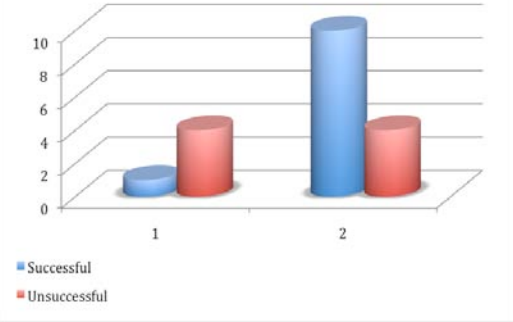
Product innovation success in the Australian defence industry – an exploratory study

<p>89.</p>	<p>In your opinion, how strong was the link between the customer's specification and relevant high-level strategic guidance?</p>	<p>Very Strong Link (circle one) Tenuous Link</p> <p>5 4 3 2 1.....0</p>	<p>S – average 3.75 1x5, 5x4, 1x3, 1x2 ESS – average 3.67 1x5, 8x4, 1x3, 2x2 F – average 2.71 4x4, 1x2, 1x1, 1x0</p>		<p><b>Strong Support – 9 of 12 successful innovators responded '4' or '5' but only 4 of 8 unsuccessful innovators responded the same way; the remainder responded '2' or less. One unsuccessful project wasn't counted because it was developed without a launch customer and never made a sale so no values were recorded</b></p>
<p>90.</p>	<p>Did the user requirements change significantly during the development and acquisition process?</p>	<p>Significant Change (circle one) No Change</p> <p>5 4 3 2 1 0</p>	<p>S – average 2.38 2x4, 2x3, 1x2, 3x1 ESS – average 2.08 3x4, 2x3, 1x2, 5x1, 1x0 F – average 2.00 2x5, 1x4, 2x1, 3x0</p>		<p><b>Not Supported</b></p>
<p>91.</p>	<p>Did the customer stick to his own schedule for critical processes and decisions?</p>	<p>Severe delays (circle one) No Delays</p> <p>5 4 3 2 1 0</p>	<p>S – average 1.25 1x4, 6x1, 1x0 ESS – average 1.58 1x5, 1x4, 1x3, 7x1, 2x0 F – average 2.14 2x4, 1x3, 1x2, 2x1, 1x0</p>		<p><b>Strong Support – 9 of 12 successful innovators responded '1' or '0' while only 3 responded '3' or above; 3 of seven unsuccessful innovators responded '3' or above. One unsuccessful project wasn't counted because it was developed without a launch customer and never made a sale so no values were recorded</b></p>

Product innovation success in the Australian defence industry – an exploratory study

<p>92.</p>	<p>What was the customer's operational tempo when the product opportunity emerged?</p>	<p>Very High (circle one) Very Low</p> <p>5 4 3 2 1 0</p>	<p>S – average 2.88 2x5, 1x4, 1x3, 2x2, 2x1 ESS – average 3.00 2x5, 3x4, 2x3, 3x2, 2x1 F - average 2.13 2x4, 1x3, 2x2, 2x1, 1x0</p>		<p><b>Strong Support – Extended Sample shows measurable difference: 5 of 12 successful innovators responded '5' or '4'. Only 2 of 8 unsuccessful innovators responded '4' the remainder were '3' or below</b></p>
<p>93.</p>	<p>How rapidly was the threat/competitive environment changing when the product opportunity emerged?</p>	<p>Very Rapidly (circle one) Not At All</p> <p>5 4 3 2 1 0</p>	<p>S – average 3.00 2x4, 4x3, 2x2 ESS – average 2.67 2x4, 6x3, 3x2, 1x0 F - average 2.25 2x4, 1x3, 2x2, 3x1</p>		<p><b>Strong Support – 8 of 12 successful innovators responded '3' or above while only 3 of 8 unsuccessful innovators responded the same way.</b></p>
<p>94.</p>	<p>What was the rate of development of the technology underpinning this product?</p>	<p>Very Rapid Development (circle one) Low Rate</p> <p>5 4 3 2 1</p>	<p>S - average 3.75 1x5, 4x4, 3x3 ESS – average 3.75 1x5, 7x4, 4x3 F – average 3.75 1x5, 4x4, 3x3</p>		<p><b>Not Supported – rate of technology development uniformly high across all projects</b></p>

Product innovation success in the Australian defence industry – an exploratory study

95.	When you began this project did you have a formal teaming or collaboration agreement with an industry partner?	1 – Yes 2 - No	S - 2x1, 6x2 ESS – 2x1, 10x2  F - 4x1, 4x2	 <table border="1"> <caption>Data for Bar Chart: Formal Teaming or Collaboration Agreement</caption> <thead> <tr> <th>Response</th> <th>Successful</th> <th>Unsuccessful</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2</td> <td>5</td> </tr> <tr> <td>2</td> <td>10</td> <td>5</td> </tr> </tbody> </table>	Response	Successful	Unsuccessful	1	2	5	2	10	5	<b>Strong Support - 10 of 12 successful innovators responded '2', but only 4 of 8 unsuccessful innovators responded the same way.</b>
Response	Successful	Unsuccessful												
1	2	5												
2	10	5												
96.	When you began this project did you have a formal teaming or collaboration agreement with DSTO?	1 – Yes 2 - No	S - 5x1, 3x2 ESS - 5x1, 7x2  F - 3x1, 5x2		<b>Not Supported - responses from both successful and unsuccessful innovators split roughly 50:50.</b>									
97.	Were there any significant factors affecting communications with defence R&D agencies such as DSTO?	97.1 – no – communication was rapid and effective 97.2 – cultural differences 97.3 – physical proximities 97.4 – security 97.5 - Other (please state).....	97.1 – 6xESS, 6xF 97.2 – 2xESS 97.3 – 1xESS 97.4 – 97.5 – 1xF		<b>Not Supported - 4 innovators, 3 successful, had no contact with defence R&amp;D agencies so did not respond</b>									
98.	Were there any significant factors affecting communications with the customer?	98.1 – no – communication was rapid and effective 98.2 – cultural differences 98.3 – physical proximities 98.4 – security 98.5 - Other (please state).....	98.1 – 8xESS, 5xF 98.2 – 2xF 98.3 – 3xESS 98.4 – 98.5 – 1xESS, 2xF		<b>Not Supported</b>									
99.	Did your company and its partner use a cross-functional project team, or were the	1 – functions and personnel separated 2 – cross-functional teams	S - 8x2 ESS – 1x1, 11x2 F - 8x2		<b>Not Supported – both tried to follow 'best practice'</b>									

Product innovation success in the Australian defence industry – an exploratory study

	specialist functions (engineering, production, marketing, R&D, etc) separated?				
100.	Were your internal or external communication channels constrained at all by the imposition of US ITAR requirements?	1 –ITARs was not a factor in this project 2 – ITARs had a minor effect 3 – ITARs had a disruptive effect on organisation and internal and external communications	S - 6x1, 1x2, 1x3 ESS – 10x1, 1x2, 1x3 F - 6x1, 1x2 ,1x3		<b>Not Supported – ITAR was not a factor in most projects in this regard</b>
101.	How, if at all, did ITAR and/or export license restrictions affect export market access?	1 – certain markets closed 2 - certain features deleted/modified for non-Australian customer 3 – little or no effect on our project 4 - did not apply to our project	S – 6x1, 1x2, 1x3,1x4 ESS – 7x1, 1x2, 1x3, 4x4 F – 4x1, 1x2, 1x3, 2x4		<b>Weak Support - all were affected the same way by ITAR, though the Extended Sample showed higher likelihood of success if project is structured so that ITAR doesn't apply.</b>
102.	Did security requirements affect key appointments or recruitment of team members?	1 – no unexpected effects 2 – minor unexpected delays in security clearance 3 – significant delays in obtaining security clearances 4 - did not apply to our project	S - 5x1, 2x2, 1x3 ESS – 6x1, 2x2, 2x3, 2x4 F - 4x1, 0x2, 2x3, 2x4		<b>Not Supported</b>
103.	Did ITAR constraints shape the composition of the project team in any	1 – no effect 2 – certain appointments/recruits veto-ed due to ITAR regulations 3 – ITAR compliance resulted in significant disruption to our organisation 4 - did not apply to our project	S – 2x1, 1x2, 1x3, 4x4 ESS – 2x1, 2x2, 1x3, 7x4 F – 2x1, 1x2, 0x3, 3x4		<b>Not Supported</b>



Product innovation success in the Australian defence industry – an exploratory study

	significant way?				
104.	Did ITAR constraints affect the project budget and/or schedule in any significant way?	<p>1 – no effect</p> <p>2 – ITARs compliance added to costs</p> <p>3 – ITARs compliance resulted in schedule delays</p> <p>4 - did not apply to our project</p>	<p>S – 3x1, 0x2, 1x3, 3x4</p> <p>ESS – 3x1, 0x2, 1x3, 7x4</p> <p>F – 3x1,0x2, 0x3, 4x4</p>		<b>Not Supported</b>

### 4.3 Analysis – Testing the Hypothesis

The case studies were designed to test the hypothesis that certain factors, described for convenience's sake as 'Independent Variables', make a direct contribution to defence product innovation success. They also sought to measure, if possible, the importance (or otherwise) of that contribution. The case study questionnaire was designed to generate both raw, quantitative data and explanatory comment which would enable a qualitative analysis of the results that is more in keeping with the exploratory nature of this research.

The Case Study Questionnaire was in two parts. The Case Study Introduction was designed to elicit basic information about the respondents and their businesses. Much of this data, as it relates to employee numbers, turnover and R&D expenditure, is discussed below; R&D is addressed in more detail later in this chapter and in Appendix 1. Question A sought to position the respondents within one or more technical domains: Platform/equipment design, manufacturing & upgrading; Software; Systems integration; Platform/equipment maintenance and support; Garrison support and 'hotel'-type services; and 'Others'.

**Table 4.3: Australia's Defence Industry – a snapshot**

Respondent	Platform/ Equipment design	Software	Systems Integration	Platform/ Equipment Sustainment	Garrison Support & 'Hotel' services	Others
1	49	4	3	38	1	4
2	49	4	3	38	1	4
3			50	50		
4			50	50		
5	10	60	10	20		
6	20	30	30	20		
7	49	4	3	38	1	4
8	80	10	10			
9	35	5	65			
10		33	33	34		
11	100					
12	90	0	5	5		
13		80	20			
14		66	34			
15	49	4	3	38	1	4
16	50		30	20		
17	100					
18	100					
19	50			50		
20	100					

#### 4.4 Success Factors – Qualitative Analysis

For the major part of the Case Study, the survey results are discussed below in more detail for each Independent Variable in turn. It must be understood that the Case Studies are designed to identify and measure differences between the successful and unsuccessful innovation projects. These differences, and the factors contributing to them, are teased out and discussed in an Interpretivist, Qualitative analysis of the explanatory comment provided by the interviewees. The effects of the Independent Variables upon the Dependent Variable are evident in the differences between successful and unsuccessful innovations, stated as a measure of that difference: 'Strong', 'Measurable', 'Weak', or 'None'. The small sample size doesn't permit a more refined scale of impacts on the Dependent Variable.

##### Variable 1 - Marketing Proficiency

This is a measure of the innovating firm's proficiency and performance in market research, understanding user needs, price and risk sensitivity, customer testing and promotion. This factor was addressed specifically in questions F, G, H and 1 to 11, of which all except F, G, 4 and 10 strongly supported the hypothesis that the it discriminated between success and failure.

Responses to all but four of these questions showed measurable differences between successful and unsuccessful innovation projects and demonstrated that Marketing Proficiency was a key contributor to innovation outcomes because it fundamentally shapes the innovation process to reflect the needs of the user. **Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to the innovator's Marketing Proficiency.**

The majority of defence innovation projects considered were in the electronic systems field, which includes weapons and sensors; the primary customer in the majority of cases (both successful and not) was the Australian Defence Force (ADF); and the majority of respondents attempted to promote and market their products and more general credentials to the customer.

However, measurable differences emerged in a number of areas: successful innovators put noticeably more effort into shaping the customer's view of his own needs (Q.5). All innovators try to gather market intelligence and network with

peers, partners and customers to seek out opportunities (Q.1), but successful innovators were far more likely to become aware of an opportunity through a direct approach from the customer. Similarly, while most innovators were pro-active in engaging the customer to determine user needs (Q.2), successful innovators were more likely to be approached directly by the customer, or to have a close enough relationship with the customer that they could identify and qualify user needs easily and quickly, suggesting an association between Product Innovation Success and proficiency in networking and market intelligence as well as technical credibility in the customer's eyes.

The size of both innovator and customer was a factor also: The Defence Materiel Organisation (DMO) has stated explicitly that it prefers to deal with prime contractors to whom it devolves responsibility for the health of a supply chain composed mainly of SMEs. This is reflected in the fact that four of the unsuccessful innovations were by SMEs attempting to pursue a relatively large-scale major capital equipment program as a prime contractor (in one case an SME's project failed for commercial reasons not related specifically to the technology or customer; in another the original innovation was developed by an SME which is now part of a major prime contractor).

Without exception those SMEs who developed successful innovations targeted clearly identified niche opportunities or niche markets.

As for verifying and clarifying customer needs (Q.3), a higher proportion of unsuccessful innovators reported delays and difficulties because the customer didn't clearly understand his own needs. This is consistent with results from Q.4, where for successful innovations the functional or user specification was more likely to developed by the ADF, or by the innovator himself based on clearly understood and clearly stated customer performance requirements.

Five (of eight) unsuccessful innovations were not designed to meet specific user specifications – the specifications were more likely to be based on an internal market analysis process divorced Measurable from the user. Three unsuccessful innovations were based on detailed functional specifications drawn up by the customer; in one case these changed significantly, marginalising the product in question, while the other two failed for unrelated reasons.

As noted in Chapter 2, these findings bear out Rothwell:

“The innovation literature strongly underlines the fact that a significant percentage of unsuccessful innovations fail because the innovator has not succeeded in satisfactorily establishing an appropriate set of user specifications and in interpreting these in the design of his new equipment. In many industrial sectors, user-need specification and product development involve more than simply a passive role for the user, and innovatory success is associated with active user involvement in product specification, design and development. Users also have an important role to play in the process of re-innovation. Moreover, it is users who are themselves technically progressive and innovation-demanding who have the greatest potential in this respect.”  
(Rothwell 1986)

The importance of identifying user needs correctly was reflected in responses to Q.6, 7 and 8: not surprisingly, successful innovations were found to be noticeably more effective in their intended role; they were more likely to meet or exceed the user’s needs; and they tended to offer better value for money than other currently available solutions. Interestingly, none of the successful innovations scoring 5/5 in this question had any direct competitors in the marketplace; all of the successes scoring 4/5 did, however, have a direct competitor. Of the unsuccessful innovations, five faced direct competition. Given the downward pressure that competition can exert on product price, these results suggest that price per se isn’t the sole major determinant of Product Innovation Success in a developmental defence project.

And Q.11 highlighted the differences starkly: successful innovations met or exceeded predicted sales volume, while unsuccessful ones achieved zero or lower than predicted sales volume. Indeed, six out of eight unsuccessful innovation projects were terminated early.

An explanation for some of these differences may be found in the responses to Q.9: Does your company employ a dedicated marketing officer or team in the market sector(s) in which you operate? Some 66 per cent of successful innovators said ‘yes’, but only 50 per cent of unsuccessful innovators. Notwithstanding that many of the companies interviewed are SMEs employing in many cases less than 50 personnel, and therefore staff (especially senior leaders) have multiple responsibilities including marketing and communications, the responses to this question highlight the importance of a systematic approach to marketing.

Generally, the responses to these questions point to a number of interlocking success factors: a systematic approach to marketing and promotion, in order to build a strong relationship with the customer; early engagement with the customer to inform him of technical progress and if possible shape his views of his own needs; detailed knowledge of customer (and user) needs; ease of access to the customer to verify and clarify user needs. It wouldn't be over-stating the case to say that building the customer's sense of 'ownership' of the innovation appears to be an essential ingredient of success.

### **Variable 2 - R&D Proficiency**

This factor is a measure of the innovating firm's proficiency in R&D, including its technical skills, its R&D management skills and its level of investment in these activities. It is addressed through Questions B, D, F, and 11.5 to 20, inclusive, of which 11.5, 13, 14, 17, 19 and 20 supported the hypothesis that this Independent Variable concerned discriminated between success and failure – most prominently in Qs 11.5 and 20.

**Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to the innovator's R&D Proficiency.**

Where an unsuccessful innovator halted development of the product in question, there was no single dominant reason (Q.12). The two most numerous were 'Lack of customer interest', and 'Overtaken by technology developments'. That first reason indicates a weak understanding of customer needs or poor customer engagement, while the second suggests one of two things which will be addressed later on: either a slow development process which allowed rivals to catch up or new technologies to emerge; or lack of wider market knowledge, and especially of the activities of rivals. However, in one case the customer changed his specification and the company decided it wasn't worth continuing development to meet the changed requirement; in another case internal commercial issues with an overseas parent company resulted in the project shutting down.

Questions 13 to 16 address the stimulus to innovate, and the resources devoted to the innovation process. Successful and unsuccessful innovators differed markedly in their primary reasons for investing in R&D: over 80 per cent of successful innovators do so principally to develop new products or IP; the remainder do so in more general pursuit of technical knowledge, without a specific product

opportunity in mind. Over 60 per cent of unsuccessful innovators said their R&D is focussed primarily on developing general technical knowledge, with the remaining minority seeking to develop new products or IP, as shown in Q.13.

This is reflected in the more methodical approach to R&D taken by successful innovators compared with unsuccessful ones: responses to Q.14 showed half of all successful innovators had a dedicated R&D department of some kind; 75 per cent of unsuccessful innovators did not. That said, the majority of SMEs lack the resources to fund and staff a dedicated R&D department; a common response from both successful and unsuccessful innovators was that the entire company functions as an R&D organisation to a greater or lesser extent, and that skills, knowledge and facilities are available on an ad hoc basis whenever necessary from within the organisation. However, the difference in responses suggests a strong association between Product Innovation Success and a systematic, market-aware approach to R&D.

Questions 15 to 18 showed little difference between successful and unsuccessful innovators: both increased their R&D (or S&T) spend for the project in question; all owned IP appropriate to the opportunity; and roughly half of the firms required a technology partner to carry out the development work – there was no difference in this respect between successful and unsuccessful innovators.

However, while all of the unsuccessful innovators determined that only a new (or disruptive) product would meet the customer's requirements, about 33 per cent of successful innovators chose to develop and extend an existing product. This finding was reflected later in the survey in responses to Question 53 – 'What level of innovation was required to meet your primary customer's needs?' Unsuccessful innovations were almost all new products, while about one third of successful innovations were incremental developments of existing products or systems.

This in turn reinforces the suggestion that a successful innovation project is shaped significantly by the innovator's knowledge of the marketplace and of customer needs. That said, without exception the unsuccessful innovators lacked an existing product with which they could undertake an incremental development process. This suggests a lack of familiarity with the technology and market in question, a shortfall that may be possibly mirrored in the customer also.

A very significant finding emerged in Questions 19 and 20: innovators adopted IP from DSTO in only five of the 20 projects surveyed – 2 successful and 3 unsuccessful. However, the two successful innovations were actually based on IP developed in DSTO and commercialised specifically for this purpose in close partnership with the company concerned. Of the three unsuccessful innovations, one was based on DSTO-developed IP which was also commercialised specifically for this project - customer processes rather than technology issues *per se* bear most responsibility for the project's failure; the second was a CTD project by an SME which embodied some DSTO IP, and failed for reasons unrelated to the technology or the licensing process; and a company licensed the IP for the third innovation from DSTO without actually having firm customer interest.

On the whole, therefore, defence industry innovators are not likely to need or use DSTO's IP – the obvious exception is in large-scale, technology-driven projects such as the Jindalee Operational Radar Network (JORN) and Laser Airborne Depth Sounder (LADS) in which the underlying science and its operational application demands the resources of a major research organisation such as DSTO. Of the five innovations which were based on IP from DSTO, the three unsuccessful firms all reported (Q.20) that its Technology Readiness Level (TRL) was too low to be useful, and so further development work was necessary; the successful innovators reported the TRL was sufficiently high to meet the needs of the project.

These findings suggest a number of conclusions: first, despite its pre-eminence within Australia's defence S&T community, industry does not consider DSTO an important source of IP for new defence products. Secondly, the reason why companies invest in R&D is important: a methodical R&D approach that is focused on developing new IP or products – things which can be exploited commercially – is associated strongly with success. So also, it would appear, is customer and market knowledge: choosing to extend or develop an existing product, rather than develop an all-new product where this isn't necessary, is also associated with success. However, this may have something to do with the customer's own familiarity with the original product, a factor which is addressed later in the survey.

Question 20 generated an unambiguous result: in every successful project which employed IP sourced from DSTO the innovators reported this was of a sufficiently high TRL; in the unsuccessful projects which employed DSTO's IP this was reported to be of a low TRL. It could be argued this judgement applies to all externally-



sourced IP and that the innovator should consider the TRL of the IP in question very carefully before adopting it.

Question 12 highlighted two factors: firstly, a lack of customer interest in the product, which may reflect poor market knowledge on the part of the innovator (if the product is irrelevant to the user's needs), or an inability to sell the product's benefits to the customer – this suggests lack of sales and marketing proficiency by the innovator. It may also point to flaws in the Customer's own Professional or technical proficiency. Secondly, the effects of competition and schedule are highlighted: if the product was overtaken by the advance of technology this suggests either that the development process was so slow that the normal technology development cycle overtook it, in which case the company lacked the technical and financial resources to undertake a timely development program; or that the company technology base was insufficient; or that the company was unaware of new technological developments within this particular market sector, or unaware of the development activities of a (possibly more nimble) rival. This suggests in turn a lack of specialist domain knowledge and proficiency in the innovator's R&D, marketing and management.

It's also possible, however, that in a market where the Customer Active Paradigm (CAP) is dominant, R&D and product development schedules and therefore outcomes are at the mercy of the customer's own processes. A slow, ponderous decision-making process can result in a protracted development process, if that process is dependent upon milestones and schedules set by the customer. This again is an issue addressed later in the survey.

### **Variable 3 - Technical Proficiency**

This factor is a measure of the innovator's design, development, prototyping, testing and manufacturing skills and resources and is addressed through Questions 21 to 29, of which only 22, 26 and 27 strongly supported the hypothesis that this variable discriminated between success and failure, while 24 offered weak support. **Therefore, factors relating to the innovator's Technical Proficiency have a Measurable impact on the likelihood of achieving Product Innovation Success.**

There was no difference in the average number of years the innovators had been involved in this particular sector (Q.21), a surrogate measure for technical and market familiarity: the average exposure to this sector was about 11.5 years for both

successful and unsuccessful innovators. And there was no difference between successful and unsuccessful innovators in their need for industry partners: the majority did not (Q.23). Half of the unsuccessful innovators were owned by an overseas prime contractor (Q.22) and the remainder were independently owned; 66 per cent of successful innovators were independently owned, the remaining 33 per cent by overseas prime contractors.

The majority of innovators kept software development in-house (Q.25) or in a very few cases sourced it from specialist contractors. However, there was a significant difference where hardware is concerned (Q.26): 75 per cent of successful innovators developed hardware in-house and less than 17 per cent sourced it from a contractor, whereas 84 per cent of unsuccessful innovators sourced their hardware from contractors. Why this difference exists and what it means is unclear at present: in the case of IT-related projects hardware is to a great extent merely a commodity and not a determinant of system performance or project success. Nevertheless, this could be some sort of indicator of overall technical proficiency or of the robustness of the company's resource base; its cause and significance remain to be explored in greater depth.

Similarly, there was a very clear and significant difference between the abilities of successful and unsuccessful innovators to test ideas and hypotheses on the customer during the development process (Q.27). All successful innovators were able to achieve this; just over half of all unsuccessful innovators reported they achieved this. This suggests a focus on 'innovation best practice' by the majority of firms, including the need for close customer engagement during the innovation process. As this research isn't extensive enough to explore Qs 26 and 27 in more detail, it may be a fruitful line of enquiry for future researchers to examine these sub-factors as Independent Variables in their own right and explore their effects on the Dependent Variable directly.

The reasons why unsuccessful innovators weren't able to engage with the customer during the development process may help explain why they were unsuccessful: in five cases there was no launch customer and therefore no user engagement to steer the development process, so the innovators simply developed what they thought were the right products. In the other cases there was a launch customer whose requirements were well understood; in one case these changed significantly at a late stage, marginalising the product; in another the product development process was

dictated by the customer's project management methodology and technical difficulties proved impossible to resolve as a result; and in the third the customer community was divided over whether or not the product in question was even necessary – the sceptics won this particular battle.

Regardless, all innovators except one built a prototype or beta version of their product or system for customer testing – again, following 'innovation best practice' (Q.28). One successful innovator also highlighted the importance of a 'good honeymoon' – achieving good early development results and sharing them with the customer as a means of demonstrating proficiency and progress. This helps build customer confidence, and therefore support when the project encounters the inevitable difficulties later on.

These results suggest that companies which command in-house the majority of technical and human resources needed for an innovation project are more likely to succeed than those which outsource key elements of the development process. This would seem to contradict some of the general innovation literature which places a high value on access to external IP and technology partners. The preponderance of independently owned successful innovators suggests that 'reach back' to the resources and IP of a large parent company isn't a major determining factor in success in this market place. However, in the cases of two successful innovations that 'reach back' capability did make an important contribution to success: these were both large, complex, technology-rich projects. Similarly, in one unsuccessful innovation, 'reach back' to a parent company's resources helped shape and refine the product – in this case, however, the project failed because the user made significant late changes to his requirements.

Very important in this context is creativity, and close engagement with the customer both in testing ideas and hypotheses and exposing him to prototypes and beta versions of new products during the development process. This has the benefit of shaping his view of what he needs and what is actually achievable, and of maintaining his confidence in the face of the inevitable risks and uncertainties in developmental projects. In turn, this suggests that R&D Proficiency, Technical Proficiency, Marketing Proficiency and Communications are closely related and that a methodical approach to both Marketing and R&D is an essential contributor to Product Innovation Success. The answers to questions in this section also appear to confirm the validity of the Customer-Active Paradigm in this market.

#### **Variable 4 - Business Proficiency**

This factor is a measure of the innovator's more generic skills in management, financial and business analysis, and project management. It is addressed through Questions 29 to 41, of which only 33 and 38 strongly supported the hypothesis that this Independent Variable discriminated between success and failure. This Independent Variable is a measure of the company's ability to build a business case for an innovation project and then implement it efficiently. The fact that both successful and unsuccessful innovators tried to follow what may be termed 'innovation best practice' and so delivered similar or identical responses to the same questions is important: strong differences between them emerged from just two questions. **Therefore, factors relating to the innovator's Business Proficiency have a Measurable impact on the likelihood of achieving Product Innovation Success.**

A key indicator of Product Innovation Success is the attitude and engagement of senior management, including the CEO. In each case the CEO was very supportive of the project and took a close personal interest in it (Q.29 and 30).

Another important indicator of Product Innovation Success is the appointment of a business or technical 'champion' to run aspects of the project (Q.37). All innovators appointed a 'leader' or 'champion' of some kind. But there was an association between Product Innovation Success and the seniority of the 'champion' (Q.38): in 75 per cent of successful innovation projects this champion had cross-functional project responsibility, equal or senior to the company's heads of marketing and engineering. By contrast, only half of the unsuccessful innovators appointed leaders with such seniority – they were more likely to appoint leaders to subordinate roles with responsibility for a single function and, by implication, no individual was charged with the overall management of the project.

In a similar vein (Q.39), successful and unsuccessful innovators both set up a new dedicated project team to develop the product or system, while in one case a company spun off a new business unit to implement a successful project. However, successful innovators were more likely to develop a new product using an existing management/technical team, and also more likely to pursue an incremental rather than disruptive innovation. This would seem to reflect the finds of Johne and Snelson (Johne and Snelson 1990) who noted that developing an all-new product generally requires a new project team while incremental innovation, or the

enhancement and upgrading of existing products, is more usually undertaken by the existing product team.

A useful surrogate measure for management proficiency, including project management, was the accuracy of the innovator's estimates of cost, schedule and technical challenges. In this sense there was little practical difference between successful and unsuccessful innovators: in only three cases out of 20 (two of them successful projects) did interviewees state they badly under-estimated some or all of these factors; the majority said they made accurate predictions or encountered only minor surprises (Q.31). And there was no practical difference between successful and unsuccessful innovators in one other area: neither felt the need to establish a new business analysis team to study the financial and business case for the project: this was all done using existing management resources (Q.32).

Similarly, for those innovators owned by an overseas parent company (Q.34), there was no difference regarding the parents' behaviour. Overseas parent companies didn't try to control local operations closely; most parents adopted either a 'hands-off' approach, or kept a loose rein on their local subsidiary, retaining only a power of veto at critical decision milestones. In only one case, where the local subsidiary of an overseas prime found itself developing something similar to a sister company in the northern hemisphere, did the parent terminate the project, and then only because the Australian project in question was a CTD and there was no external mechanism to fund further development once this project concluded.

But when asked if sufficient, and accurate, customer and budget information was available to build a robust business case (Q.33), there was a significant difference between successful and unsuccessful innovators: nearly 90 per cent of the latter said 'no', while a majority of the former said 'yes'. There could be three explanations for this: either the unsuccessful companies failed to succeed because they couldn't find the information they required (which is a function of their marketing and management proficiency); or there was no customer requirement; or the customer didn't know what he wanted and how much he was willing to pay, or simply wouldn't tell the innovator. Again, the importance of detailed customer knowledge (a function of marketing proficiency) is highlighted.

Nevertheless, there was no significant difference between successful and unsuccessful innovators regarding their ability to meet their own schedules for key activities and decisions (Q.40): the majority encountered slight delays at worst, and

mostly experienced none. Any project delays, this implies, were caused by others. This judgement could be seen as self-serving and should be treated with some caution.

Interestingly, given the attention paid to R&D costs, the majority of innovators did not apply for assistance such as a Federal or State government grant to help finance R&D and other innovation activities (Q.35, 36). Only one of out eight unsuccessful innovators and two out of 12 successful innovators did so. Of the successes one was engaged in a lengthy, high-technology development program which required considerable amounts of prototype and component testing and validation to raise the TRL and reduce risk; the other was considerably less demanding in a technical sense but required considerable testing and development to make it suitable for the market - in this case, the product was designed exclusively for the export market. Interestingly, in neither case did the innovator have a guaranteed customer, only strongly expressed interest from potential customers with whom he kept in close touch.

An unsuccessful innovator developed a prototype for an extended, customer-funded user trial following a lengthy self-funded development program; in the customer's view the trial proved unsuccessful and no sales of this product have taken place since.

That suggests that access to external development funding is less critical to Product Innovation Success in the Australian defence industry, and in particular to traversing the so-called 'Valley of Death', than in other industry sectors. This could reflect a common feature of Australian (and other countries') defence projects where much of the product development work required is carried out once the contract is signed, and so paid for by the customer rather than from the innovator's own capital or cash flow. It could also mean the sample size is too small to reflect the true number of companies which did apply for and receive COMET and other grants, and why they did so.

As noted earlier, those companies that did apply for R&D grant support were engaged in relatively high-risk developmental work on all-new products, one of them based on a highly disruptive sensor technology. These reflect most accurately the non-defence innovation paradigm where a typical innovator assumes much more of the financial risk in raising the Technology Readiness Level (TRL) of the product. In the non-defence market, however, there are generally multiple

customers and therefore multiple opportunities to compete for sales, so the commercial risks are offset by the ability to target a number of customers more or less concurrently - this is not generally a feature of the defence market.

### **Variable 5 - External Expertise**

This factor is a measure of the innovator's willingness to source essential knowledge and expertise from partners and other sources; it also takes into account the terms of access to that expertise. It is addressed through Questions 42 to 51, of which only 47 strongly supported the hypothesis that this Independent Variable discriminates between success and failure; Q.46 offered weak support. Both successful and unsuccessful innovators tried to follow what may be termed 'innovation best practice' and so delivered similar or identical responses to the same questions. Strong differences between them emerged from just two questions. **Therefore, the likelihood of achieving Product Innovation Success is impacted only Weakly by factors relating to the innovator's access to, and willingness to source, external expertise.**

The majority of innovators had some kind of formal collaboration agreement with DSTO, or another Australian Defence S&T agency (Q.42) and they did engage with DSTO during the course of the project (Q.43); this suggests a role for DSTO beyond that of simply providing IP for commercialisation.

Roughly half of the innovators (with no distinction between successful and unsuccessful) employed some IP, expertise or R&D facilities from an outside source, including parent companies and DSTO (Q.44). In most cases, where external IP or expertise was required, this related to the core technology of the innovation; unsuccessful innovators were more likely to require IP and expertise to support a separate, less-critical technology area of an integrated solution (Q.45). Again, as in Q.27, it's not clear why this difference exists. It could be argued that unsuccessful innovators were unsuccessful because they failed to understand (or correct) the weaknesses of their own technical positions.

As previously noted, the source of the original IP in successful innovations was overwhelmingly in-house R&D; unsuccessful innovators were more likely, however, to try and source their IP from elsewhere, including DSTO (Q.46). Successful innovators were far more likely to require access to Defence-owned test and certification laboratories and ranges (Q.47): some 75 per cent of them, compared

with around 50 per cent of unsuccessful innovators, suggesting they were more likely to be developing innovations of direct value to the ADF, and therefore in partnership (however loosely) with the ADF and so requiring official certification for things like flight safety or ballistic performance.

Of the three successful innovators who didn't require Defence T&E assets, one incorporated Government-Furnished Equipment (GFE) in any case; the other two were designing for the export market – any T&E required was carried out privately or by the export customer.

Of the unsuccessful innovators, three had developed their products as privately funded ventures and conducted their own T&E processes in-house or with (in one case) an overseas industry partner. One didn't require local T&E assets to complete the development process, despite being developed originally for an ADF requirement; this product achieved its first sale overseas. One specific element of the design was tested to destruction overseas to demonstrate its performance.

Generally, DSTO's IP was licensed on an exclusive basis (Q.48), but the terms of the license did not affect the business case for the project and weren't a determinant of Product Innovation Success (Q.49). The same applied to IP sourced from providers other than DSTO (Q.50 and 51).

These results suggest three things: firstly, DSTO is not a significant source of IP for commercialisation; secondly, DSTO and other specialist defence T&E assets still have an important role to play in the innovation process, particularly in test and evaluation (T&E), and therefore a relatively close and harmonious relationship with DSTO is important to the innovator; and thirdly, that considerations of IP access and licensing terms are relatively minor factors in defence innovation outcomes.

Another interpretation of the results would be that DSTO, as the ADF's S&T authority, is an important technology 'gatekeeper' and that innovators have little choice but to engage with DSTO in order to establish their technical credibility as well as their understanding of the ADF's technical requirements, and it is therefore in their interests to make this engagement as fruitful as possible.

#### **Variable 6 - Innovation Impetus**

This factor measures the drivers for innovation and R&D investment, including the customer's need for increased capability and lower purchase and operating costs,



and the manufacturer's need for reduced production costs and increased profits. It is addressed through Questions 52 to 54, of which 53 and 54 showed a measurable difference between successful and unsuccessful innovators – these relate to the level of innovation required and to the company's own motivations. **Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to the innovator's motivations and R&D investment.**

It emerged that a successful innovation was considerably more likely than an unsuccessful one to be an incremental development of an existing product instead of an all-new (and therefore disruptive) innovation. This would seem to reinforce the importance of Marketing Proficiency as a means of determining the user's actual needs, and of Business and Technical Proficiency in trying to meet these quickly and economically.

The fundamental impetus for product innovation is the customer's needs, and innovators reported that the most important need expressed by the customer was for a significant leap in existing operational capability (Q.52); less important were the emergence of a significantly different task or mission requiring new equipment or technology, the need to improve the performance of existing equipment types and the need to reduce operating costs.

Indeed, only one successful innovator reported the latter as the customer's primary need – this was a company developing products for an export market niche where northern hemisphere prime contractors were developing high-end equipment that was too expensive and sophisticated for certain markets. There was therefore an unfulfilled need for simpler, more affordable equipment which the company set about addressing

This suggests that the ADF's views of its own needs seem to be driven more by its existing knowledge, shaped by current operations, than by any projections of emerging threats or opportunities. One conclusion could be that the ADF is a reactive innovator, in a sense, rather than a force which seeks to fundamentally shape the battlespace by the development and employment of a radically new and disruptive technology.

(That said, the ADF's willingness to invest in developmental over the horizon radar technology, for example, suggests a preparedness to be more ambitious in a technical sense than the projects in this case study suggest. Similarly, the RAAF and

RAN base their specifications for new combat platforms (which may have a service life of 30 years or more) on sophisticated analysis of technology trends as well as intelligence estimates of the emerging capabilities of key military players in Australia's region and further afield; DSTO makes a critical contribution to these analyses. However, the RAAF's combat aircraft are largely bought off the shelf with at most minor modifications; most of the key elements of RAN surface combatants such as weapons and sensors are acquired off the shelf; and while the RAN's current (and likely also its future) submarine fleet is a unique platform design, its combat system, weapons and sensors are generally based on off the shelf equipment – in some cases developed jointly with the USA.)

As noted previously Q.53 addressed the level of innovation required to meet the primary customer's needs: successful innovators were significantly more likely to follow an incremental development path, enhancing or adapting an existing product or system to meet customer needs (5 out of 12); all of the unsuccessful innovations involved an all-new product or system. In four cases these were products for which no formally stated customer requirement existed.

As for the innovators' own motivations, there was a clear difference between successful and unsuccessful firms (Q.54): successful firms sought to seize market leadership (40 per cent) or develop new products (32 per cent), or to extend an existing product line (16 per cent); unsuccessful firms thought it more important to develop a new product line (50 per cent) than seize market leadership (25 per cent) or exploit new technology (25 per cent). The key point of difference between success and failure is that successful firms were more likely to be conscious of their market position, and try to improve this, and were more likely to invest systematically in developing and extending an existing product line: this resonates strongly with responses to Q.13, in which unsuccessful firms stated they were more likely to invest in R&D in order to gain technical knowledge, not necessarily to develop a new product or IP.

This also resonates strongly with Cooper's finding that a systematic innovation strategy is strongly associated with Product Innovation Success and with the company's overall performance: "New product performance and strategy are closely linked... The implications of this strategy-performance link are critical to the management of firms' new product efforts. The existence of this link points to the

need to define clearly the firm's new product strategy as a central and integral part of the corporate plan." (Cooper 1984).

In the case of one unsuccessful innovation, the company was also trying (with support from Defence and DSTO) to satisfy a strategic capability requirement. This innovation didn't fail for technical reasons.

### **Variable 7 - Market size and growth**

This factor measures the size and diversity of the market, market access and barriers to entry. It is addressed in Questions 55 to 59, of which 55, 57 and 59 were found to show considerable differences between successful and unsuccessful innovations. Responses to these questions demonstrate that Product Innovation Success depends significantly on the way the innovator handles some of the factors inherent in the size and growth of the market. **Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to Market Size and Growth.**

In one area (Q.58) there was no difference between successful and unsuccessful firms: they almost unanimously pursued emerging markets where demand was growing strongly; in a very few cases they saw opportunities in mature markets with steady demand; none of them sought to break into declining markets. In this sense they all followed the accepted best practice.

Successful and unsuccessful firms differed significantly in their view of the potential market (Q.55): successful firms unanimously believed there was potential for repeat sales of the same product to the same or other customers. Some 12 per cent of unsuccessful firms thought the market opportunity represented an opportunity for a single sale of the product or system in question; 50 per cent believed, like successful firms, there was potential for follow-on sales to the same customer as well as to others; and the remainder believed a single sale would satisfy the primary customer's needs but that there was potential for additional sales to other customers.

Interestingly, in view of Cooper and Kleinschmidt's research in this area (Kleinschmidt and Cooper 1988) the innovator's international outlook, or lack of it, seemed to make little difference to the project's prospects of success: half of all of the innovations examined, split evenly between success and failure, were designed with export needs in mind (Q.56).

However, a discriminator in favour of success emerged in Q.57: 75 per cent of successful innovators stated that if there had been no potential for export or follow-on sales they would still have continued with development of the product or system in question; only 50 per cent of unsuccessful firms agreed with them. Two of the successful innovators who would not have continued development had a strong export market focus: in one case the entire market was overseas; in the other the launch customer was from overseas, and most subsequent sales have been to export customers. A third innovator recognised that the ADF is too small a customer to justify the development effort by itself.

Of the unsuccessful innovators who would not have continued development without the potential for an export customer, three had done extensive market research, but had failed to secure a domestic customer.

This suggests a number of things: first of all, in certain markets the ADF is too small a customer to be able to support a viable industry capability by itself, and therefore to support a product innovation business case predicated on sales to the ADF alone. Secondly, and conversely, there are some sectors of the Australian defence market which are worth pursuing for their own sake, regardless of the existence of a follow-on export market. Indeed, for successful innovators success or failure is not determined by whether they secured follow-on or export sales: the initial opportunity must be able to justify the innovation effort and investment in itself, and is the measure of success or failure – subsequent sales are a bonus.

Thirdly, there's a general recognition by successful firms that it's important to secure a domestic sale (both for market credibility and to establish a product line securely) before attempting to tackle the export market. And finally, whether or not the launch customer is local or overseas is immaterial: there must be one.

Another important difference emerged in Q.59: while there was general agreement that Defence did not help innovators to access the export market (and in one case was judged to be downright obstructive), two successful innovators found Defence very helpful and a third found Defence moderately helpful – every other response stated Defence was unhelpful, and unsuccessful projects scored particularly low on this scale. On closer examination it was found the projects where innovators reported the highest levels of export support were projects in which Defence was in some way a partner of the innovating firm – in one case, the product concerned was based on IP developed by DSTO in response to an identified ADF need.

## Variable 8 - Market competitiveness

This factor measures the competitiveness of the market. It is addressed in Questions 60 to 63, of which only 63 was found to show strong differences between successful and unsuccessful innovations. Responses to these questions demonstrate no direct correlation between the factors associated with Market Competitiveness and Product Innovation Success. But they did highlight the fact that in a highly competitive Australian domestic market the factor which contributed most to achieving Sales (which implies in turn achieving Functional Success) was understanding customer needs; the second most important was price/value for money. This in turn highlights the importance of Marketing Proficiency to identify accurately both user needs and customer price sensitivity, and where one has primacy over the other. **Therefore, the likelihood of achieving Product Innovation Success is impacted only Weakly by factors relating to Market Competitiveness.**

Both successful and unsuccessful innovators found that competition was more intense in the export market than domestically, though innovators generally tried to enter or create a market niche where there was little or no competition (Q.60 and 61).

They also reported that Defence encourages new players to enter markets in order to stimulate competition and use this as a mechanism to reduce prices and/or increase value for money (Q.62). The exceptions to this rule were where Defence itself had developed the IP and was developing the product in partnership with the company (two cases), or where an all-new product was being developed under a sole-source contract or a CTD. In the case of unsuccessful innovations, two were all-new and so had no competitors (and no customers, either), and one was a CTD.

Successful and unsuccessful innovators differed in their responses to competitive pressure (Q.63): while both focussed to some degree on price or value for money, successful innovators were significantly more likely to focus on understanding the customer's needs properly (40 per cent of respondents, versus 12 per cent of unsuccessful innovators); and in cases where there was no competition the focus was exclusively on interpreting and understanding those needs.

It will be seen that where Defence itself (through DSTO) had developed the IP and was a partner in the product development process, this was generally because no alternative existed which could be acquired off the shelf. In three cases DSTO's IP

was developed into an item of operational equipment. In two of these cases the technology was unique and the inevitable difficulties didn't prevent successful development. In the third case an Electronic Warfare (EW) system was developed for a unique ADF platform; this platform was retired unexpectedly early and the EW system was adapted for other ADF platforms for which off the shelf EW alternatives did indeed exist. The development process was hindered by slow decision-making (and therefore funding) on the customer's part and the contractor's own lack of investment in the product and process (pointing towards a weak business case for the program).

### **Variable 9 - Time to market**

This factor is a measure of the urgency of customer need, competitive pressure and cost. It is addressed through Questions 64 to 74, of which 65, 67, 69, 70, 73 showed significant differences between successful and unsuccessful innovations, while 68, 72 and 74 showed Measurable weaker support. **Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to Time to Market.**

Urgency of customer demand was not in itself a factor which determined Product Innovation Success (Q.64): about half of all projects, divided evenly between success and failure, were characterised by urgent demand. The difference between success and failure seems to emerge in Q.65 where, although half of all innovations were a response to an urgent need, in all but one of the unsuccessful projects the customer's acquisition process did not reflect this sense of urgency. The same is true, incidentally, of more than 56 per cent of successful projects, but in this case there seems to be a better alignment of acquisition process and urgency of user need. Indeed, one of the successful innovation projects was what the DMO terms a Rapid Acquisition Project (RAP) designed to meet an urgent user need as quickly as possible.

In the case of two unsuccessful projects, an urgent user need was not reflected at all in the acquisition process, despite in one case the project being based on IP developed by DSTO specifically to meet this need; this was the case in only one of the successful innovation projects. What this suggests is an acquisition process that lacks a mechanism for coping with urgent user demand. This might be the result of risk-aversion in the decision-making process, or a process that is too complex and slow (which may also be the result of risk-aversion).

That said, in all cases project timescales allowed time for an all-new or incremental development process, which given the nature of this research is perhaps to be expected (Q.66).

Regardless, over 90 per cent of successful innovators stated that being first or early to market was a factor in the commercial success of the product in question (Q.67); only 50 per cent of unsuccessful innovators made this statement, reflecting the fact that half of the unsuccessful projects were terminated in any case.

As to the reason why this was so, successful innovators stated that the most important reasons were to achieve leverage for follow on sales, and to establish or consolidate a strong competitive position (Q.68). In 16 per cent of cases the opportunity represented a single opportunity in a single market so speed to market was of the essence. One respondent stated that in his particular sector speed to market wasn't a particular advantage, but customer-funded development was a huge advantage. For unsuccessful innovators the most important factor seems to have been establishing or consolidating a strong competitive position.

This is reflected in the speed with which innovators made their first sale (Q.69): successful innovators were significantly more likely to achieve this milestone on the anticipated schedule. Unsuccessful innovators were far more likely to find their first sale came far more slowly than anticipated. This was reflected in turn by responses to Q.70 – 'Were you first, or early, to market?' No unsuccessful innovator beat a rival to the market, though three reported they had no competition and another three reported they were "early enough to benefit". Three successful innovators made the same claim; but seven out of 12 reported they were first to market and benefited from beating the opposition.

Counter-intuitively, however, competitive pressure didn't make a significant difference to project schedule (Q.71): the majority of successful and unsuccessful innovators reported that schedule wasn't the principal determinant of competitiveness, where there was any competition, and this echoes the responses given to Q.63: it will be recalled the majority of successful innovators focussed on ensuring they understood customer needs properly. This isn't to say that poor schedule performance is somehow acceptable, merely that speed to market *alone* did not determine the success of most innovation projects.

It should be noted, however, that speed to market in Australia is to a significant degree dictated by the customer's own acquisition process: an open tender process puts everybody on the same start-line, regardless of whether the solution being offered is developmental or already in production for another customer. The maturity of the design at this specific milestone appears to be a factor in mitigating any project risk and in how quickly the winning bidder can bring the product in question into service, but doesn't necessarily reflect how well it meets the customer's needs. And in most cases, the customer's preferred in-service date was normally set before the tender process got under way, though this could be changed in response to technical, manufacturing or budget factors.

Successful innovators reported that their project costs were generally more sensitive to schedule delays than unsuccessful innovators (Q.74). The fact that they achieved success regardless suggests these innovators took greater care to ensure their projects maintained their schedule or that potential causes of delay were identified in advance and suitable allowances made.

Interestingly, half of all unsuccessful projects didn't require access to Defence T&E or certification facilities or ranges (Q.73); almost all successful projects did (the two exceptions were export-driven innovations), and 75 per cent of successful projects had made sufficient allowance in their schedule for the testing and certification process – a convenient surrogate measure of management (and especially project management) and technical proficiency: time to market wasn't affected by delays and difficulties encountered during testing, or gaining access to specialist defence facilities.

However, Defence's acquisition and internal decision-making processes took little account of potential market benefits for an Australian firm if an equipment source selection was completed in a timely fashion (Q.72). In 75 per cent of unsuccessful projects Defence was indifferent to the effects of its decisions on the product's other market prospects; this was true also in 50 per cent of successful projects – but about 33 per cent of successful projects enjoyed some defence support.

This reflects the findings of Q.56, 57 and 59 – unsuccessful innovations seemed more dependent upon the promise of exports to strengthen their business case and, given the nature of the marketplace, depended more upon Defence's support. However, it's not clear that Defence's reported indifference made any difference to actual export outcomes in these specific cases.



## Variable 10 - Customer Characteristics

This factor measures customer characteristics and their effect on Product Innovation Success, including willingness to innovate, domain knowledge, technical knowledge, risk tolerance and appointments of key personnel. It is addressed through Questions 75 to 83, responses to all of which except 76 and 77 showed measurable differences between successful and successful innovations. **Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to Customer Characteristics.**

As the primary customer for almost all of the innovations studied in this research, Defence's own familiarity with the products or technology in question seems to have some impact, though not statistically strong, on Product Innovation Success (Q.75), although where the customer had previously acquired a similar product or system, there was a slight association with Product Innovation Success. In half of the unsuccessful innovations, Defence had never actually bought, still less been involved in the development of, such items before although off the shelf alternatives were available. In seven out of 12 successful innovations it had; and in the other cases no such product existed anywhere else and so Defence was forced to acquire a developmental item.

Interestingly, previous work related to the capability in question by DSTO or some other defence S&T organisation doesn't seem to be a pre-condition for success (Q.76): both successful and unsuccessful innovators reported that DSTO had done work in the relevant area before, typically as part of its S&T advisory role in support of ADF capability development and acquisition but in some cases also as the original source of all or much of the IP in the product concerned. Similarly, there were no differences between successful and unsuccessful innovators in their opinion of whether the customer understood his real operational needs, or had done any modelling or experimentation to verify and refine his needs: both reported this was the case (Q.77 and 78). Similarly (Q.80), innovators reported a uniform understanding by the customer of the technical aspects of the project.

However, successful innovators were significantly more likely to report the customer was innovative in his processes and practices in order to meet the operational challenges he faced (Q.79): buying a new and innovative piece of equipment wasn't enough – innovative customers were prepared to adopt new structures, processes and procedures to use the equipment better and become more

efficient and effective at their job. Three of the unsuccessful innovators reported interesting results: in one case the project was dominated by an ambitious but highly risk-averse and controlling customer who lacked deep technical understanding; the other two unsuccessful projects encountered an uninterested and risk-averse customer lacking a specific need for the product and feeling no pressure to experiment.

Similarly, where the customer actively sought innovative technical solutions to his operational problems there was a strong association with Product Innovation Success (Q.81); Product Innovation Success was also strongly associated with the customer's level of risk tolerance (Q.82) and this in turn was strongly affected by his level of professional and technical understanding of the technology and operational context (Q.83). It's interesting that risk tolerance is associated with Product Innovation Success, and not the reverse: one would assume that risk tolerance invites risky projects with a higher chance of failure. One explanation put forward was that risk-aversion creates conditions for failure by slowing the development and approval process, and so strangling funding and continuity of personnel involvement; and this seems to have been the case in one of the unsuccessful innovations in which DSTO's IP was being commercialised to meet a strategic capability need.

The defence market is characterised by the Customer-Active Paradigm (CAP) identified by von Hippel (Von Hippel 1976); therefore the trigger for a great deal of innovation in the defence industry is a customer who can identify his own needs and pro-actively pursues innovation and change in his processes, procedures and equipment, either to stay ahead of emerging threats or in direct response to sudden threats and contingencies. Responses to these questions, and those addressing Independent Variables 11 and 12 – *Customer Processes* and *Customer Environment*, suggest that a technically and professionally adept customer is more likely to innovate, and to demand innovation from his suppliers, to be risk-tolerant in developmental projects and better able to manage project risks.

#### **Variable 11 - Customer processes**

This factor measures the customer's capability development and acquisition processes such as risk management, acquisition and project management and their effect on innovation outcomes. It is addressed by Questions 84 to 91, of which 87, 88, 89 and 91 were found to show measurable differences between successful and

unsuccessful projects. **Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to the Customer's Processes.**

The customer's acquisition method seems to reflect the outcomes noted in Q.81 to 82 above: the majority of successful innovations were acquired by the ADF (or other primary customer) after either a competitive open tender, or on a sole-source basis following some sort of market survey or request for proposals (Q.85). Only 25 per cent were the subject of a collaborative development program involving the innovator and an organisation such as DSTO.

Unsuccessful projects were marginally more likely (43 per cent) to be collaborative projects, which seems counter-intuitive, but this may be accounted for by responses to Q.88 – 'In your opinion, how faithfully did the customer's acquisition process reflect user needs?'. This question acknowledges the separation between the ADF, the DMO and DSTO and the potential for the latter two to lose sight of the ADF's fundamental needs and drivers. The more strongly the acquisition process reflected user needs the better the chance of Product Innovation Success. The four lowest scores in this question (1 or 0) were recorded by unsuccessful innovations, two of them (Projects 1 and 3) developmental projects carried out in collaboration with the customer.

Similarly, the stronger the link between the customer's specification and relevant high-level strategic guidance such as the Defence White Paper, the more successful the project was likely to be (Q.89).

The fact that collaborative projects were more likely to be a failure is counter-intuitive; taken in conjunction with the findings from Q.88 and 89, this suggests that the basis for the collaboration was somehow flawed and that either the innovator or the collaborating agency within Defence wasn't paying sufficient attention to user needs, or that Defence lacks tools and processes able to reconcile the needs of both a developmental project and the intended users.

However, this is consistent with the findings of Q.84, that the prospects for a successful outcome were improved enormously if a 'champion' or 'sponsor' emerged within the customer group, representing the user and providing some focus and a sense of urgency. This was considered a highly important factor by both successful and unsuccessful innovators, the latter lamenting the fact in some cases that there was no such sponsor or champion for their projects and attributing part of

the failure to this factor. Responses to this question from unsuccessful innovators suggest that even the best process, fuelled by the most urgent need, can fail to deliver results if there is not some individual within the customer organisation who is charged with (or simply assumes) responsibility for seeing the project to a successful conclusion.

As mentioned earlier, one successful innovator (Company K) noted that continuing sponsor or champion support depended heavily on the contractor delivering early successes: meeting milestones and schedules and instilling confidence that he would deliver on the project's promise.

It was found (Q.86 and 87) by both successful and unsuccessful innovators that the customer's capability development and acquisition processes generally took into account the major risk factors in an innovation project – cost, schedule and technical; and that the customer's acquisition strategy neither discouraged nor strongly encouraged innovation by a contractor. In each case, responses slightly favoured successful innovators, but not to a statistically significant degree: capability development and acquisition process which were strongly shaped by risk factors had a slightly stronger association with success; and an acquisition strategy which encouraged innovation by the contractor also had a slightly stronger association with success.

There are two areas in particular where customer behaviour can affect project outcomes: if he changes his user requirements during the development process; and if he fails to stick to his own stated schedule for processes and key decisions. Successful and unsuccessful innovators both experienced some change in user requirements, but by roughly the same amount and in only one case (Project 15) was this significant (Q.90). But it was found that successful innovation projects encountered significantly fewer delays in customer processes and key decisions (Q.91).

### **Variable 12 - Customer Environment**

This Independent Variable measures the strength of customer need (including the threat environment), and the evolution of the customer operating environment (including threat and technology evolution) and their effect on innovation outcomes. It is addressed through Questions 92 to 94, of which 92 and 93 exposed important differences between successful and unsuccessful innovation projects.

**Therefore, the likelihood of achieving Product Innovation Success is impacted Strongly by factors relating to the Customer's Environment.**

The effect of the customer's operating tempo was believed to be significant because it is a measure of the rate of expenditure of resources and an indicator of the customer's need for new or improved capabilities. In fact (Q.92) a higher operating tempo does have a strong association with Product Innovation Success. This resonates with the findings from Q.64 and 65, regarding the urgency of the user need and its effect on the acquisition process: they showed an association between the urgency of the user need and the acquisition process employed with, again, a difference between successful and unsuccessful innovation projects.

There was also some resonance with Q.52 – the fundamental impetus for innovation: the majority of innovators reported the most important user need was a significant leap in operational capability. This reinforces the suggestion that the ADF's views of its own needs seem to be shaped by current operations and that the ADF is in many respects a reactive innovator.

Four of the five innovations which incorporated DSTO IP were developed at a time when the ADF's operational tempo was low or very low. This isn't to say they were in any way redundant or irrelevant, but respondents believed the end users felt no particularly urgent need for them. The two that succeeded, Projects 2 and 6, did so in part because one became a joint Australia-US developmental program, which brought in extra funding, offset the risk significantly and created an obligation for Defence to continue with the project; and the other because the innovation was developed to help equip a new maritime platform which was being developed in parallel.

It seems the rate of change of user's threat environment (Q.93) is also a greater determinant of Product Innovation Success than the rate of change of the technology underpinning the product or system (Q.94). In the former case a rapidly changing threat environment was much more likely to be associated with a successful innovation, even if the capability goal sought by user and innovator was relatively stable. In the latter case, however, technology was evolving very rapidly and the challenge for both customer and innovator (successful as well as unsuccessful) was to capture the required technology at the appropriate stage of the development cycle.

It could be argued, based on these results, that innovation is stimulated by the immediacy of the need, as experienced by users on the battlefield, rather than a more measured (and arguably theoretical) intelligence-led analysis of potential threats and future needs. In some cases the latter would seem almost to impose a solution on a disinterested (even uninterested) user, or operator in defence parlance, whose attention isn't really engaged until he is confronted directly with a threat or discontinuity which demands a rapid, even disruptive, response.

These results seem to echo Tishler and Dvir's findings in their study of 110 Israeli defence projects (Tishler, Dvir et al. 1996) which found the three most important factors (of eight) in defence project success were, in descending order of importance, a sense of urgency - the more urgent the need, the greater the chance of success; the professional qualifications, sense of responsibility for project outcome and continuity of personnel appointments within the customer 'team'; and pre-project preparation, including proving technological feasibility and establishing the correct project structure.

However, as noted earlier, the planning horizon of the RAAF and RAN can be up to half a century and their platform and combat equipment specifications do reflect sophisticated estimates of both technology growth and evolving threats. Nevertheless, most of the platforms they operate will be acquired off the shelf (albeit, in some cases, "Australianised" to a greater or lesser degree). These estimates inform the equipment selection process and the force structure required to obtain maximum combat effect from the equipment the ADF fields. Generally, they do not shape the design and configuration of an indigenously designed and built platform, except in the case of the RAN's Collins-class submarine and its probable successor, the Future Submarine.

### **Variable 13 - Communications**

This Independent Variable measures the effectiveness of innovator's processes, in particular his internal and external communications, in some cases using the nature and strength of collaborative arrangements with DSTO, stakeholders, customer and partners as a surrogate measure. It measures some of the same factors making up Independent Variable 4 – Business Proficiency and is addressed through Questions 95 to 99, of which only 95 was found to show a strong difference between successful and unsuccessful innovations. It is clear both successful and unsuccessful innovators tried to follow what may be termed 'innovation best practice' and so

delivered largely similar responses to the same questions: very few strong differences between them emerged. **Therefore, the likelihood of achieving Product Innovation Success is impacted only Weakly by factors relating to the innovator's business proficiency as it applies to Communications.**

The quality of a company's communications can help or impede a number of factors, including speed to market and both functional and technical performance; in the present context the existence of a teaming agreement with industry partners seems to be associated with Product Innovation Success while there seems to exist an *inverse* correlation between a teaming agreement with DSTO and Product Innovation Success.

Good external communications are strongly associated with Product Innovation Success, both to support marketing and promotional goals and also to sustain essential relationships with the customer, external stakeholders and partners. Similarly, internal communications are also important because these are the links which bind separate functions within the innovating organisation. Useful surrogates measures of communications proficiency include collaboration agreements with partners and stakeholders, and regular engagement with them, and the establishment of cross-functional project teams (breaking down firewalls between individuals, departments and functions) to develop a new innovation – this is where the differences emerge between companies with a mechanistic structure and companies structured along organic lines.

Interestingly, over 80 per cent of successful innovators did not have a formal teaming or collaboration agreement with an industry partner, as opposed to 50 per cent of unsuccessful innovators who did (Q.95). Similarly, nearly 60 per cent of successful innovators didn't have formal teaming or collaboration agreements with DSTO (Q.96); interestingly, the same was true for 60 per cent of unsuccessful innovators. In itself, this suggests that DSTO was considered irrelevant to the innovation process, but must be seen in the light of findings from Questions 42 and 43: in fact responses to Q.96 directly contradict the findings of Q.42, but this can be accounted for in part by the fact that the companies concerned may have had relatively close and friendly relations with DSTO but didn't necessarily have formal collaboration agreements in the technology or operational domain specifically addressed by the innovation in question.

Generally, communications between the innovators and DSTO was found to be rapid and effective (Q.97), though about 20 per cent of successful innovators reported cultural differences as a stumbling block in communications with DSTO. Interestingly, although communications with the customer were generally rapid and effective (Q.98), it was unsuccessful innovators who reported cultural differences were a stumbling block (25 per cent), while successful innovators were more likely to complain about physical separation and the difficulties this imposed (25 per cent).

Finally, all but one of the 20 innovators surveyed reported they employed a cross-functional project team for this innovation program, rather than separating specialist functions such as engineering, production, marketing and R&D. The use of integrated, cross-functional teams has emerged as 'best practice' in product innovation and here, as in other areas, Australian defence industry innovators stated they had adopted this practice.

It should be noted, however, that Q.38 highlights the importance of a senior team leader or 'champion' within the innovating organisation, an individual with cross-functional responsibility for success. Having a cross-functional team would appear to be pointless unless there is a leader charged with overall responsibility for success and who has the authority to drive his team towards it. The fact that most respondents stated they adopted, for want of a better word, an "organic" structure for their innovation activities, regardless of the outcomes, suggests that at least some of the companies surveyed played lip service to the idea of cross-functional teams and simply didn't understand how critical it is to appoint key project leaders with the right levels of authority and responsibility.

#### **Variable 14 - Market Regulation**

This factor, addressed through questions 100 to 104, measures the constraints on the project imposed by security, export controls and ITARs (the US State Department's intrusive and cumbersome International Transfer in Arms Regulations) and their effect on Product Innovation Success. **Therefore, the likelihood of achieving Product Innovation Success is not impacted at all by factors relating to Market Regulation.**

The defence market is very highly regulated for a variety of reasons, and this represents both a constraint on the industry (and customers) and a barrier to entry



into this sector. In the majority of projects studied ITAR constraints were not a factor constraining either internal or external communications (Q.100), recruitment and the composition of the project team (Q.103), or the project budget and schedule (Q.104) in any significant way.

However, ITAR and other export license restrictions (both Australian and others) did have an effect on export market access in a number of successful and unsuccessful innovations (Q.101). Their most common effect was to close off certain markets to the exporter (due to the nature and source of the technology embodied in the innovation), or result in deletion or modification of certain sensitive features.

And, as was to be expected, Australian domestic security requirements did have an effect on recruitment and appointment of team members. In the majority of cases the requirement for security checks had been taken into account, but both successful and unsuccessful innovators were disrupted by unexpected minor and even major delays in obtaining necessary security clearances.

#### **4.5 Effects of the Independent Variables**

The foregoing analysis of the Case Study results suggests each of the hypothetical Independent Variables affects Product Innovation Success to varying degrees via a number of subordinate factors, which in turn are of varying levels of importance. The fact that some factors appear to have a weaker impact on the likelihood of Product Innovation Success than others shouldn't be misconstrued: the smaller differences between successful and unsuccessful innovators in these cases emphatically doesn't mean these factors can be considered irrelevant. Indeed, it could be argued that if a successful innovator acted in a certain way or embodied certain characteristics then these are associated with Product Innovation Success, even if an unsuccessful innovator did exactly the same. For example, 'Customer Processes' includes a factor 'Customer appoints a project champion'. The difference between successful and unsuccessful innovators is 'Low' because both groups insisted this was a vital factor in Product Innovation Success.

Rather, the Case Studies identify weaknesses in the behaviour or the innate characteristics of unsuccessful innovators - and in some cases of customers for unsuccessful products. The factors that were found to have the strongest impact on the likelihood of Product Innovation Success are those where an unsuccessful innovator is most likely to differ from a successful one; or where adverse customer

attributes or behaviours or adverse market conditions, if encountered, will most probably reduce the likelihood of success.

The factors themselves emerge either directly or by inference from the interviewees' responses to the case study questions, and in particular those which showed a strong difference between successful and unsuccessful innovation projects. In most cases the responses either stated or inferred strong support for generic innovation success factors identified in the Literature Review in Chapter 2. Therefore, in the breakdown of product innovation success factors which follows, these factors are listed using similar or identical terminology to that employed by Rothwell, Henard & Szymanski, Montoya-Weiss & Calantone and Cooper (Rothwell, Freeman et al. 1974; Cooper 1980; Rothwell 1985; Montoya-Weiss and Calantone 1994; Henard and Szymanski 2001). Alongside them, under 'Independent Variables' 7-14, are factors associated specifically with the defence market. These are marked with a 'D'.

In most cases the factor is addressed explicitly in at least one question and the response highlights the differences between successful and unsuccessful innovators. These factors can therefore be assigned a level of importance based on the likelihood of an unsuccessful innovation project differing from a successful one: 'High', 'Medium' or 'Low'. Where there was no significant difference the factor's absolute importance, or lack of it, ascribed by the Case Study respondents to the factor in question was recorded instead.

### **1. Marketing Proficiency – Strong Impact**

- Familiarity with the market (inferred, not stated) **High**
- A methodical, systematic approach to marketing **High**
- A close customer relationship **High**
- Pro-active in determining user needs **High**
- Pro-active in shaping customer's view of his needs **High**
- Understanding customer price sensitivity (inferred, not stated) **Low**
- Sufficient information to build a sound business case - **High**

### **2. R&D Proficiency – Strong Impact**

- Familiarity with technology in this market (inferred, not stated) **High**
- A methodical, systematic approach to R&D **High**
- In-house prototyping capability **Medium**
- Sound project screening capabilities (inferred, not stated) **Medium**
- The availability of in-house IP **High**
- Absorptive capacity **High**
- Pro-active in seeking to test ideas and hypotheses on customer **High**

### **3. Technical Proficiency – Measurable Impact**

- Familiarity with technology and manufacturing in this sector (inferred, not stated) **Medium**
- Reliance on external partners and sources of technology **Low**
- The ability to manage schedule **High**

- In-house Software and Hardware capabilities **High**
- An Organic rather than Mechanistic structure (inferred, not stated) **Medium**

#### 4. Business Proficiency – Measurable Impact

- R&D funding access **Low**
- The ability to manage schedule **High**
- The ability to make accurate cost, schedule and technical forecasts **High**
- An Organic rather than Mechanistic structure (inferred, not stated) **Medium**
- A supportive, engaged CEO **High**
- Appointment of a Senior Project Leader/Champion **High**
- Use of cross-functional project teams **High**

#### 5. Willingness and Ability to Source External Expertise – Weak Impact

- Relationship with DSTO or other government defence R&D agency (D) **Medium**
- Reliance on external partners and sources of technology **Low**
- Access to critical technology **Medium**
- Absorptive capacity (inferred, not stated) **Medium**
- TRL of External IP **High**
- Access to Defence T&E facilities **High**

#### 6. Innovation Impetus – Strong Impact

- Customer needs **Low**
- Innovator's focus on market position **High**
- Innovator's willingness to consider incremental innovation **High**

#### 7. Market Size & Growth – Strong Impact

- Potential for repeat sales to same or other customer **High**
- Business case satisfied by domestic market (D) **High**
- Development partnership with Defence (D) **High**
- Export Orientation (product designed with later export needs in mind) **Low**
- Emerging market with growing demand **Medium**

#### 8. Market Competitiveness – Weak Impact

- Niche market, little competition **Low**
- Intensity of competition in marketplace **Low**
- Competitive edge from customer understanding **High**
- Innovator's ability to tackle export market without Defence support (D) **Medium**
- Understanding customer price sensitivity (inferred, not stated) **Low**

#### 9. Time to Market – Strong Impact

- Technical Proficiency **Low**
- Ability to manage schedule **Low**
- Urgency of user need reflected in acquisition strategy (D) **Strong**
- Making first sale on or ahead of schedule (Ability to manage schedule) **High**
- Innovator's ability to tackle export market without Defence support (D) **High**
- Urgency of user need (D) **Low**
- Adequate schedule allowance for T&E (D) **Strong**

#### 10. Customer Attributes – Strong Impact

- Customer familiarity with product/system type (D) **Low**
- Customer's technical and professional understanding (D) **Medium**
- Customer seeks innovative technical solutions (D) **Strong**
- Customer has funded or undertaken previous work by DSTO/other R&D organisation (D) **Medium**
- Customer validates needs through modelling/simulation (D) **High**
- Customer understands and articulate own needs (D) **Strong**

- Customer has high level of risk tolerance (D) **Strong**
- Customer seeks to innovate in practices and processes (D) **Strong**

**11. Customer Processes – Strong Impact**

- Customer sticks to his own schedule for decisions and processes (D) **Strong**
- User’s needs and desired outcome reflected in acquisition process (D) **Strong**
- Risk factors reflected in Capability Development and Acquisition processes (D) **Low**
- Stable operational requirement (no changes during development) (D) **Low**
- Customer appoints a project champion (D) **Low**
- Strong link with White Paper/ higher level guidance (D) **Strong**

**12. Customer Environment – Strong Impact**

- High operational tempo (D) **Strong**
- Rapidly evolving threat environment (D) **Strong**
- Rapid technology growth (D) **Low**

**13. Communications – Weak Impact**

- Teaming or collaboration agreement with DSTO (D) **Low**
- Use of cross-functional project team **Low**
- Cultural understanding of both DSTO and customer (D) **Low**

**14. Market Regulation – No Impact**

- ITAR effect on exportability or export market access (D) **Low**

**4.6 Defence Industry R&D – Case Study & Survey**

Case study respondents were asked to state how much they spent on R&D in the previous financial year. Some were reluctant to disclose an exact dollar figure, others to disclose what percentage of their revenue is spent on R&D. However, using open source figures for company revenue, it was possible to estimate R&D investment as a percentage of revenue for each member of the group. Some interesting patterns emerged. Eliminating duplications – that is, counting a company only once even when its products were the subject of more than one case study – it emerged that the smaller the company the greater the share of its revenue was spent on R&D; the only exception was a small group of firms whose revenue fell into the \$10-20 million band (see Table 4.4).

**Table 4.4: R&D Investment – broken down by company size**

	<b>Band 6</b>	<b>Band 5</b>	<b>Band 4</b>	<b>Band 3</b>	<b>Band 2</b>	<b>Band 1</b>
<b>Revenue (\$ millions)</b>	>100	50-100	20-50	10-20	5-9	<5
<b>Number of Companies</b>	3	0	2	3	4	3
<b>R&amp;D % of Revenue</b>	3.87	N/A	10	5.83	16.75	17.7*

\* With the outlier included this figure rose to 28.33

There was one significant outlier, a small firm which developed a commercially unsuccessful innovation and reported spending some 50 % of its revenue on R&D; the average R&D investment of firms in this revenue band was 28.33 %; removing the outlier reduced this figure to 17.5 %.

Similarly, averaging the R&D investment of unsuccessful innovators gave a figure of 6.99 % of revenue without the outlier, and 12.36 % when the outlier was included. By contrast, successful innovators devoted on average 9.62 % of their revenue to R&D (see Table 4.5). This resonates with the findings of Sohn and Moon that suggest a threshold of 2.5% of revenue as the basis for successful IP commercialisation (Sohn and Moon 2003).

**Table 4.5: R&D Investment – comparing success with failure**

	R&D % Revenue	Number of Band 6	Number of Band 5	Number of Band 4	Number of Band 3	Number of Band 2	Number of Band 1
Successful	9.62	4	0	2	2	3	1
Unsuccessful	6.99*	4	0	0	1	1	2
Total	N/A	8	0	2	3	4	3

\* With outlier removed; when outlier was included the average rose to 12.36%

Notwithstanding some statistical issues discussed below, these figures tell an interesting story: firstly, Australian defence companies which undertake product innovation projects spend significant amounts of their revenue on self-funded R&D. Secondly, successful innovators generally spend more on R&D than unsuccessful innovators. Thirdly, it would appear that smaller firms are more likely to be product innovators than larger ones, although a number of defence industry prime contractors have been relatively prolific developers of new products. Fourth, size is not a predictor of success: of eight projects undertaken by companies with a revenue of greater than \$100 million, half were judged unsuccessful. However, of the 12 companies whose revenue was less than \$50 million a year, eight were successful innovators. Failures only outnumbered successes where revenue fell below \$5 million a year, which points to a potential structural issue: smaller defence companies may be too small to command the non-technical resources required for Product Innovation Success in the rather demanding defence market.

Finally, the level of self-funded R&D expenditure isn't necessarily a predictor of success, either. For example, the "outlier" who spent 50 % of his revenue on R&D did not develop a commercially successful product, while the one company in this band which was successful spent less than the others by a considerable margin.

These companies were in the band with the lowest revenue and so potentially vulnerable to internal as well as external structural and resource issues. However, this result suggests an association with the *Quality* of R&D activity rather than simply the *Quantity* of R&D investment.

Closer study of the eight projects undertaken by companies with a turnover greater than \$100 million reveals another factor. One of these firms, Company B, developed two innovations, one successful, the other unsuccessful. Both were in a very similar technology domain and were developed almost concurrently, but for different users - and therefore customers - within the ADF. As the firm concerned was an acknowledged subject matter expert in this domain and could reach back to an overseas parent with extensive resources and expertise, what is the difference between these projects? Clearly, from analysis of the Case Studies, the Customer's Processes (shaped by his professional and technical proficiency and risk-aversion) made the major difference, not the level of company R&D. The two customers adopted very different processes and established very different relationships with the same company, and achieved very different outcomes.

The second firm, Company A, was responsible for four projects, but one of these had been conducted by another firm prior to a merger. Of the three projects carried out by the company itself, two were in related technical domains and were carried out almost concurrently. Again, they were for different "customers" within the ADF and in this case both were developed from DSTO's original IP, which in turn was developed in response to identified and important ADF needs. And once again, a key discriminator between success and failure in each case seems to have been the different characteristics and processes of the two customer groups, though the innovator also acknowledged serious errors of his own making in the case of the unsuccessful project. The third project was unsuccessful because the customer changed one of his key functional requirements at an advanced stage in the development process; as a result the company decided to withdraw from the contest.

The third firm, Company D, developed two successful innovations. One was a commercialisation of DSTO's technology; the other an all-new product for which no off the shelf competition existed – indeed, this product was developed for (and won) the same contest from which the previous company chose to withdraw.

It is not statistically significant but is worth noting also that this third company invested significantly more than the other two firms in self-funded R&D. These examples suggest that in Australia's defence market the innovators' own processes and proficiencies and the scale of their R&D investment are strongly related to product innovation success but are not necessarily the sole determinants: the customer's characteristics and processes are also important and may even over-ride all other factors.

#### **4.7 R&D Data Issues**

The R&D investment figures cited above should be treated with some caution: while at first glance they strongly support the hypothesis that Product Innovation Success is directly related to R&D investment, there are some anomalies in the data.

Firstly, companies were asked to provide the R&D expenditure for the previous financial year. However, as many of these innovations were developed a number of years earlier any relationship between R&D spend and innovation success (or failure) is diluted as a result: searching meaningful R&D expenditure figures for projects several years in the past proved an unwelcome burden which many innovators declined to shoulder. Asking them for the previous year's R&D expenditure became more of an attempt to measure how systematic the company was about its R&D investment.

Secondly, in some cases the innovations were developed by companies which have subsequently merged or been acquired, further diluting the relationship between R&D spend and innovation outcome. Thirdly, a number of companies featured repeatedly in the Case Studies as both successes and failures highlighting success factors beyond simple R&D investment. One company features four times and two companies featured twice – by the criteria applied for this research their projects were a mix of successful and unsuccessful innovations.

And finally, some companies were reluctant to disclose what they considered sensitive data, including R&D expenditure. So individual companies and their projects have not been identified individually; for the purposes of comparison R&D investment has been estimated.

#### 4.8 Industry R&D Survey

The R&D investment data provided by the Case Study respondents should be considered alongside the responses to the author's separate Defence Industry R&D Survey conducted in late-2009 and early-2010 and described at Appendix 1. As noted previously, this drew a disappointing response – there were too few respondents to provide a statistically valid analysis of R&D investment across Australia's defence industry. The 19 respondents provided illustrative rather than definitive data.

The survey results show that over 40% of respondents spend more than 5% of their revenue on self-funded R&D. Overall, some 57.9% of respondents invest over 2% of their revenue on R&D. This compares extremely well with the average figure of 0.37% reported by the Intellectual Property Research Institute of Australia (IPRIA) in its 2005 R&D and Intellectual Property Scorecard (IPRIA 2005). It is also well above that scorecard's average figure for defence industry R&D of 1.5% of revenue. The survey results are discussed in greater detail in Appendix 1.

**TABLE 4.6: R&D Survey – Industry R&D**

Level of R&D (% of Revenue)	<1%	1-2%	2-5%	>5%
Number of respondents	31.6%	10.5%	15.8%	42.1%

These figures, and the R&D investment reported in the Case Studies, are consistent with AADI Defence's findings in the state of Victoria (Schofield, Ho et al. 2010). In the 2009-10 financial year AADI found that Victorian defence companies spent an average of 4.2 % of their revenue on R&D, with over half of them spending 5 % or more; they also found that SMEs spend considerably more of their revenue on R&D than larger firms (again, consistent with the author's findings); and that most of these companies' new technology and IP was developed in-house (50 %) or with a partner (30 %), rather than acquired from an external source (17 %) – again, this is partly consistent with the Case Study results, though a much smaller proportion of Case Study respondents were likely to have a research partner. The conclusion to which these figures are pointing is that Australia's defence industry, and in particular its smaller SMEs, spend above the industry average on self-funded R&D.



Why do they do this? The Industry R&D Survey sought to determine the value of R&D activity to the company's profitability and business growth. Over the period 2006-07 to 2008-09, 52.6% of respondents reported an increase in profitability (10.5% said 'significant') and 57.9% reported an increase in growth, of whom 26.3% reported a significant increase. This is too small a sample to be truly representative, but these responses suggest a definite association between R&D investment, profitability and growth.

Similarly, when questioned on their companies' financial performance and overall performance (a combination of growth, profit and financial performance), 73.7% stated that performance met expectations and 15.8% stated that performance exceeded expectations. Again, this points to a general association between R&D investment and company performance.

Questions 7 to 10 of the Industry R&D Survey were the same as those posed in 2004 by Wylie, and a comparison between his results and my own is in Appendix 1. Question 7 asked respondents to rate the importance to their business of the "Introduction of new or substantially changed products for sale" and "Introduction of new or substantially changed production processes". The majority of respondents - 17 and 16, respectively - rated each initiative as 'Moderately' important, or higher; some 11 of 19 respondents rated the importance of new production processes as 'High' or 'Very High'; 10 of 19 respondents rated new products as 'High' or 'Very High' – seven rated new products as 'Moderately' important. These responses would seem to suggest a systematic approach to R&D by respondents which is reflected in their Innovation Impetus; looking back at responses to the previous questions, there would also appear to be an association between systematic, targeted R&D investment and company performance, though the sample size is too small to state such an association with any real confidence.

Question 8 addresses the importance of various sources of IP. It mirrors the Case Study results in that 13 of 18 respondents rated the importance of in-house R&D as 'High' or 'Very High'; eight respondents also rated the importance of IP from a parent company as 'High' or 'very High'. Otherwise, respondents generally ascribed 'Low or 'Very Low' importance to IP purchased or licensed from a vendor in Australia (14 of 18 respondents); a vendor overseas (10 of 18); and, counter-intuitively, from a parent company (also 10 from 18). The importance placed by

respondents on in-house R&D again suggest a link between R&D investment and business performance.

Responses to Question 9 suggest the majority of innovative defence companies in Australia are in what Wylie classifies as the 'Engineering and Technology' domains. Interestingly, all 18 respondents stated they devoted some R&D expenditure to this domain while eight said they also devoted R&D funding to 'Information, computing and communication sciences', and only three put any funding towards R&D into 'Physical, chemical or earth sciences'. One stated he put 50% of his R&D expenditure towards improving manufacturing processes, the equivalent of his combined R&D expenditure on ICCS (20%) and Engineering and technology (30%).

These classifications, drawn from the Australian Bureau of Statistics, don't map conveniently on to any of the classifications in the Case Study (Question A), so it's hard to draw any helpful conclusions from the responses to this question.

In response to Question 10 – "Defence suppliers undertake R&D or innovation activities for many reasons, such as meeting new defence requirements or making the existing defence business more profitable. Please estimate the proportion (%) of your business's R&D/innovation expenditure between 2006-07 and 2008- 09 that was undertaken for the following reasons:" some 15 of 18 respondents (again, one skipped the question) stated they did so 'To develop in-house new proprietary IP or technology for sale to Australian or other overseas defence customers.' Of these, 11 devoted 50% or more of their R&D expenditure to this purpose. A similar number stated they devoted R&D expenditure to 'Adapt[ing] IP or technology sourced elsewhere'; of these only three allocated more than 50% of their R&D budget to this purpose. Some 11 respondents stated they invested in R&D 'To improve profits by developing and introducing more efficient arrangements to supply defence-related goods and services', of whom one stated he devoted 100% of his R&D budget to this purpose.

Interestingly, only 5 of 18 respondents stated they invested in R&D 'Under contracts with Australian or overseas defence agencies.' This is an acknowledgement that some of the industry's R&D activity is funded by Defence. However, it's not clear whether this is contract R&D or work undertaken once a company is in contract to develop a new piece of equipment, or undertaking a Defence-funded Initial Design Activity (IDA) or similar process to mitigate project risks prior to competitive selection. In any case, responses to this question suggest very strongly the majority

of defence industry R&D work is self-funded and, in turn, that this investment tends to be reflected in the company's financial performance. To quote the IPRIA: "All other things being equal, innovation pays." (IPRIA 2005). The IPRIA's own research is discussed more fully in Appendix 1.

#### 4.9 Discussion

It's clear from this analysis of the Case Study results that the author's hypothesis has merit: 8 of the 14 factors identified as hypothetical 'Independent Variables' have a Strong Impact on the likelihood of Product Innovation Success, two have a Measurable Impact, three have a Weak Impact and one has No Impact at all. There is a **Strong** or **Measurable** association between *Product Innovation Success* and four Innovator Attributes: *Marketing, R&D, Technical* and *Business Proficiency*. There is also a Strong or Measurable association between *Product Innovation Success* and two Innovator Behaviours: *Innovation Impetus* and *Time to Market*.

There is a **Strong** association between the way the innovator responds to *Market Size & Growth* and *Product Innovation Success*. Finally, there is also a Strong Association between *Product Innovation Success* and the way both the innovator and the customer deal with three crucial factors: *Customer Characteristics, Customer Processes* and *Customer Environment*.

There was a **Weak** association between *Product Innovation Success* and three other factors: *Willingness and Ability to Source External IP, Market Competitiveness*, and *Communications*. One sole factor, *Market Regulation*, seemed to have no impact at all: this was simply a passive feature of the defence business environment which all innovators handled with roughly similar success – it wasn't in any way a factor discriminating between success and failure.

It will be seen that none of these factors exist in isolation. To take one example, the effects of *Customer Processes* and *Characteristics* have a Strong Impact on the likelihood of *Product Innovation Success*, but in many cases these will be moderated significantly – either amplified or attenuated - by the innovator's own *Marketing* and *Business Proficiency*. Similarly, *Communications* and *Time to Market* are to some degree measures of the innovator's *R&D, Technical* and *Business Proficiency*, as well as of *Customer Characteristics* and *Processes*. The differences between successful and unsuccessful innovations, so far as *Communications* and *Time to Market* are concerned, are reflected in differences between the Proficiencies of successful and

unsuccessful innovators, which may in turn also reflect the way the innovators handle certain Customer behaviours.

The Case Study and R&D Survey results support the argument that companies which undertake Product Innovation projects, and those companies which took the trouble to respond to the author's R&D survey, are inherently more inclined to invest in R&D than their peers in the defence industry. This suggests, therefore, a strong association between self-funded R&D investment and Product Innovation Success – however, it doesn't confirm a direct correlation and further work is required to establish an incontrovertible proof of this connection.

Nevertheless, the argument that such an association exists is strengthened by the fact that only four product innovation projects examined in the Case Studies were based on original IP from DSTO (and two of these failed). One other project was based partly on IP developed by the innovator's industry partner. Overall, 15 of the 20 product innovations examined were based on IP developed in-house.

#### **4.10 Conclusion**

This Chapter has set out the results of the Case Studies and Industry R&D Survey and identified the role that industry R&D plays in innovation success. It also sets out the partial proof of the author's hypothesis that 14 groups of factors described for convenience as 'Independent Variables' have an impact on defence product innovation outcomes. Chapter 5 will discuss these findings in more detail, and use them to develop the outline of a model for Product Innovation Success in the Australian defence industry.

## Chapter 5 – Discussion

### 5.1 Introduction

This Chapter discusses the results of case studies conducted in late-2009 and early 2010 of 20 Australian defence product innovation projects. Their results were presented in Chapter 4 and this Chapter examines the mechanisms by which the Independent Variables exert the influence they do, both individually and jointly, directly and indirectly, and then synthesises them into a rudimentary model for Product Innovation Success.

The case studies showed a number of factors that distinguish between successful and unsuccessful projects. These factors were identified in a study of responses to a questionnaire designed to determine which, if any, of 14 separate factors discriminated for or against *Product Innovation Success*.

It will be recalled that the basic measure of *Product Innovation Success* is the sale of the product concerned to a satisfied customer – in the defence market, as in others, simply achieving a sale is insufficient: the customer must be satisfied with what he has received. As noted in Chapter 3 the determinants of sales success boil down to three factors which to a large degree are measures of the innovator's own business and technical proficiency:

1. **Function** - whether or not the product actually worked and met the user's needs.
2. **Timeliness** - whether or not the product reached the market (or the launch customer) at the appropriate time.
3. **Cost** - a measure of the efficiency of both business planning and technical execution.

It could be argued that in the defence market there are some strategic circumstances where any cost will be borne and almost any delay forgiven in order to field some vital operational capability; more often, some operational contingency requires very rapid fielding of new or improved equipment. In the context of the current research, where the ADF has open access to many local and overseas equipment suppliers, cost and schedule are two key factors influencing its choice, and therefore these are key factors determining the innovator's success, or lack of it.

A fourth, but underlying, factor which has a significant bearing on these is:

**4. R&D Investment** – a measure of the extent to which the innovator invests in R&D and adopts a systematic and methodical approach to the innovation process generally, and also of his capacity to absorb technology and IP sourced externally.

However, as the defence market in Australia is shaped by the Customer-Active Paradigm (CAP), each of these factors is moderated to a sometimes-significant degree by the customer's characteristics and behaviours and the market environment.

In the event the results showed that 8 of the 14 factors tested in the case studies have a Strong Impact on the likelihood of *Product Innovation Success*; 2 have a Measurable Impact; 3 have a Weak Impact; and one has No Impact at all.

There is a Strong or Measurable association between *Product Innovation Success* and four Innovator Attributes: *Marketing, R&D, Technical and Business Proficiency*. There is also a Strong or Measurable association between *Product Innovation Success* and 2 Innovator Behaviours: *Innovation Impetus* and *Time to Market*.

There is a Strong association between the way the innovator responds to *Market Size & Growth* and *Product Innovation Success*. Finally, there is also a Strong association between *Product Innovation Success* and the way both the innovator and the customer deal with three crucial Independent Variables: *Customer Characteristics, Customer Processes and Customer Environment*. There was a Weak association between *Product Innovation Success* and three other Independent Variables: *Willingness and Ability to Source External IP, Market Competitiveness, and Communications*. Finally, *Market Regulation* seemed to have no impact at all: this was simply a passive feature of the defence business environment which wasn't in any way a factor discriminating between success and failure.

As noted in Chapter 4 the strength of the association between any of these factors and *Product Innovation Success* is not a measure of the relevance of that specific factor in the production innovation process. Rather, it is a measure of the likelihood of an unsuccessful innovation project differing from a successful one in that specific case. To the extent that this difference favours the successful project it highlights both the relevance of the individual factors which make that difference and the importance of identifying them and ensuring they align sufficiently with the innovator's goals.

The Case Study Questionnaire results along with the explanatory comment generated during the Case Study interviews made it possible to examine and confirm two of the hypotheses stated in Chapter 3: firstly, that certain generic *Product Innovation Success* factors apply to innovation projects in Australia's defence industry; and secondly that there are also factors specific to the Australian defence market which can affect product innovation outcomes.

## 5.2 Classification of Factors

These generic and defence-specific factors can be classified into five types: the first are *Innovator Attributes* – in effect the internal resources of the innovating company, including the strength of its leadership, its financial resources, its proficiency in marketing and R&D, its engineering and technical strength and its familiarity with the market, the customers and the relevant products and technologies. These are intrinsic to the innovator in the sense they have developed in response to the company's own development and growth strategy over a significant period of time and cannot rapidly be changed or improved significantly, except for the worse through some traumatic event.

The second type are *Innovator Behaviours* - activities and processes where his level of proficiency affects the outcome. For example, the more proactive an innovator is in determining user needs (a measure of marketing proficiency), the greater the chances of success. These factors are not intrinsic in the sense that they can be changed or improved relatively quickly, by recruiting or training key personnel or changing the company's operating procedures, in response to calls from the firm's leadership or to external changes such as unexpected market developments or technological breakthroughs.

These factors, as they have emerged from analysis of the case study results, are consistent with generic product innovation success factors identified in the Literature Review in Chapter 2 and used in Chapter 3 to shape the list of hypothetical innovation success factors that were tested in the case study questionnaire. This research generally confirms that the organisational attributes and behaviours associated with companies which innovate successfully in the non-defence market are seen also in successful defence industry innovators.

The third type are *Customer Attributes*, intrinsic customer factors which the innovator cannot control but which shape the project and affect the outcome – for

example, a high level of risk tolerance on the customer's part is associated strongly with *Product Innovation Success* and is the product, in turn, of the customer's own professional and technical expertise: his understanding of the job he's doing, his proficiency in the necessary skills, and his understanding of the role technology (including industry capability) plays in helping him perform it. Again, these are not attributes which are easily or quickly developed, so can be considered intrinsic to the customer.

The converse to this is a risk tolerance arising from professional and technical incompetence or ignorance. The result can be disastrous over-confidence and utterly unrealistic expectations about the project outcome.

The fourth type are *Customer-Controlled* factors - these are dependent upon or shaped by the customer's behaviour. For example, if the customer appoints a technically and/or professionally competent project champion of sufficient authority there is a very strong association with Product Innovation Success. But this classification includes factors deeper than simple customer behaviour such as market environment factors which are the outcome of conscious policy decisions rather than factors intrinsic to the market place or to the customer. For example, Defence's historical unwillingness to help Australian defence industry exporters (when compared with the export support offered to their respective defence industries by the governments of Great Britain and France, for example) is a policy-driven feature of the market. It is moderated when Defence is in a development partnership with the innovator and therefore has some stake in a successful innovation and subsequent export venture, or when Defence makes a conscious decision (as it does, from time to time) to actively support Australian defence exporters.

The fifth type are *Market Environment* factors intrinsic to the market place which aren't necessarily (or easily) controlled by the customer and which have a significant shaping effect on the market, or potentially present a significant obstacle to success. For example, a business case for a new product development program which can't be satisfied by domestic demand alone is generally characteristic of an unsuccessful product innovation, though exceptions to this rule identified in the case studies highlight the fundamental importance of *Innovator Attributes* and *Behaviours*. Similarly, the absence of an "emerging market with growing demand" is a significant risk factor; the existence of such a market is a positive sign.



To some extent the effects of *Customer Attribute*, *Customer-Controlled* and *Market Environment* factors are determined – either magnified or mitigated - by the innovator's own responses to them and these responses in turn are shaped by innovator characteristics such as *Marketing* and *Business Proficiency*.

While the *Market Environment* is the passive landscape on which most of the product innovation activity takes place, the *Customer Attribute* and *Customer-Controlled* factors are very strong features of the defence market. These classifications emerge from two sources: the first is Von Hippel's theory of the Customer-Active Paradigm, or CAP (Von Hippel 1976; Von Hippel 1978; Rothwell 1986), which ascribes significant importance to the role of the customer in the initiation of product innovation. The second is the author's own unpublished research which identified a possible effect on defence product innovation outcomes arising from the role played by the customer's own capability development and acquisition processes and higher-level policy decisions (Ferguson 2005).

These in turn shaped (to various degrees, some only slightly) 6 of the factors whose hypothetical effects on *Product Innovation Success* were tested in the case studies: *Market Size & Growth*, *Market Competitiveness*, *Time to Market* (these three are the by-product to some degree of the customer's monopsony powers), *Customer Attributes*, *Customer Processes* and *Customer Environment* – in this last case the customer doesn't control the environment as such; rather his response to changes in his operating environment shape market conditions for the industry and its innovators.

As noted in the previous chapter, none of the 14 factors addressed in the survey questionnaire exist in isolation. To take one example, *Communications* and *Time to Market* are also to some degree measures of the innovator's *R&D*, *Technical* and *Business Proficiency* (though they may also be affected by certain *Customer Processes* or by unexpected changes in *Customer Environment*). The differences between successful and unsuccessful innovations, so far as *Communications* and *Time to Market* are concerned, are reflected in differences between the Proficiencies of successful and unsuccessful innovators, which reflect in turn differences between the *Innovators' Attributes*. Therefore, underlying factors such as the inherent *Innovator Attributes* of the innovating companies can be seen to be significant determinants of *Product Innovation Success*.

### 5.3 Re-Classification and Refinement of Factors

Chapter 4 included a list of the factors that were tested in the case studies and the minor factors that emerged from the Qualitative Analysis, along with a measure of their importance. These subordinate factors can be classified into the five separate types listed above, as follows:

#### 1. Marketing Proficiency

- Familiarity with the market – **Innovator Attributes**
- A methodical, systematic approach to marketing - **Innovator Behaviour**
- A close customer relationship - **Innovator Behaviour**
- Pro-active in determining user needs - **Innovator Behaviour**
- Pro-active in shaping customer's view of his needs - **Innovator Behaviour**
- Understanding customer price sensitivity (inferred, not stated) - **Innovator Behaviour**
- Sufficient information to build a sound business case – **Market Environment**

#### 2. R&D Proficiency

- Absorptive capacity – **Innovator Attributes**
- Familiarity with technology in this market – **Innovator Attributes**
- A methodical, systematic approach to R&D - **Innovator Behaviour**
- In-house prototyping capability – **Innovator Attributes**
- Sound project screening capabilities – **Innovator Attributes**
- The availability of in-house IP – **Innovator Attributes**
- Pro-active in seeking to test ideas and hypotheses on customer - **Innovator Behaviour**

#### 3. Technical Proficiency

- Familiarity with technology and manufacturing in this sector – **Innovator Attributes**
- The ability to manage schedule - **Innovator Attributes**
- Access to and reliance on external partners and sources of technology – **Innovator Attributes**
- In-house Software and Hardware capabilities – **Innovator Attributes**
- An Organic rather than Mechanistic structure (inferred, not stated) - **Innovator Attributes**

#### 4. Business Proficiency

- R&D funding access – **Market Environment**
- The ability to manage schedule - **Innovator Attributes**
- The ability to make accurate cost, schedule and technical forecasts - **Innovator Attributes**
- An Organic rather than Mechanistic structure (inferred, not stated) – **Innovator Attributes**
- A supportive, engaged CEO – **Innovator Attributes**
- Appointment of a Senior Project Leader / Champion - **Innovator Behaviour**
- Use of cross-functional project teams - **Innovator Behaviour**

#### 5. Willingness and Ability to Source External Expertise

- Relationship with DSTO or other government defence R&D agency - **Innovator Behaviour**
- Access to and reliance on external partners and sources of technology – **Innovator Attributes**
- Access to critical technology – **Innovator Behaviour**
- Absorptive capacity (inferred, not stated) – **Innovator Attributes**
- TRL of External IP – **Market Environment**
- Access to Defence T&E facilities - **Customer-Controlled**

#### 6. Innovation Impetus

- Customer needs – **Customer Attributes**

- Innovator's focus on market position - **Innovator Behaviour**
- Innovator's willingness to consider incremental innovation - **Innovator Attributes**

## 7. Market Size & Growth

- Potential for repeat sales to same or other customer – **Market Environment**
- Business case satisfied by domestic market – **Market Environment**
- Development partnership with Defence – **Customer-Controlled**
- Export Orientation – **Customer-Controlled**
- Emerging market with growing demand – **Market Environment**

## 8. Market Competitiveness

- Niche market, little competition – **Market Environment**
- Intensity of Competition in the marketplace – **Market Environment**
- Innovator's ability to tackle export market without Defence support – **Customer-Controlled**
- Competitive edge from customer understanding - **Innovator Behaviour**
- Understanding customer price sensitivity (inferred, not stated) - **Innovator Behaviour**

## 9. Time to Market

- Technical Proficiency – **Innovator Attributes**
- Ability to manage schedule - **Innovator Attributes**
- Urgency of user need – **Customer-Controlled**
- Urgency of user need reflected in acquisition strategy – **Customer-Controlled**
- Making first sale on or ahead of schedule (Ability to manage schedule) – **Innovator Attributes**
- Adequate schedule allowance for T&E - **Innovator Behaviour**
- Innovator's ability to tackle export market without Defence support – **Market Environment**

## 10. Customer Attributes

- Customer's familiarity with product/system type – **Customer Attributes**
- Customer's technical and professional understanding – **Customer Attributes**
- Customer seeks innovative technical solutions – **Customer Attributes**
- Customer has funded or undertaken previous work by DSTO/ other R&D organisation – **Customer Attributes**
- Customer validates needs through modelling/simulation – **Customer Attributes**
- Customer understands and articulates own needs – **Customer Attributes**
- Customer has high level of risk tolerance – **Customer Attributes**
- Customer seeks to innovate in practices and processes – **Customer Attributes**

## 11. Customer Processes

- Customer sticks to his own schedule for decisions and processes – **Customer-Controlled**
- Acquisition process reflects user's needs and desired outcome – **Customer-Controlled**
- Risk factors reflected in Capability Development and Acquisition processes – **Customer-Controlled**
- Stable operational requirement (no changes during development) - **Customer-Controlled**
- Customer appoints a project champion – **Customer-Controlled**
- Strong link with White Paper/ higher level guidance – **Market Environment**

## 12. Customer Environment

- High operational tempo – **Market Environment**
- Rapidly evolving threat environment – **Market Environment**
- Ongoing technology growth – **Market Environment**

## 13. Communications

- Teaming or collaboration agreement with DSTO - **Innovator Behaviour**

- Use of cross-functional project team - **Innovator Behaviour**
- Cultural understanding of both DSTO and customer - **Innovator Behaviour**

#### **14. Market Regulation**

- ITAR effect on exportability or export market access – **Market Environment**

This list can be re-made with the major factors deleted and the subordinate factors re-classified under the headings of *Innovator Attributes*, *Innovator Behaviour*, *Customer Attributes*, *Customer Controlled* and *Market Environment*. The re-made list is shown below: duplications have been eliminated, along with one factor, “Making first sale on or ahead of schedule” which is a characteristic of successful projects but a sign of success rather than a structural determinant of success; this leaves 62 factors.

#### **1. INNOVATOR ATTRIBUTES**

- Familiarity with this market
- Familiarity with technology and manufacturing in this sector
- In-house prototyping capability
- In-house Software and Hardware capabilities
- The availability of in-house IP
- Access to and reliance on external partners and sources of technology
- Sound project screening capabilities
- The ability to make accurate cost, schedule and technical forecasts
- The ability to manage schedule
- An Organic rather than Mechanistic structure (inferred from Case Study results, not stated)
- A supportive, engaged CEO
- Absorptive capacity (inferred from Case Study results, not stated)

#### **2. INNOVATOR BEHAVIOUR**

- A methodical, systematic approach to marketing
- Innovator’s focus on market position
- Innovator’s willingness to consider incremental innovation
- A close customer relationship
- Intimate understanding of both DSTO and customer
- Pro-active in seeking to test ideas and hypotheses on customer
- Pro-active in determining user needs
- Pro-active in shaping customer’s view of his needs
- Understanding customer price sensitivity (inferred from Case Study results, not stated)
- A methodical, systematic approach to R&D and R&D investment
- Relationship with DSTO
- Teaming or collaboration agreement with DSTO
- Appointment of a Senior Project Leader/Champion
- Use of cross-functional project teams
- Adequate schedule allowance for T&E

#### **3. CUSTOMER ATTRIBUTES**

- Customer familiarity with product/system type
- Customer understands and articulate own needs
- Customer’s technical and professional understanding
- Customer has funded or undertaken previous work by DSTO/other R&D organisation
- Customer seeks to innovate in his practices and processes
- Customer seeks innovative technical solutions
- Customer has high level of risk tolerance

#### 4. CUSTOMER-CONTROLLED FACTORS

- Urgency of user need
- Customer validates needs through modelling/simulation
- Urgency of user need reflected in acquisition strategy
- User's needs and desired outcome reflected in acquisition process
- Risk factors reflected in Capability Development and Acquisition processes
- Access to Defence T&E facilities
- Customer sticks to his own schedule for decisions and processes
- Development partnership with Defence
- Defence support in export market
- Stable operational requirement (no changes during development)
- Customer appoints a project champion

#### 5. MARKET ENVIRONMENT

- Size of domestic market (inferred from Case Study results, not stated)
- Sufficient information to build a sound business case
- Emerging market with growing demand
- Niche market, little competition
- Business Case satisfied by domestic market
- Potential for repeat sales to same or other customer
- Innovator ability to tackle export market without Defence support
- Strong link with White Paper/higher level guidance
- High operational tempo
- Rapidly evolving threat environment
- Ongoing technology growth in field concerned
- External R&D funding access
- External Access to critical technology
- TRL of External IP
- ITAR effect on exportability or export market access

There are three factors in this list which are of particular importance. The case study responses and subsequent analysis in Chapter 4 showed they are directly linked to project failure and can therefore be termed 'Red Flags':

- Customer understands and articulate own needs (see Major factors 1 and 10)
- Sufficient information to build a sound business case (see Major factor 1)
- Emerging market with growing demand (see Major factor 7)
- TRL of External IP (see Major factors 2 and 5)

To some extent these are all self-evident, but the Case Studies show a strong link with project failure: If the customer doesn't understand and/or cannot articulate his own needs; if there's insufficient market information on which the innovator can build a strong business case for the project; and if the market is mature and demand is either static or declining, then the project is at very high risk of failure. Similarly, if the project demands external IP, the innovator must ensure this is of an appropriate level of maturity or, again, the project is at high risk of failure. These factors can be seen as a test of the innovator's own *Marketing*, *R&D* and *technical*

*Proficiency* in the sense they require the innovator to make informed technical and business decisions, though they are also a reflection of the *Market Environment* and *Customer Attributes*. Their emergence in a product innovation project should be a signal to the innovator (or his customer) to examine the project closely.

#### 5.4 Comparison with existing models

Do the Case Study and R&D Survey results demonstrate that generic innovation success factors apply also in the defence market? In short, yes. Furthermore, the results also confirm the existence of success factors that are specific to the defence market – factors reflecting both market conditions and the behaviours and attributes of the defence customer.

It will be seen from Table 5.1 that many though not all of the *Innovator Attributes* and *Behaviours* map directly on to the Generic success factors identified by Rothwell and others in Project SAPPHO (Rothwell, Freeman et al. 1974). They also resonate strongly with the 18 factors impacting on new product performance identified by Montoya-Weiss and Calantone (Montoya-Weiss and Calantone 1994) and most of Ben-Ari’s 15 key indicators of marketing success in the defence electronics industry (Ben-Ari 2004). These are also listed in Table 5.1, positioned to highlight their links to the author’s Case Study findings.

**Table 5.1: Generic Product Innovation Success Factors – a four-way comparison**

SAPPHO	FERGUSON	MONTOYA-WEISS & CALANTONE	BEN-ARI
Marketing proficiency	A methodical, systematic approach to marketing Innovator’s focus on market position Pro-active in shaping customer’s view of his needs Understanding customer price sensitivity (inferred, not stated) Sound project screening capabilities	Strategic impetus Protocol – firm’s knowledge and understanding of marketing and technical aspects prior to project start Proficiency of predevelopment activities Proficiency of market-related activities Speed to market	Understanding and knowing the customer Mutual trust and confidence Efficient marketing and management Motivated marketing and technical team
R&D proficiency	In-house prototyping capability In-house Software and Hardware capabilities The availability of in-house IP A methodical, systematic approach to R&D R&D funding access Access to critical technology Relationship with DSTO Teaming or collaboration agreement with DSTO	Proficiency of predevelopment activities Proficiency of technological activities	Providing leading edge technology
Understanding user needs	A close customer relationship Intimate understanding of both DSTO and customer The ability to test ideas and	Product advantage	Understanding and knowing the customer Ability to demonstrate the product or system

Product innovation success in the Australian defence industry – an exploratory study

	hypotheses on customer Pro-active in determining user needs		Mutual trust and confidence
Communications proficiency	Use of cross-functional project teams Relationship with DSTO Teaming or collaboration agreement with DSTO Access to critical technology	Internal/ external communications	Efficient representative and/or agent Efficient marketing and management
Management strength	A supportive, engaged CEO Sound project screening capabilities The ability to manage schedule The ability to make accurate cost, schedule and technical forecasts Appointment of a Senior Project Leader/Champion	Company resources Top management support, control and skills Costs Financial/business analysis	Senior management support Efficient marketing and management Efficient representative and/or agent
Familiarity – technical and market	Familiarity with this market Familiarity with technology and manufacturing in this sector	Marketing synergy (Strategic) Technological synergy Protocol – firm’s knowledge and understanding of marketing and technical aspects prior to project start Proficiency of predevelopment activities	Past experience with similar projects Good past performance of the company
Overall understanding of determinants of success	Sufficient information to build a sound business case Development partnership with Defence – helpful in export market Urgency of user need Urgency of user need reflected in acquisition strategy	Protocol – firm’s knowledge and understanding of marketing and technical aspects prior to project start	Competitiveness in price and in terms of payment Past experience with similar projects Good past performance of the company
Competitive pressure	Emerging market with growing demand Niche market, little competition Ability to manage schedule Competitive edge from customer understanding Understanding customer price sensitivity (inferred, not stated) Making first sale on or ahead of schedule	Market size and growth Market competitiveness Speed to market	Global politics Government support Competitiveness in price and in terms of payment Good past performance of the company
Organic structure, rather than mechanistic	An Organic rather than Mechanistic structure (inferred, not stated)	Organisational structure of new product team	
Risk	Sound project screening capabilities The ability to make accurate cost, schedule and technical forecasts Innovator’s willingness to consider incremental innovation Innovator’s focus on market position	Environment, including risk and regulation	

Because the table structure is determined by the 10 SAPPHO success factors and their order of importance, the Montoya-Weiss & Calantone and Ben-Ari factors appear jumbled and random. Some of them also appear more than once because, like the Independent Variables discussed earlier in this Chapter, none of these success factors exists in isolation – they have multiple effects and frequently overlap and interlock.

Ben-Ari's 'Marketing Compass' (Ben-Ari 2004) lists 15 'indicators' of marketing success in the defence electronics industry which are assessed and measured on a five-point scale from 'Very Poor' to 'Very Good' in order to determine the performance and likelihood of success of defence industry marketing managers. These resonate with many of the findings of Project SAPPHO, as well as those of researchers cited earlier (Cooper 1980; Montoya-Weiss and Calantone 1994; Slater and Mohr 2006).

His research did not examine innovation specifically or exclusively. However, a customer adopting a new product or a new technology, even one that has been proven elsewhere, is innovating by introducing change into an existing context and the exporter is a key part of that innovation process. To the extent that innovation success is a by-product of marketing, communications and technical proficiency, Ben-Ari's findings validate my own research in ascribing importance to certain Innovator Attributes and Innovator Behaviours. Furthermore, they provide the foundations for a theoretical "bridge" over which my own research is able to extend existing generic innovation models into the highly specialised domain of the defence market.

Most of Ben-Ari's 15 indicators map easily onto the success factors identified in Project SAPPHO and by Montoya-Weiss and Calantone. However, as noted in Chapter 2, the issues of 'government support', 'global politics' and 'transfer of technology' are distinguishing features of the international defence market, and significant environmental variables in Cooper's taxonomy. The defence market is dominated by governments for domestic political and global geo-strategic reasons. It is also highly regulated for national security reasons and to ensure general compliance with international treaties and agreements on the transfer and proliferation of different types of weapons and weapons-related technologies. While my research is focussed primarily on product innovation to meet the needs of the domestic market, it also acknowledges the importance of an export market which can help expand the innovator's customer and revenue base, and therefore the role of the innovator's parent government in accessing that market. In this sense, my research and Ben-Ari's appear mutually reinforcing.

All these studies generally support each other strongly and don't disagree in any significant aspect, leading to the conclusion that so far as *Innovator Attributes* and *Behaviours* and aspects of the *Market Environment* are concerned, generic success



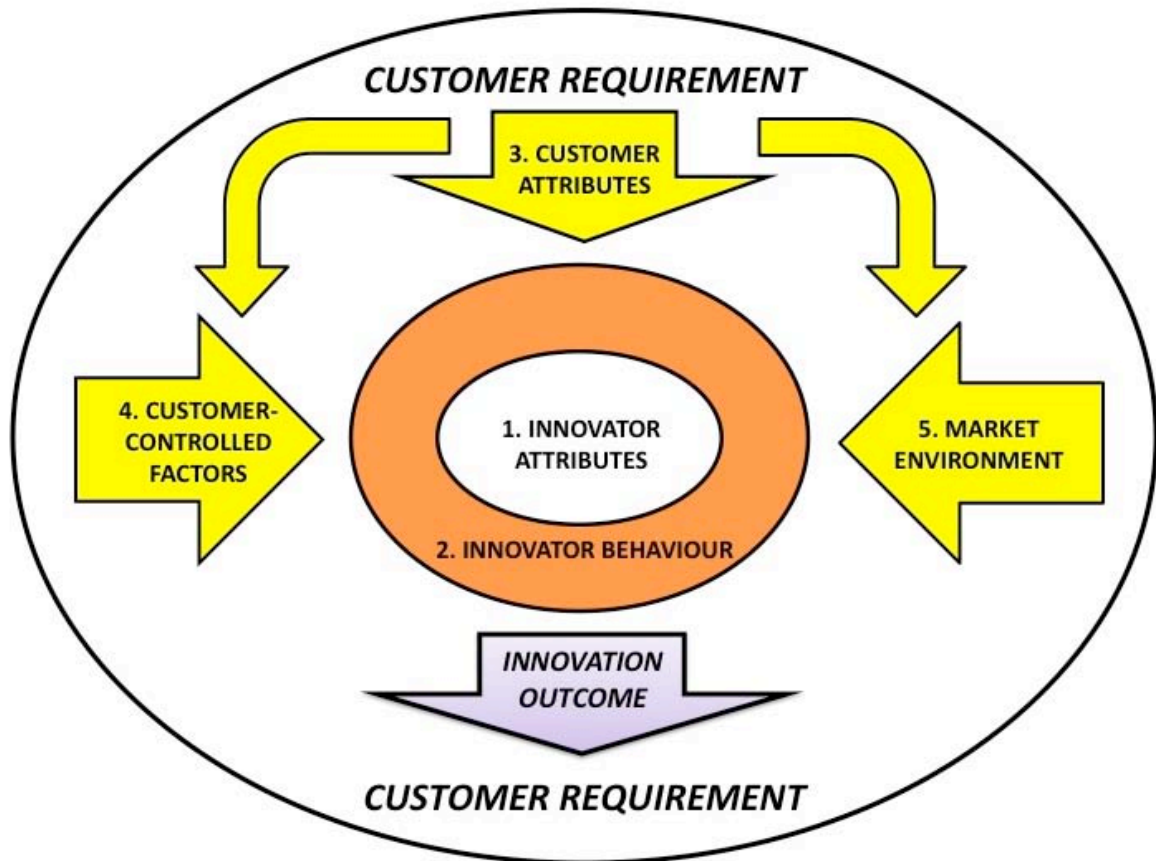
factors and models developed in the non-defence markets for scientific and industrial goods apply equally to Australia's defence market.

However, their importance is moderated by other factors specific to the defence market, which means that a model for *Product Innovation Success* in the Australian defence industry may incorporate features of generic models, but must also account for those *Innovator Attributes*, *Customer Attributes*, *Customer Controlled* and *Market Environment* factors identified in the Case Studies and which are absent from Table 1. Such a model must incorporate these in order to reflect the unique conditions and behaviour of the defence market.

To summarise very briefly: the defence *Market* is different and unique; it could be argued that in many key respects the defence *Industry* is not.

### **5.5 The Forces Acting on the Product Innovation Process**

Figure 5.1 sets out a conceptual Functional Model for *Product Innovation Success* in the Australian Defence Industry that is based on the five classifications identified earlier. This object-oriented model shows how the five groups of factors relate to each other and shape the product innovation outcome. The existence of the Customer-Active Paradigm (CAP) means the innovation process resembles to some degree a closed cycle. Furthermore, in a monopsony and monolithic market such as defence the customer shapes the Market Environment and controls market behaviour to a significant degree.



**Figure 5.1: Product Innovation Success in the Australian Defence Industry – an Object-Oriented Model**

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This is the first model, to my knowledge, which attempts to integrate the CAP into a general model for Product Innovation Success and visualise the mechanisms by which it shapes the outcome. Its value lies, first, in the way it acknowledges the monopsony nature of the defence market, the paramountcy of the CAP and the resulting primacy of the Customer Requirement within it: the entire innovation process begins and ends with the customer and his operational requirement. Secondly, it places the innovator at the heart of the process: *Customer Attributes*, *Customer Controlled factors* and *Market Environment* represent external forces acting on the innovator. A successful innovation outcome is the product of *Innovator Behaviour*, influenced and shaped by intrinsic *Innovator Attributes* and the three external forces acting on him. And just as *Innovator Behaviour* is shaped by *Innovator Attributes*, so *Customer Attributes* shape to some degree both the *Customer Controlled factors* and, due to the CAP and the customer's monopsony status, the *Market Environment*. This means the innate characteristics of the customer are an important factor in determining product innovation outcomes in such a market.

## 5.6 A Predictive Model for Product Innovation Success

The individual factors making up the five key components of this model, and their relative importance, are listed in Table 5.2 (see next page). Their relative importance, and the levels of influence on innovator behaviour and project outcomes exerted by the *Customer Attributes*, *Customer Controlled* and *Market Environment* factors make this table a rudimentary predictive model for *Product Innovation Success*.

The measure of relative importance is either 'High', 'Medium' or 'Low' because, as discussed earlier the small sample size makes it difficult to create a more graduated and statistically valid scale of measurement. These measures were obtained from the difference in the importance attributed to these factors by successful and unsuccessful innovators and, where there was no significant difference between them, measuring the absolute importance, or lack of it, ascribed by the Case Study respondents. Factors assessed as being of Low importance cannot be ignored but did not show up in the Case Studies as significant determinants of Product Innovation Success

However, as noted earlier, four factors are labelled 'Red Flags' – these are critical *Customer Controlled* and *Market Environment* factors which determine project outcomes: if these factors are not right, the project is at high risk of failure.

More generally, it will be seen that the *Innovator Attributes* and *Innovator Behaviour* factors are all considered of High importance; for the purposes of the conceptual model in Figure 5.1 it could be argued that it is incumbent on the Innovator to ensure, so far as he's capable, that his organisation embodies the attributes and demonstrates the behaviours listed below. These will enhance his chance of achieving Product Innovation Success.

However, the *Customer Attributes*, *Customer Controlled* and *Market Environment* factors will shape the innovator's behaviour and in some cases may represent impassable obstacles to Product Innovation Success. The majority of these factors direct the innovator to examine that specific element of the project and determine an appropriate response/approach. For example, if the customer has a track record for not sticking to his own schedule for decisions and processes, the project costs may be higher as the development process may take longer and this must be taken into account in developing the business case for the project. An extended development process also raises the prospect of technology obsolescence or the emergence of a

new or stronger competitor. In this example, the onus is on the innovator to employ his marketing and business skills and judgement to determine, first, whether or not the risk is justified by the potential reward and, second, what product and project development strategy will deliver the best chances of success.

**Table 5.2: A Rudimentary Predictive Model for Defence Product Innovation Success**

<b>1. INNOVATOR ATTRIBUTES</b>	<b>IMPORTANCE</b>	<b>SATISFIED?</b>
Familiarity with this market	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Familiarity with technology and manufacturing in this sector	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
In-house prototyping capability	<b>MEDIUM</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
In-house Software and Hardware capabilities	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
The availability of in-house IP	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Sound project screening capabilities	<b>MEDIUM</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
The ability to make accurate cost, schedule and technical forecasts	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
The ability to manage schedule	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Organic rather than Mechanistic structure	<b>MEDIUM</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
A supportive, engaged CEO	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Absorptive capacity	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
<b>2. INNOVATOR BEHAVIOUR</b>		
Reliance on external partners and sources of technology	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
A methodical, systematic approach to marketing	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Innovator's focus on market position	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Innovator's willingness to consider incremental innovation	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
A close customer relationship	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Intimate understanding of both DSTO and customer	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Pro-active in seeking to test ideas and hypotheses on customer	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Pro-active in determining user needs	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Pro-active in shaping customer's view of his needs	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Understanding customer price sensitivity	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
A methodical, systematic approach to R&D	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Consistent, systematic R&D investment	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Relationship with DSTO	<b>MEDIUM</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Teaming or collaboration agreement with DSTO	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Appointment of a Senior Project Leader/Champion	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Use of cross-functional project teams	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N

Adequate schedule allowance for T&E	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
<b>3. CUSTOMER ATTRIBUTES</b>		
<b>Customer understands and articulates own needs</b>	<b>RED FLAG</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer familiarity with product/system type	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer has funded or undertaken previous work by DSTO/ other R&D organisation	<b>MEDIUM</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer seeks to innovate in practices and processes	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer has high level of risk tolerance	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer seeks innovative technical solutions	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer's technical and professional understanding	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
<b>4. CUSTOMER-CONTROLLED FACTORS</b>		
Urgency of user need	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Urgency of user need reflected in acquisition strategy	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer validates needs through modelling/simulation	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
User's needs and desired outcome reflected in acquisition process	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Access to Defence T&E facilities	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Value of DSTO's IP	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer sticks to his own schedule for decisions and processes	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Development partnership with Defence	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Defence support in export market	<b>MEDIUM</b>	
Risk factors reflected in Capability Development and Acquisition processes	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Stable operational requirement (no changes during development)	<b>MEDIUM</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Customer appoints a project champion	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
<b>5. MARKET ENVIRONMENT</b>		
<b>Sufficient information to build a sound business case</b>	<b>RED FLAG</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
<b>Emerging market with growing demand</b>	<b>RED FLAG</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
<b>TRL of External IP</b>	<b>RED FLAG</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Size of domestic market	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Niche market, little competition	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Business Case satisfied by domestic market	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Potential for repeat sales to same or other customer	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Innovator's ability to tackle export market without Defence support	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Strong link with White Paper/ higher level guidance	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
High operational tempo	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
Rapidly evolving threat environment	<b>LOW</b>	<input type="checkbox"/> Y <input type="checkbox"/> N

Ongoing technology growth	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
External R&D funding access	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
External Access to critical technology	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N
ITAR effect on exportability or export market access	<b>HIGH</b>	<input type="checkbox"/> Y <input type="checkbox"/> N

This Table includes four factors described earlier in the Chapter as ‘Red Flags’:

- Customer understands and articulate own needs
- Sufficient information to build a sound business case
- Emerging market with growing demand
- TRL of External IP

To some extent these are all self-evident, but the Case Studies show a direct link with project failure: If the customer doesn’t understand and/or cannot articulate his own needs; if there’s insufficient market information on which the innovator can build a strong business case for the project; and if the market is mature and demand is either static or declining, then the project is probably is at high risk of failure. Similarly, if the project demands external IP, the innovator must ensure this is of an appropriate level of maturity or, again, the project faces a high risk of failure.

This combination of the conceptual model and the list of component factors represents a predictive tool which may help defence product innovators choose whether or not to pursue a specific opportunity, and how to structure their approach to the project. The third column titled ‘Satisfied?’ is a check list of factors which the innovator should complete as part of his planning process, and then revisit throughout the project in order to ensure he remains on track and that key external factors – *Customer Attributes*, *Customer Behaviour* and *Market Environment* – haven’t changed in significant ways.

While not all factors will be critical to all projects, completing this check list is important for two reasons: first, it requires the innovator to take a methodical approach to the innovation process; and second, it requires him to identify attributes and behaviours which require change or improvement in some fashion in order to enhance his prospects for success. The ‘Red Flags’ should not be seen as a reason for automatic termination of the project but are so strongly associated with the risk of project failure they should therefore be treated as an automatic trigger for review of the project.

Each opportunity to innovate is different - in scale, in technology domain, in market sector and even in the innovator's own impetus. This Conceptual Model may not be detailed enough (because it is not built on a wide enough sample of defence projects) to be applicable to all defence projects, but it does provide a framework within which the innovator can use his own judgement, informed by his market and customer knowledge and his own expertise and technical and business proficiency. It also prompts him to test his knowledge and proficiency: as much as anything else it is a challenge to complacency.

## **5.7 Conclusion**

This Chapter has refined the results of the case studies and confirmed that the likelihood of achieving Product Innovation Success in the Australian defence industry is affected by a mix of generic innovation success factors and factors specific to the defence market. These have been synthesised into a model describing the internal and external forces acting on the product innovation process and a rudimentary predictive model for Product Innovation Success.

## CHAPTER 6 – Conclusions and directions for future research

### 6.1 Introduction

This Chapter summarises the research findings and discusses their implications. It includes answers to the three research questions, limitations of the research, implications for theory, policy and practice, and identifies directions for future research.

### 6.2 The Research Questions

The Preface to Chapter 1 set out the three core questions that are the focus of this exploratory research:

- What are the factors that determine the success or failure of product innovation projects by companies in Australia's defence industry?
- Can these factors be measured and used to create a model, or a more general set of pre-conditions, for successful product innovation within Australia's defence industry?
- To what extent is R&D investment an indicator of product innovation success in the Australian defence industry?

The research achieved its goal: the previous Chapter presented detailed answers to all three questions which confirmed the hypothesis stated in Chapter 2 (see p.xx) that innovation success depends to a significant degree upon factors such as the quality of a company's management, its internal processes, its understanding of the customer's needs, the technology it is dealing with and the market in which it is operating, and the competitive pressures it is facing. In fact, there are a number of generic and defence-specific factors which determine the success or failure of the Australian defence industry's product innovation projects; these can be synthesised into a model which provides some predictive value; and self-funded R&D investment appears to be strongly associated with innovation success, though more work is required to establish a direct, causal link.

### 6.3 Innovation Success Factors

Some 62 factors were found to be associated with Product Innovation Success in Australia's defence industry. These fall under five headings: *Innovator Attributes*, *Innovator Behaviour*, *Customer Attributes*, *Customer Controlled* and *Market Environment*.



The research found that existing generic models for product innovation success and success factors identified in studies by a number of researchers apply also in the defence market. These factors focus on *Innovator Attributes* and *Innovator Behaviour* and can be likened to 'Innovation Best Practice', and it was found that most defence industry innovators, both successful and unsuccessful, followed, or tried to follow, this best practice. Clearly, this is a necessary condition for innovation success, but not in itself a determinant.

What the research showed was that while defence is indeed a unique market, the attributes and behaviours of successful defence companies are generally the same as those of companies that are successful in other markets for high-technology industrial and scientific goods and services. Their behaviours are driven by the needs of the market, but shaped by their inherent attributes. Those attributes can be distilled down to a handful of key characteristics: management strength, situational awareness (that is, knowledge and insight about the market and its behaviour, key players and competitors and the technological threats and opportunities shaping all of these), financial strength, and technological strength.

However, the defence market in Australia, as in most countries, is shaped by the Customer-Active Paradigm (CAP). The ADF is normally the genesis of an emerging customer requirement. If this cannot be met by acquiring equipment or weapons on a Commercial or Military Off The Shelf (COTS or MOTS) basis, the ADF is the trigger for the innovation process which follows: generally in a partnership with DSTO its Capability Development Group (CDG) studies the problem, identifies its principal leverage points and identifies elements of a solution. It then seeks a supplier or developer using the processes of the CDG and the Defence Materiel Organisation (DMO) to solicit market interest and select a contractor.

The defence market is monopsonistic – there is only one customer, so he has the power to control the size and behaviour of the market and the conditions of entry to it – and monolithic: equipment, weapons, platforms and services are generally acquired through a central agency, the DMO. For very good reasons the ADF (like all defence forces) seeks uniformity of equipment in order to achieve uniformity of training, tactics, procedures and logistics support and the economies of scale in each of these areas which this uniformity can provide.

Therefore Product Innovation Success is determined to a significant extent by *Customer Attributes* and *Customer Controlled* factors including the customer's shaping

effect on the *Market Environment*. It could be argued that these factors are intrinsic features of the marketplace and that any innovator with the right combination of management, marketing, financial and technological strength should be able to flourish under these conditions. That is to ignore the moderating effect that such a specialised market has on generic innovator behaviour – market and customer behaviour significantly affect things like project timescales, investment and cash flow requirements and IP access and protection, for example, which is why specialist domain knowledge is so important and why therefore it is essential to create a model for Product Innovation Success which takes into account both generic factors and those domain-specific factors unique to the defence market.

#### 6.4 A Model for the Product Innovation Process

The conceptual model set out in Chapter 5 and reproduced below, is believed to be the first that integrates the generic and defence-unique factors affecting product innovation outcomes in the Australian defence industry.

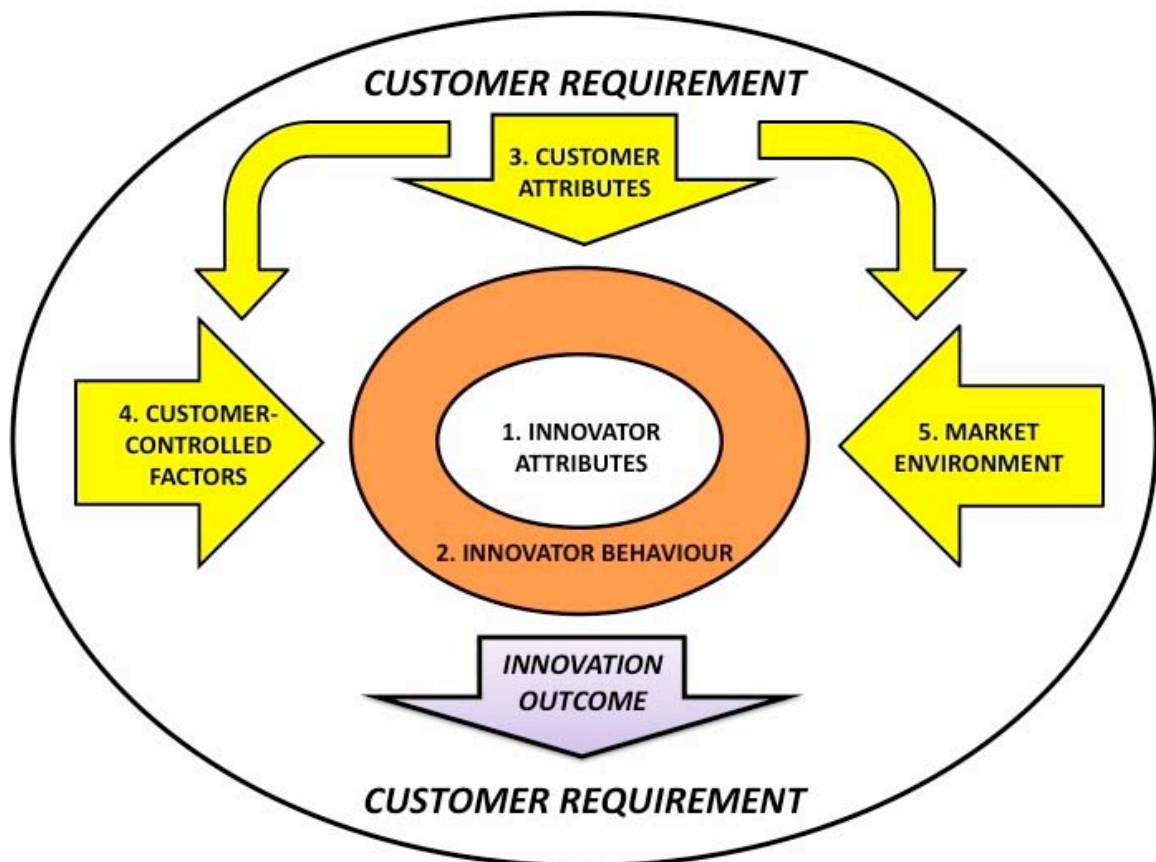


Figure 6.1 - Product Innovation Success in the Australian Defence Industry – an Object-Oriented Model

The value of this model lies in the way it acknowledges the paramountcy of the CAP: the entire innovation process begins and ends with the customer and his operational requirement. Secondly, it places the innovator at the heart of the process: while the customer largely shapes the market environment, the onus is on the innovator himself to negotiate this landscape successfully. The DMO uses competition in the form of competitive tenders to selected contractors who, in its judgement, offer the best value for money. The innovator must make the right decisions and implement them appropriately, and his ability to do so is very much a factor of his own intrinsic characteristics.

Thirdly, the individual factors that make up the rudimentary Predictive Model for Product Innovation Success in Table 5.2 set out in detail the essential attributes of a successful innovator, the innovator behaviours which contribute to success and the customer attributes and behaviours which shape the market and therefore the decision-making and behaviours of the innovator. These are a check list of factors to be aware of and/or conditions to be satisfied.

### **6.5 The role played by industry R&D**

One of the conditions for Product Innovation Success is self-funded R&D by the innovator. While the research failed to determine a conclusive figure for the Australian defence industry's self-funded R&D investment, it did establish a link between R&D investment and innovation success. It achieved this in two ways: first by showing that 16 out of the 20 projects examined were based on IP developed from internal R&D, not from the commercialisation of IP developed by an external R&D agency such as DSTO.

Secondly, the author's R&D Survey tended to confirm a link first detected in the Case Studies between a methodical approach to conducting R&D and product innovation success. Furthermore, in the only two instances where an innovator sought and obtained some sort of R&D grant, both developed highly successful products, reinforcing the positive link between targeted (in other words, methodical and systematic) R&D investment and the likelihood of product innovation success. As for the exact level of self-funded R&D companies undertake, it appears that the companies which took part in the Case Studies spend more on average than the rest of the industry, as reflected in AADI's figures for defence companies in Victoria and the ABS statistics for the industry as a whole – though it was noticeable that the biggest companies, those whose revenue exceeded \$100 million a year, spent a

much lesser proportion of their revenue on average than smaller firms, and much less than major defence companies in the US and Europe (see Appendix 1).

It's the conventional wisdom that industry will invest in R&D only to the extent it can derive a measurable and worthwhile benefit from doing so. Therefore the R&D activity and investment by Australia's defence companies would appear to reflect their view of the market and their prospects of selling indigenously developed equipment and weapons to a risk-averse Defence.

Smaller companies are generally able to identify and target niche opportunities and markets and this may make them more likely to invest in R&D that helps them secure these opportunities. Larger companies try to achieve this also, but tend to seek out higher-value roles as prime contractors or developers of major equipments. This brings them into direct competition with overseas defence firms who are often better able to compete on both price and risk – if foreign firms (or allied defence forces) can offer a MOTS product this may be preferred over a locally-produced developmental product. This in turn may deter the larger companies from investing in large-scale product-related R&D; if they do invest in R&D this is generally to sustain their absorptive capacity, enhance their manufacturing capabilities and, where suitable product opportunities present themselves, pursue these.

## **6.6 Limitations of the research**

The acknowledged limitations of this research fall in two areas: the sample size, and the available figures for industry self-funded R&D.

The sample size, as noted in Chapter 3, was constrained by the Case Study methodology. This set out consciously to copy that used in Project SAPPHO – a straight comparison between successful and unsuccessful innovation projects in the same market sector (Rothwell, Freeman et al. 1974). The limiting factors in this approach were the relatively small size of Australia's defence industry, which limited the number of candidate companies, and the relatively small number of unsuccessful product innovation projects. The difficulty in selecting candidate projects was compounded by the need to ensure that prolific companies didn't feature too often and so skew the results in some way, and also by the need to match unsuccessful projects with successful projects of a comparable scale and complexity. It was also found that a number of small companies were reluctant to take part, citing lack of time on the part of the key individuals concerned.

For this reason, while the Case Studies did identify clear differences between successful and unsuccessful projects, the small sample size made it impossible to determine degrees of difference in a statistically valid way, and therefore to assign more than a crude weighting to individual success factors. Therefore the individual success factors are treated very simply – their importance is rated as either *High*, *Medium* or *Low*.

Overall, the Predictive Model set out in Chapter 5 may not be detailed enough nor built on a wide enough sample of defence projects to be applicable to all defence projects. Nevertheless, it provides a decision-making framework with an inherent though limited predictive capacity within which the innovator can use his own judgement informed by his market and customer knowledge and his own expertise and technical and business proficiency

### **6.7 Limitations of the Industry R&D Survey**

Similarly, the R&D Study drew a disappointingly small response from the defence industry: just 19 firms took part, so the results of this survey are illustrative rather than definitive. And the Case Studies also generated industry R&D statistics which can't be described as definitive. A sample of 20 companies doesn't provide a statistically valid representation of the industry as a whole, and the difficulties that some companies felt in exposing what they considered to be sensitive information made it difficult to provide a solid basis for comparison.

Furthermore, there were difficulties in identifying the R&D investment associated with a specific project – some of the projects were completed prior to a company merger or take-over while others had been undertaken several years prior, which meant that the precise R&D investment in a specific project was frequently impossible to establish. Therefore companies were asked to state their R&D investment for the previous financial year; this provided a somewhat low-resolution snapshot of recent patterns of industry R&D activity and investment.

### **6.8 Implications for Theory**

So far as can be determined, this research is the first to seek out and examine product innovation success factors in the Australian defence industry. It therefore places a single marker in a theoretical landscape which is yet to be surveyed and mapped fully. However, my research does extend existing theory on product innovation into this new landscape: generic innovation models and success factors

have been shown to apply also in the defence market. But their predictive value is moderated by factors unique to the defence marketplace.

My research shows that Product Innovation Success factors identified in a range of studies and meta-analyses apply also in Australia's defence market. In Chapter 5 I highlighted the similarities between my own findings and those of Rothwell, Montoya-Weiss & Calantone and Ben-Ari; these similarities extend to a range of other studies including Project SAPPHO (Rothwell, Freeman et al. 1974; Rothwell 1985), Project NewProd (Cooper 1980) as well as work by other researchers (Utterback 1971; Cooper 1980; Parkinson 1982; Cooper 1984; Rothwell 1986; Kleinschmidt and Cooper 1988; Johne and Snelson 1990; Montoya-Weiss and Calantone 1994; Goldsmith 1995; Lux and Rorke 1999; Henard and Szymanski 2001; Cooper, Edgett et al. 2002; Robert G Cooper, Edgett et al. 2002; Sohn and Moon 2003; Yencken and Gillin 2003; Sohn and Moon 2004; Cornford 2006; Slater and Mohr 2006; Paladino 2007; Rosa and Rose 2007; Chen, Damanpour et al. 2009) (Ben-Ari 2004).

The features which distinguish the defence market from others demand a new or modified theoretical approach to innovation research. Many of these features – for example the Customer-Active Paradigm (CAP), driven by the specialised knowledge of a relatively small community of expert practitioners - are found in other markets.

It is the unique combination of the CAP and the Monopsonistic and Monolithic nature of the defence market, moderated by the customer's risk aversion, which sets this market apart in Australia, as noted in Chapter 1. Extensions of innovation theory into the defence market must absorb and integrate these features in order to create a proper understanding of the factors affecting Product Innovation Success in that market, and how they interact. My own research and the resulting model is a first step in that direction; it should not be the last.

The Monopsonistic nature of the defence market, and the fact that the Monopsony is 'owned' by the Australian government (through the Department of Defence), means the market has been shaped to varying degrees at different points in history by national and departmental politics moderated to some degree by State-level politics and players. However, the thrust of political debate on defence acquisition in Australia has tended to focus on higher level strategic issues of technology access and appropriate levels of defence self-reliance (Bruni 2002). The mechanics of

selecting equipment, ensuring value for money, directing and undertaking R&D and formulating and administering defence industry policy has tended to be the function of bodies such as the CDG and DMO and their predecessors within the Federal bureaucracy. The literature on these aspects of defence procurement has tended to examine policy rather than process (Dibb 1986; Dibb 1992; Defence 1997; Hawke 2000; Hinge 2000; Kinnaird 2003; Moon, Smith et al. 2004; Trenberth 2004; di Bartolomeo 2005; Middleton, Bowns et al. 2006; Wylie 2006; Wylie, Markowski et al. 2006; Wylie 2007; Mortimer 2008; Brabin-Smith 2009; Pappas 2009; Wylie 2009).

The exceptions have tended to examine DSTO's role and the mechanisms for transferring technology and IP from DSTO to industry (Moon, Smith et al. 2004; Trenberth 2004; Finn 2010).

My research tries to address the practical aspects of defence innovation and procurement which are shaped, of course, by policy. In that sense, I am trying to close the gap between Australian defence policy, and defence industry policy in particular, and innovation theory in the wider industrial world. This thesis is a first attempt to create that link and provides a basis for future research by others.

The implications of my research to innovation theory in the defence market are confined deliberately to the field of product innovation for the military end user. There has been no attempt to develop a theoretical model for innovation in the defence services sector, nor for innovation to generate improvements in manufacturing, marketing and logistics processes. These bear a resemblance to the processes employed in other high-technology and highly regulated industries such as commercial aviation and pharmaceuticals and models developed for these sectors may be capable of being extended into the defence market also, but this is not part of my research.

## **6.9 Implications for Industry Practice**

The implications of this research are twofold: first, for the defence industry; and secondly for Defence itself – the ADF, CDG, DMO and DSTO and those formulating and administering defence policy.

This thesis is not intended as a “how to” manual for defence companies seeking to develop new products: it is not an engineering, design or marketing manual. Rather, it highlights a mixture of organisational and cultural attributes of successful

defence industry innovators and the customer and market environment factors which direct their behaviour.

An important finding of this research (one which is consistent with other research outside the defence sector) is that good ideas and good technology are essential, but they are not enough. The innovator must understand the customer and his needs; he must be capable technically of developing a good idea into a product which meets those needs, and he must be capable of building and delivering it to an acceptable price and level of quality and within a reasonable schedule. The emphasis, therefore, is on a company's proficiency in a holistic sense: all of the *Innovator Attributes* and *Behaviours* listed above are important components of a company's competitiveness and ability to develop innovative new defence products successfully.

This has implications for the management style and structure of defence companies as well as management, technical and marketing skill training and development within the defence industry, and for investment in R&D. Fundamentally, defence companies seeking to flourish as defence product innovators can draw upon examples and models in other high-technology industry sectors. However, the strongest parallels will be found in industry sectors where there is a high level of detailed discourse between innovator and customer: this is typical, indeed almost characteristic, of sectors such as advanced machine tools, scientific instruments, medical equipment and aerospace. The consumer market requires innovators to conduct extremely detailed and extensive market research but still places the innovator at a considerable remove from the customer, compared with the industrial and scientific markets.

### **6.10 Implications for Defence Policy and Practice**

*Customer Attributes*, *Customer Controlled* factors and the *Market Environment* shape innovation outcomes also; to a considerable extent Product Innovation Success is a function of the innovator's ability to deal with these factors. Some of them – the 'Red Flags' - are potentially insurmountable stumbling blocks to innovation success; the innovator may be able to work around or compensate for shortfalls in some of the others. The *Customer Controlled* factors are not structural but are instead procedural or policy related and it is in the customer's power to change these or to allow exceptions if he sees fit.



Therefore the policy implications for Defence are, again, two-fold. A Conceptual Model now exists which highlights the role of the customer in defence product innovation, and how the customer's attributes and behaviours shape the process and eventual outcome.

To the extent Defence and the DMO feel a responsibility to contribute actively to successful product innovation projects the model provides, first, a checklist of intrinsic attributes and customer behaviours which Defence should embrace and adopt in order to facilitate the desired outcome. Where the Customer-Active Paradigm applies, Defence must recognise its own role in the product innovation process and engage closely with the innovator. An acquisition process designed to achieve best value for money from a COTS or MOTS purchase is unsuited to the relatively high-risk environment of a developmental project that requires close cooperation between the customer and innovator. This model also provides tools to help the DMO identify innovators with the right attributes and behaviours to deliver the results Defence requires.

Secondly, in describing the combination of innovator and customer attributes and behaviours and market factors contributing to innovation success, the model provides a framework on which Defence can create and grow a defence industry policy which provides an environment in which Product Innovation Success is more likely. This links to the previous paragraph in as much as policy settings which explicitly encourage and support Product Innovation Success require the customer to ensure his own processes, skills and policies are attuned to these goals. This has implications for the mix and types of skills required in CDG and DMO project offices and for the role of DSTO.

### **6.11 Implications for Defence Policy - DSTO**

The importance of DSTO to the defence of Australia cannot be denied. But the organisation is not a significant source of IP for Australian defence product innovators. Any change in defence (and defence industry) policy that encourages and seeks to facilitate product innovation by Australia's defence industry should naturally consider DSTO's position and the mechanisms, procedures and policies required to transfer and commercialise IP developed within the organisation.

As noted earlier, this research has established a link between company R&D investment and innovation success. It achieved this by showing that 16 out of the 20

projects examined were based on IP developed from internal R&D, not from the commercialisation of IP developed by an external R&D agency such as DSTO – notwithstanding the importance of a close relationship between industry and DSTO. The R&D Survey also tended to confirm a link between a methodical approach to conducting R&D and product innovation success. Given that the majority of defence R&D (or S&T) funding in Australia is allocated to DSTO, it is arguable that Australia's defence industry, and the ADF, pays an opportunity cost due to the low priority accorded to IP commercialisation by defence and DSTO.

A more deliberate and focussed IP commercialisation policy might have the effect of a 'virtual' increase in Australian industry R&D if the appropriate commercial links can be formed between DSTO and industry. But as this research demonstrates, real benefits are unlikely without a more forward-leaning stance by Defence and the ADF: unless they acknowledge and embrace the Customer-Active Paradigm and engage more whole-heartedly in the innovation process it's unlikely that demand from industry for DSTO's IP will see sustained growth. In any case, the internal policy and governance reforms required within the ADF, CDG, DMO and DSTO (not to mention the higher levels of the civilian bureaucracy within both defence and the other major Federal government departments) to enable a more systematic commercialisation process of genuine military and economic benefit make such a change either very unlikely or a slow, drawn-out process, possibly requiring decades rather than years.

### **6.12 Directions for future research**

The limitations of this research, described earlier, provide a useful starting point for future research.

In particular, it would be useful to be able to determine a true figure for Australian industry's defence-related R&D and establish and characterise the nature of the direct relationship between levels of R&D investment and Product Innovation Success. This would require a considerably bigger sample size in order to establish the link between R&D investment and the success of a company's product development activities.

Secondly, responses to the Case Study questionnaire suggests future researchers might profitably revisit the 'Independent Variables', integrate some of the sub-factors making them up into Independent Variables in their own right and then

analyse their effect on product Innovation Success: notably the four 'Red Flags' and, more generally, *Customer Knowledge*, *Operational Tempo* and *Rapidly Changing Threat Environment* and the roles and seniority of a project's *Business or Technical Champions* within both the customer and innovator organisations.

Thirdly, the small sample size used in this research constrains the conclusions which may be drawn from the Case Study results. The sample size is the natural consequence of the methodology employed, which sought to compare successful projects with unsuccessful projects of a comparable size and nature. But extending the study to cover more projects without attempting to match comparable successes and failures, and even if there is a preponderance of successful projects, would add to my original findings and provide industry planners and policy makers with more refined data.

Fourthly, while my research concentrates exclusively on defence product innovation in Australia, there is no reason why future research shouldn't examine defence product innovation in other countries, as well as defence equipment sustainment which is a more significant source of revenue for Australia's defence industry than manufacturing. There is no reason to believe that generic innovation success factors which have been shown to apply to the attributes and behaviours of Australian defence companies should not apply also to defence companies in, say, the USA, the UK or countries in Europe, Scandinavia and elsewhere. This hypothesis would need to be tested, however. Similarly, there is reason to think that at least some of the product innovation success factors identified in this research might apply also in the sustainment field, but again this hypothesis would need to be tested.

More importantly, the research should seek to identify and quantify, if possible, factors unique to the defence markets in these countries. While it's unrealistic to expect that the defence-unique factors which shape product innovation outcomes in Australia apply in exactly the same way in other markets, it is likely the model I have constructed for Australia's defence industry can be adapted and extended to provide a predictive tool for defence industry innovators and policy makers in these other countries.

### **6.13 Conclusion**

This research presents a conceptual model for Product Innovation Success in the Australian defence industry. This model, which includes a predictive capability, is

capable of being refined and enhanced, and the landscape of Australia's defence business environment remains to be surveyed and mapped properly. But this work contributes to, and extends into a new area, the general body of theory on product innovation and makes a practical contribution to defence industry policy and practice in Australia.

## APPENDIX 1 – Defence Industry R&D Survey

It is almost axiomatic that high-technology products and services are the end result of some form of Research and Development (R&D), followed by some form of commercialisation process, and then by more R&D, leading to market entry. This end-to-end process can be termed 'Innovation' and doesn't apply solely to high-technology products and services. However, the higher the levels of technology embodied in the product or service in question, the more important the role of R&D in the innovation process.

The literature on innovation success that is cited in Chapter 2 highlights the importance of a methodical approach to R&D by an innovator, and the importance of R&D proficiency as a factor in successful product innovation. Gillan and Yencken, for example, identify a linkage between R&D investment and product innovation success (Yencken and Gillin 2003). Most of this literature is based on studies of non-defence companies and markets and part of the purpose of the author's research is to establish whether factors (such as R&D investment and proficiency) that have been shown to affect product innovation outcomes in the non-defence sector are similarly important in the defence sector.

It is hypothesised that there are certain factors which determine the success or failure of product innovation projects by Australian companies. Some of these are generic in the high-technology marketplace, and some of them are specific to the defence market. In a high-technology market place one of the significant factors affecting product innovation outcomes might be the level of resources that Defence and industry invest in R&D. An association has been shown to exist between levels of industry R&D and Product Innovation Success (see Chapters 4 and 5), but it's impossible to explore this relationship without access to accurate and detailed figures on R&D expenditure by both defence and Australia's defence industry.

Every two years the Australian Bureau of Statistics (ABS) publishes figures for government, academic and industry expenditure on defence-related R&D in Australia (ABS 2010). No other body of defence R&D statistics covering the same periods, and collected using a consistent, year-on-year methodology, are known to exist, although the Intellectual Property Research Institute of Australia (IPRIA) included defence industry R&D figures as a small sub-set of the R&D and

Intellectual Property Scorecards it published between 2004 and 2007 (IPRIA 2004; IPRIA 2005; IPRIA 2006; IPRIA 2007). However these bodies of statistics appear to contradict each other quite significantly; more importantly, the ABS figures do not present industry R&D investment as a proportion of revenue, while the IPRIA figures do. These frustrating discrepancies between the ABS and IPRIA figures prompted the author to explore further.

In late-2009, during the author's three-month Defence Industry Fellowship with the Defence Materials Technology Centre (DMTC), a survey was conducted of Australian defence companies to determine the amount they spend on R&D. The survey questionnaire asked, so far as possible, the same questions posed by Wylie in his 2004 study of the Australian defence industry (Wylie 2004) in order to provide a stable comparison between sets of data gathered six years apart. This would enable changes in behaviour or outlook to be identified and would also provide an R&D expenditure figure which would either vindicate or cast further doubt on the ABS figures. It should be noted Wylie's paper did not publish all of the responses to his 2004 survey, and the original copies of the responses themselves are no longer available, so the only possible comparisons are between the 2009 survey and the data published by Wylie in 2004.

The first six questions were framed by the author and designed to establish whether any link exists between R&D investment and the general performance (profitability, growth and financial performance) of companies in the Australian defence industry. Given the difficulties experienced elsewhere in obtaining firm dollar figures for R&D investment and financial performance, the questions were framed in a more general way. The survey questions and complete set of responses are listed at Appendix 2.

It was unrealistic to expect that every company generating all or most of its revenue from defence activity would respond, and therefore gross expenditure on defence-related R&D would be impossible to obtain. But it was hoped sufficient data would be gathered to enable a realistic assessment of the proportion of revenue Australian defence companies devote to R&D. The survey was carried out online using the Survey Monkey questionnaire system via the DMTC's Survey Monkey account.

The survey was publicised through a number of Australian industry associations, through Australian Defence Magazine (ADM) and through the Defence Materials Technology Centre (DMTC); nevertheless, although the survey was conducted

'blind' and participants were assured total discretion, participation rates were disappointingly low with only 19 companies responding.

Therefore the results can't be considered 'definitive' in any sense of that word, but they are certainly illustrative and in one instance the result was unambiguous: in response to Question 1 only 31.6% of respondents stated they spent less than 1% of turnover on R&D; 10.5% stated they spent between 1.1 and 2%; and the remainder, some 67.9% stated they spent over 2% - of whom 42.1% stated they spent over 5%. This is considerably more than the average industry R&D spend determined by IPRIA (see below).

In response to Question 2, some 63.2% of respondents stated that they conducted R&D on innovation activities in areas defined by the Department of Defence as Priority Industry Capabilities (PIC). This suggests an awareness within the industry of the customer's strategic needs and priorities.

Questions 3 and 4 address the value of R&D activity to the company's performance; Q.3 addressed profitability while Q.4 addressed business growth. Over the period 2006-07 to 2008-09, 15.8% of respondents reported a moderate or significant decrease in profitability and 15.8% reported a moderate decrease in growth. On the other hand, 52.6% reported an increase in profitability (10.5% said 'significant') and 57.9% reported an increase in growth, of whom 26.3% reported a significant increase. This is too small a sample to support firm conclusions, but responses to these questions do point to a definite association between R&D investment, profitability and growth.

Questions 5 and 6 address the company's financial performance and overall performance (a combination of growth, profit and financial performance). Responses to both questions were identical: 10.5% reported their companies' performance failed to meet expectations; 73.7% stated that performance met expectations and 15.8% stated that performance exceeded expectations. Again, this points to a general association between R&D investment and company performance.

Questions 7 to 10 were the same as those posed in 2004 by Wylie. Question 7 asked respondents to rate the importance to their business of the "Introduction of new or substantially changed products for sale" and "Introduction of new or substantially changed production processes". In 2009 the majority of respondents, 17 and 16,

respectively, rated each initiative as 'Moderately' important, or higher; some 11 of 19 respondents rated the importance of new production processes as 'High' or 'Very High'; 10 of 19 respondents rated new products as 'High' or 'Very High' – seven rated new products as 'Moderately' important. These responses would seem to suggest a systematic approach to R&D by respondents which is reflected in their Innovation Impetus; looking back at responses to the previous questions, there would also appear to be an association between systematic, targeted R&D investment and company performance, though the sample size is too small to state such an association with any real confidence.

In Wylie's 2004 study it was found that 55 of 93 respondents rated the importance of new products as 'High' or 'Very High' ('Critical' in Wylie's nomenclature) while 37 of 83 respondents rated new or changed processes as 'High' or 'very High'. Wylie also found that organisational innovation was an important factor in company development and growth: his definition of Innovation included 'Revised organisation or personnel structures' (36 of 92 rated this 'High' or 'Very High'); 'Upgrading employee skills' (53 of 92 rated this 'High' or 'Very High'); and 'Revising relations with customers, distributors or suppliers' (53 of 97 rated this 'High or Very High'). These other measures of innovation, because they did not focus explicitly on product innovation, were not considered in the author's 2009 Defence Industry R&D Survey. They could be the basis of fruitful ongoing research in the future.

It should be noted in 2009, compared with 2004, there was more visible enthusiasm for improving production processes than for developing new products: this may be an echo of the Case Study findings inasmuch as technical proficiency and familiarity with the technology and manufacturing process in a given domain is strongly associated with Product Innovation Success.

Question 8 addresses the importance of various sources of IP. It mirrors the Case Study results in that 13 of 18 respondents rated the importance of in-house R&D as 'High' or 'Very High'; eight respondents also rated the importance of IP from a parent company as 'High' or 'very High'. Otherwise, respondents generally ascribed 'Low or 'Very Low' importance to IP purchased or licensed from a vendor in Australia (14 of 18 respondents); a vendor overseas (10 of 18); and, counter-intuitively, from a parent company (also 10 from 18). The importance placed by



respondents on in-house R&D again suggest a link between R&D investment and business performance.

These findings echo Wylie's from 2004: he found 48 of 81 respondents rated 'In-House R&D' as 'High' or 'Very High'; 15 of 55 respondents rated collaborative research the same way; 17 of 39 rated IP from a parent as 'High' or 'Very High' (16 rated this source 'Low' or 'Very Low'. The importance of in-house R&D as a source of IP over other external sources remains constant.

Responses to Question 9 suggest the majority of innovative defence companies in Australia are in what Wylie classifies as the 'Engineering and Technology' domains. Interestingly, all 18 respondents stated they devoted some R&D expenditure to this domain while eight said they also devoted R&D funding to 'Information, computing and communication sciences', and only three put any funding towards R&D into 'Physical, chemical or earth sciences'. One stated he put 50% of his R&D expenditure towards improving manufacturing processes, the equivalent of his combined R&D expenditure on ICCS (20%) and Engineering and technology (30%).

These classifications, drawn from the Australian Bureau of Statistics, don't map conveniently on to any of the classifications in the Case Study (Question A), so it's hard to draw any helpful conclusions from the responses to this question. In any case, Wylie didn't publish the responses to this question.

In response to Question 10 – "Defence suppliers undertake R&D or innovation activities for many reasons, such as meeting new defence requirements or making the existing defence business more profitable. Please estimate the proportion (%) of your business's R&D/innovation expenditure between 2006-07 and 2008-09 that was undertaken for the following reasons:" some 15 of 18 respondents (again, one skipped the question) stated they did so 'To develop in-house new proprietary IP or technology for sale to Australian or other overseas defence customers.' Of these, 11 devoted 50% or more of their R&D expenditure to this purpose. A similar number stated they devoted R&D expenditure to 'Adapt[ing] IP or technology sourced elsewhere'; of these only three allocated more than 50% of their R&D budget to this purpose. Some 11 respondents stated they invested in R&D 'To improve profits by developing and introducing more efficient arrangements to supply defence-related goods and services', of whom one stated he devoted 100% of his R&D budget to this purpose.

Interestingly, only 5 of 18 respondents stated they invested in R&D ‘Under contracts with Australian or overseas defence agencies.’ In one case this amounted to 80% of the company’s R&D spend; the other four devoted between 10 and 20%. This is an acknowledgement that some of the industry’s R&D activity is funded by Defence. However, it’s not clear whether this is contract R&D or work undertaken once a company is in contract to develop a new piece of equipment, or undertaking a Defence-funded Initial Design Activity (IDA) or similar process to mitigate project risks prior to competitive selection. In any case, responses to this question suggest very strongly the majority of defence industry R&D work is self-funded and systematic and directed by a clear vision of what it is intended to achieve. Again, Wylie didn’t publish the results to this question, either.

Question 11 simply asked respondents to offer any comment they wished to add on their businesses’ R&D and innovation activities or on Australia’s defence R&D environment more generally. Three respondents chose to comment. One, obviously a multi-national manufacturer of commercial (ie non-defence) as well as defence equipment stated:

“[Company X’s] R&D is principally commercially focused on a global basis. R&D in the Defence & Aerospace sector is performed as part of our industry segments approach. This may find it’s way into embedded functionality in any of our COTS hardware or software product lines or may be developed for tailoring, adoption and integration of COTS hardware and software for Defence-specific purposes.”

The other two addressed the defence R&D environment more specifically. The first stated:

“The key driver of successful innovation is market demand. In the Australian defence space this is solely determined by the policies surrounding defence capability development and acquisition. Unless there is a clear path to a contracting mechanism to procure a capability, the likelihood that innovation investments will lead to successful commercial outcomes is very low.”

The second was quite blunt:

“DMO’s obsessive need to ensure there is no competitive advantage to local SMEs is harming local capability in Australia. There is no longer an advantage

to bid from a local capability and sometimes it appears that being a local capability in the eyes of DMO is actually detrimental.”

The second and third comments acknowledge and validate (though unconsciously) the Customer-Active Paradigm (CAP) and the monopsony defence customer’s critical shaping effect on the size and behaviour of the Australian defence market and the barriers to entry (or lack of them) facing local and overseas players.

### Defence R&D in Australia – a wider context

Discussion of defence R&D, whether by Defence itself or by industry, is enriched by placing it in a broader context. Tables 1 and 2 show Australia’s overall R&D investment by government and industry, and Australia’s investment in defence R&D. There are two striking contrasts here: while total government R&D expenditure nearly doubled in dollar terms between 1992 and 2009, the fast-growing economy means it declined by more than a third as a percentage of GDP. Meanwhile industry’s total R&D investment has grown six-fold with the expanding economy to \$16.8 billion, or 61% of the national total.

**Table 1: Australian R&D Expenditure 1992-2009 (then-year A\$ million)**

	National	Government Total	Higher Education	Business	Business % of Total*	Government R&D Spend (% of GDP)
<b>1992-93</b>	6,483	1,824	1,695	2,862	44.15	0.43
<b>1994-95</b>	7,466	1,976	1,829	3,508	46.99	0.42
<b>1996-97</b>	8,792	2,064	2,307	4,235	48.16	0.39
<b>1998-99</b>	8,918	2,043	2,555	4,095	45.91	0.35
<b>2000-01</b>	10,417	2,355	2,789	4,982	47.83	0.35
<b>2002-03</b>	13,211	2,482	3,430	6,940	52.53	0.33
<b>2004-05</b>	15,968	2,486	4,327	8,676	54.33	0.27
<b>2006-07</b>	21,777	3,095	5,433	12,639	58.04	0.28
<b>2008-09</b>	27,740	3,420	6,717	16,858	60.77	0.27

Source: Australian Bureau of Statistics.<sup>1</sup>

In 2008/09, Australia invested 2.2% of its GDP in R&D, amounting to some \$27.7 billion. Some 3% of this (\$800.8 million) was spent on defence R&D. However, Defence does not mirror the rest of the economy, as Table 2 shows. Contrary to the overall national trend, Government defence R&D—in effect DSTO’s budget—has

more than doubled in dollar terms as a relatively stable 2% of the rapidly growing defence budget; and the defence budget has consumed a consistent 1.8-2.0% share of GDP over this time. Meanwhile, industry's share of defence R&D has declined.

**Table 2: Australian Defence R&D Expenditure 1992-2009 (then-year A\$ million)**

	Defence Budget	Total Defence R&D	Government Defence R&D**	Government Defence R&D (% of Defence Budget*)	Higher Education Defence R&D	Business Defence R&D	Total Defence R&D (% Defence Budget*)
1992-93	9,509	346.2	208.9	2.20	2.9	134.4	3.64
1994-95	10,104	373.1	226.2	2.24	4.8	142.0	3.69
1996-97	10,611	437.0	234.0	2.21	7.2	195.8	4.12
1998-99	11,738	348.9	205.0	1.86	5.8	138.0	3.17
2000-01	14,453	401.1	238.6	1.65	4.3	158.1	2.78
2002-03	19,513	527.7	283.8	1.45	10.9	232.9	2.70
2004-05	20,569	616.6	309.3	1.50	29.2	278.0	3.0
2006-07	22,189	925.3	507.4	2.29	40.8	377.0	4.17
2008-09	24,081	800.8	486.0	2.02	55.4	259.4	3.33

Sources: Australian Bureau of Statistics, Defence Portfolio Budget Statements and Annual Reports, ASPI Defence Budget Briefs 2003-2010; SIPRI Military Expenditure Database NB: Expenditure in AUD\$ '000s

The sharp contrast between business investment as a proportion of total defence R&D and as a proportion of national R&D is highlighted in Table 3. The latter has grown by nearly 30% since 1992 while the former has remained more or less constant during the same period, despite the significant growth in the defence budget over that time.

In relative terms, therefore, it appears the Federal government invests nearly seven times as much in defence R&D as it does in other forms of R&D across the economy as a whole. However, straight comparisons may be meaningless: DSTO's budget comes directly from Defence and therefore, as noted in Chapter 1, isn't subject to the same competition for resources and isn't subject to the same oversight mechanisms as other government R&D funds from sources such as the Federal Department for Innovation, Industry, Science, Research and Tertiary Education (DIISRTE).

**Table 3: Australian Defence and National R&D Expenditure 1992-2009: Some Comparisons**

Financial Year	Government R&D (% of GDP)	Government Defence R&D (% of Defence Budget*)	Total Defence R&D (% of National R&D)*	Government Defence R&D (% of national*)	Business R&D (% of Total Defence R&D*)	Business R&D (% of National*)
1992-93	0.43	2.20	5.34	11.46	38.80	44.15
1994-95	0.42	2.24	5.00	11.45	38.07	46.99
1996-97	0.39	2.21	4.97	11.34	44.80	48.16
1998-99	0.35	1.86	4.97	10.04	39.56	45.91
2000-01	0.35	1.65	3.91	10.13	39.40	47.83
2002-03	0.33	1.45	3.85	11.44	44.14	52.53
2004-05	0.27	1.50	3.86	12.44	45.10	54.33
2006-07	0.28	2.29	4.25	16.39	40.75	58.04
2008-09	0.27	2.02	2.89	14.21	32.40	60.77

\* denotes calculated by author

Sources: Australian Bureau of Statistics. 81120DO001\_200809 and 81120DO008\_200809 "Research and Experimental Development, All Sector Summary, Australia, 2008-09", October 2010.

As shown in Table 3 Australian industry's declining contribution to national defence R&D (despite nearly doubling in dollar terms) is surprising: the high-technology defence sector seems to be under-investing in R&D compared with the rest of the private sector. This may reflect both industry perceptions of the defence market's risks and rewards, and a significant, decade-long shift from manufacturing to sustainment activity as a primary source of the industry's income.

Defence needs industry: with very few exceptions it buys every product and service it consumes from a commercial supplier. But Defence has no default preference for Australian suppliers. Defence's principal needs of Australian industry are for services, rather than products – for maintenance, repair and upgrading of the ADF's equipment, most of which is imported. In some years, over 60% of the DMO's capital acquisition budget goes to foreign prime contractors. This makes the defence industry R&D figures compiled by the ABS look more impressive. However, the ABS figures fail to find an echo in other studies of business R&D. This is probably because there have been few other coherent attempts to measure R&D investment by Australian businesses, either as a proportion of GDP or as a proportion of total business revenue, so there are few other bodies of statistical information which allow a direct comparison with the ABS's figures.

The Intellectual Property Research Institute of Australia (IPRIA), in its annual R&D and Intellectual Property Scoreboard, attempts to gather such information, though from a different statistical base. The Scoreboard hasn't been collated consistently since 2007, but a mid-decade snapshot is instructive. The IPRIA draws its figures from IP Australia and the IBISWorld database of Australia's Top 2,000 companies and notes that across Australian industry as a whole in the 2004-05 financial year, for example, Business Expenditure on R&D (BERD) accounted for 0.37 per cent of total revenue compared with a world best practice figure identified in the 2004 Scorecard of about 1 per cent in Finland (IPRIA 2004; IPRIA 2005; IPRIA 2006; IPRIA 2007).

Does this matter? In short, yes – the 2005 Scorecard measured the average return on shareholders funds over five years of 30 companies out of the 50 who spend most on R&D (the other 20 companies didn't have consistent records going back five years). It found the weighted average return, after tax, for these 30 companies was 17.1 per cent, or more than double the 7.7 per cent return averaged by the nation's Top 1,000 enterprises – “All other things being equal, innovation pays,” the Scorecard notes. These 30 companies spent an average of 1.19% of their revenue on R&D, compared with the national average of 0.37%.

So how does the defence industry rank? The 2005 IPRIA Scoreboard includes a snapshot of defence R&D by a small number of significant defence manufacturers: ADI Ltd, BAE Systems Australia, Boeing Australia, Saab Systems, Tenix Defence and Thales Underwater Systems. Today, ADI Ltd and Thales Underwater Systems now form Thales Australia, while Tenix is part of BAE Systems Australia.

On the IPRIA figures these companies spent \$20.2 million between them in 2003-04 on R&D, or an average of 1.5 per cent of their turnover (Table 4). This was over five times the national BERD average for that year, and was matched only by the Top 50 companies in the 2005 Scorecard. In 2005-06, however, the combined R&D spend of these six companies fell significantly, both in dollar terms (though two firms recorded an increase) and as a percentage of revenue. Their total R&D spend fell by roughly 10%, while their R&D spend as a proportion of revenue was more than halved. It should be noted that these figures don't necessarily reflect the R&D spend of these companies in the second decade of the 21st century.

**Table 4: Australian Defence Industry R&D**

	Revenue 2004 \$M*	R&D Spend 2003-04 \$M^	R&D spend (% of revenue)	Revenue 2005 \$M**	R&D Spend 2005-06 \$M^	R&D spend (% of revenue)
<b>ADI</b>	594.5	7.622	1.28	656.075	9.804	1.49
<b>BAE Systems Australia</b>	475	1.759	0.37	525.0	2.849	0.54
<b>Boeing Australia</b>	284	0.1	0.03	375.0	0.1	0.026
<b>Saab Systems</b>	123	1.975	1.6	177.00	1.277	0.72
<b>Tenix Defence</b>	600	5.4	0.9	650.00	2.044	0.31
<b>Thales Underwater Systems Group</b>	65	3.375	5.2	79.60	2.22	2.79
<b>Total/Average</b>	<b>2141.5</b>	<b>20.231</b>	<b>1.56</b>	<b>2462.675</b>	<b>18.294</b>	<b>0.728</b>

\* Source - Australian Defence Magazine Dec 2004-Jan 2005 - ADM Top 40 Defence Contractors 2004, pp27-47

\*\* Source - Australian Defence Magazine Dec 2005-Jan 2006 - ADM Top 40 Defence Contractors 2005, pp14-36

^ Source - Intellectual Property Research Institute of Australia - R&D and Intellectual Property Scorecards 2005, 2007

Relating these figures to the Australian Defence Magazine (ADM) annual listing of the Top 40 Australian defence companies, the aggregate turnover of the 2005 Top 40, compiled in December 2005, was \$5.45 billion. If all of these companies had spent 0.728 per cent of their revenue on R&D this would amount to a Top 40 defence sector BERD of \$39.67 million. Even if they were to spend 1.5% of their revenue on R&D this would still amount only to \$81.5 million. It is hard to reconcile these sums with the ABS figure for total business defence R&D investment in 2004-05 of \$278 million. It's not clear whether this discrepancy reflects an error in the IPRIA figures, or in the way the ABS collates and presents R&D expenditure figures.

What proportion of defence industry revenue is represented by the ABS's figures for R&D? The figures don't say because the ABS does not measure the total income of Australia's defence industry. No source of statistical data records such a figure, and while it could be argued that the defence industry's gross income for a given year equates roughly to the DMO's in-country expenditure for that year (adjusting for any export sales), the available DMO figures for 2004-05 do not state what proportion of its budget was spent in Australia.

However, the IPRIA's figures are drawn from companies' own annual reports and suggest that Australian defence companies spend a much lower proportion of their

income on R&D than the ABS figures suggest – though still well above the national industry average (IPRIA 2005).

The significant discrepancies between these bodies of statistics were one reason why the author attempted to determine for himself defence industry R&D investment, in both absolute dollar terms and as a proportion of industry revenue.

Overall, the ABS's statistics are the most complete and consistent industry R&D figures (in a year on year sense) available in Australia. Even if they seem to overstate business expenditure on defence R&D somewhat, they still suggest that by comparison with the rest of the economy Australia invests relatively heavily in defence R&D, both in the private sector and the public sector. In fact, according to the IPRIA, an industry-wide average of between 2% and 5% of revenue (depending on whose figures one is inclined to accept) makes Australia's defence industry one of the highest-spending sectors on R&D in the Australian economy.

If this apparently high R&D figure truly reflects Australian defence industry R&D investment, it is comparable with the R&D expenditure recorded by US and European companies. To provide some basis for comparison, Table 5 shows the self-funded R&D investment reported in 2009 by a number of foreign defence manufacturers from whom Australia buys significant amounts or types of defence equipment. While these firms spend around 5% of their revenue on self-funded R&D, customer-funded R&D can amount to four or five times this sum; arguably, the levels of defence industry R&D achieved in Australia bear comparison with those of the large northern hemisphere companies.

All of the companies in this table distinguished in their accounts and financial reports between self-funded R&D, which is included in their accounts, and customer-funded R&D which generally isn't. Only some of the European and Scandinavian firms reported a figure for their customer-funded R&D activities - it will be seen that total R&D expenditure for these firms is four or five times the amount spent on self-funded R&D, and there is no reason to think this ratio doesn't apply also to US companies.



**Table 5: Defence Industry R&D – International comparisons (A\$ billions)**

COMPANY	2009-10 Revenue (AUD\$Bn)	Total R&D Expenditure (including customer-funded - AUD\$Bn)	Total R&D % of Revenue	Self-funded R&D Expenditure (AUD\$Bn)	Self-funded R&D % of Revenue
<b>BAE Systems</b>	35.56	1.83	5.13%	0.35	0.98%
<b>Boeing*</b>	69.69	#		6.63	9.52%
<b>EADS*</b>	56.32	#		3.68	6.54%
<b>Elbit</b>	2.89	#		0.22	7.67%
<b>Kongsberg Defence</b>	2.30	#		0.11	4.64%
<b>Lockheed Martin</b>	46.12	#		0.77	1.66%
<b>Raytheon</b>	25.41	#		0.58	2.27%
<b>Saab AB</b>	3.51	0.69	19.59%	0.17	4.88%
<b>Thales</b>	16.97	3.29	19.38%	0.87	5.12%
<b>Group Total/Average</b>	<b>258.77</b>			<b>13.38</b>	<b>4.81%</b>

Source – company annual reports and financial statements

AUD\$1=US\$0.98=£0.63=€0.76=SKR7=NKR6

# denotes customer-funded R&D figures not disclosed

\* denotes high level of civil product R&D

There are differences between accounting and mandatory financial disclosure practices in the USA and Europe. Elbit, an Israeli firm, publishes its accounts in the USA and presents them in US dollars, while BAE Systems conducts a significant proportion of its business in the USA and so aims to honour US accounting practice. US firms are also able to include bid and proposal costs under the broader heading of R&D, which Australian firms cannot. As Boeing's 2009 Annual Report states:

“Our total research and development expense amounted to \$6.5 billion, \$3.8 billion and \$3.9 billion in 2009, 2008 and 2007, respectively. These amounts are net of Boeing 787-related research and development cost sharing payments from suppliers of \$0, \$50 million and \$130 million in 2009, 2008 and 2007, respectively... Research and development costs also include bid and proposal efforts related to government products and services, as well as costs incurred in excess of amounts estimated to be recoverable under cost sharing research and development agreements. Bid and proposal costs were \$343 million, \$330 million and \$306 million in 2009, 2008 and 2007, respectively.” (Boeing 2010)

The Raytheon Company similarly reported in its 2009 Annual Report:

“During 2009, we expended \$565 million on research and development efforts compared with \$517 million in 2008 and \$502 million in 2007. These

expenditures principally have been for product development for the U.S. Government, including bid and proposal efforts related to U.S. Government programs. We also conduct funded research and development activities under U.S. Government contracts which are included in net sales.” (Raytheon 2010)

The importance to major US defence companies of government sales (principally to the US Department of Defense) was highlighted by Lockheed Martin whose 2009 Annual Report reported that some 85% of its net sales were to the US government, either as a prime contractor or a sub-contractor; of the remainder, 13% of sales were to foreign governments (including Australia). (Lockheed Martin 2010)

Although Table 5 is a low-resolution and selective snapshot of a large and diverse industry, it suggests that defence companies which make a majority, or a significant proportion, of their sales to the US Department of Defense spend less on self-funded R&D than companies making the majority of their sales to European defence customers. The exception is Boeing who, as noted above, spent an unusually high proportion of its revenue on R&D in 2009; normally it would spend less than two thirds of this sum; Boeing also generates around half of its revenue from the commercial aviation market in which customer-funded R&D is an exception rather than the rule. However, this applies also to EADS which generates significant proportions of its revenue from civil sales of airliners and helicopters.

Even if Boeing’s self-funded R&D is treated as an ‘outlier’ and removed from the figures, the average proportion of revenue which these companies devote to self-funded R&D is still 4.2%. This would appear to be comparable with the levels of Australian defence industry R&D reported by the ABS. The difference is, firstly, that the ABS figures include customer-funded R&D though not bid and proposal costs; and secondly that in 2009 these nine companies between them spent the equivalent of half of Australia’s total defence budget on self-funded R&D – nearly \$13.4 billion. Whatever the relativities, the sheer quantity of money spent by the US and European defence giants generates a very different set of outcomes.

Obviously size matters - the US, UK and France have relatively large domestic defence markets, invest heavily in defence R&D and are also major exporters of defence equipment and services. They, along with a handful of other major defence exporters, are able to dominate global markets because their volume of domestic and export sales supports, and is in turn supported by, considerable amounts of

both public and private sector R&D. It is very hard for Australia to be relevant, still less make a positive contribution, when its R&D spend is so comparatively small.

Nevertheless, published and estimated R&D levels suggest in turn that the defence industry sector should be performing better overall than most of Australia's manufacturing industry – as noted earlier, the IPRIA discovered a direct correlation between levels of R&D (or innovation) investment and growth, profitability and the return on shareholders' funds, while the author's Defence Industry R&D Survey found a similar association. It's not clear from available figures that this is in fact the case. As noted in Chapter 1 the DMO has attempted to evaluate defence industry performance by tracking key indicators reported by its top seven Australian materiel suppliers (whom it did not name). The indicators were the pre-tax Return on Sales (ROS), Return on Assets (ROA) and Return on Equity (ROE, see Table 6). These fluctuated significantly over the period in question, and it is possible they are heavily affected by fluctuations in the performance of just one or two large companies. Nevertheless, they show an average return on sales over the decade of less than 6%. In only four of the 10 years did the ROS and ROA exceed 5%, and these dropped as fast as they climbed.

**Table 6: Industry Return on Sales, Assets and Equity (ROS, ROA, ROE - %)**

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	AVGE %
<b>ROS</b>	3.60	2.70	4.80	8.40	10.00	12.30	8.40	3.20	2.50	2.20	<b>5.81</b>
<b>ROA</b>	3.50	2.70	5.00	8.50	10.00	12.40	8.20	3.00	2.10	2.20	<b>5.76</b>
<b>ROE</b>	18.20	13.50	22.60	31.80	34.40	34.40	21.00	10.00	8.00	5.70	<b>19.96</b>

Therefore, despite investing heavily in R&D by Australian industry standards, it couldn't be said that the defence industry's financial performance has benefited from this investment to the same extent that would be expected in other industry sectors. That said, Australia's bigger defence companies seem generally to spend less of their revenue than the SMEs on R&D, and so Table 6 might reflect the consequences of under-investing in R&D; again, this is potentially fertile ground for future research.

So the available statistics, and the author's own research, suggest Australian defence product manufacturing companies spend above the defence industry average on R&D, and the defence industry as a whole spends well above the total national

industry average on R&D. But the declining share of the DMO's acquisition budget that is spent in Australia suggests this R&D expenditure has been insufficient to help the local defence industry maintain, still less increase, its share of the domestic capital defence equipment market.

## APPENDIX 2 – Australian defence industry R&D, Innovation and Competitiveness

**This Appendix contains the covering letter inviting responses to the author's R&D survey in late-2009, and the complete list of questions and aggregated responses.**

This survey is being conducted as part of research for a University of Adelaide Ph.D Thesis titled *Factors Affecting Innovation Performance in the Australian Defence Industry*. It is designed to gather information concerning innovation, commercialisation and competitiveness in the Australian defence industry, with a particular focus on R&D and Innovation activities. This survey will also update elements of a defence industry survey conducted in 2004 by Robert Wylie (formerly of ACIL Tasman) on behalf of the Australian Industry Group Defence Council, Australian Industry Defence Network, the Defence Materiel Organisation and other bodies. Questions asked previously by Mr. Wylie are marked with an “ \* ”.

Unless specified, this survey is seeking combined information for the financial years 2006-07, 2007-08 and 2008-09.

This survey is anonymous. You are not required to identify yourself or your company. The content of all individual survey responses will remain Commercial-in-Confidence to me. The information provided will be used to contribute to aggregated findings. No respondents will be able to be identified by readers of the final report. The results will form part of the Ph.D Thesis and may also be published on a stand-alone basis in a reputable journal before the Thesis is submitted.

If you'd like a copy of the aggregated results of this survey, please email me after completion of the survey. This will not affect your anonymity in any way, and will also help ensure that only authorised respondents take part in the survey on behalf of individual companies.

There are 10 questions in the survey, and at the end you will have an opportunity to provide any other explanation or comment about your business's R&D, innovation and competitiveness that you consider necessary.

If you have any queries or complaints about this survey please contact me direct at the address below, or if you wish to discuss with an independent person matters related to making a complaint, or raising concerns on the conduct of the project, or the University policy on research involving human participants, or your rights as a participant, please contact the Secretary of the University of Adelaide's Human Research Ethics Committee (HREC) on phone (08) 8303 6028.

Thank you in anticipation of your support.

**Gregor Ferguson**

Research Fellow, Defence Materials Technology Centre (DMTC)

1. Please estimate the proportion (%) of your business's revenue that was invested in R&D and/or innovation **between 2006-07 and 2008-09**:

- a. 0 to 0.5 per cent
- b. 0.6 to 1 per cent
- c. 1.1 to 2 per cent
- d. 2.1 to 5 per cent
- e. More than 5 per cent

<b>% of Revenue</b>	<b>0 to 0.5</b>	<b>0.6 to 1</b>	<b>1.1 to 2</b>	<b>2.1 to 5</b>	<b>&gt; 5%</b>
	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>
% of respondents	15.8 %	15.8 %	10.5 %	15.8 %	42.1 %

2. **Between 2006-07 and 2008-09**, did you conduct R&D or Innovation activities in areas defined by the Department of Defence as Priority Industry Capabilities (PIC)?

<b>YES</b>	<b>NO</b>
63.2 %	36.8

3. **Between 2006-07 and 2008-09**, what happened to the profitability of your business?

<b>RESPONSE OPTION</b>	<b>% of Respondents</b>
There was a significant decrease	5.3%
There was a moderate decrease	10.5%
It remained relatively stable	31.6%
There was a moderate increase	42.1%
There was a significant increase	10.5%

4. **Between 2006-07 and 2008-09**, what happened to the growth of your business?:

<b>RESPONSE OPTION</b>	<b>% of Respondents</b>
There was a significant decrease	0%
There was a moderate decrease	15.8%
It remained relatively stable	26.3%
There was a moderate increase	31.6%
There was a significant increase	26.3%

5. **Between 2006-07 and 2008-09**, your business's financial performance has:

RESPONSE OPTION	% of Respondents
Failed to meet expectations	10.5%
Met expectations	73.7%
Exceeded expectations	15.8%

6. Between 2006-07 and 2008-09, your business's overall performance (i.e. its combination of growth, profit and financial performance) has:

RESPONSE OPTION	% of Respondents
Failed to meet expectations	10.5%
Met expectations	73.7%
Exceeded expectations	15.8%

\*7. On a scale of 1 (very low) to 5 (very high), please rate the importance to your business of the following initiatives or strategies **between 2006-07 and 2008-09**:

INITIATIVE OR STRATEGY	Very Low 1	Low 2	Moderate 3	High 4	Very High 5
Introduction of new or substantially changed products for sale (Number of respondents)	1	1	7	4	6
Introduction of new or substantially changed production processes (Number of respondents)	2	1	5	9	2

\*8. On a scale of 1 (very low) to 5 (very high), please rate the importance to your business of the following sources of intellectual property **between 2006-07 and 2008-09**:

SOURCE OF IP	Very Low 1	Low 2	Moderate 3	High 4	Very High 5
Purchase of IP through license or other arrangement:					
- From a vendor in Australia	5	9	2	1	1
- From a vendor overseas	5	5	1	5	1
Supply of IP from parent company	5	5	0	4	4
In-house R&D	0	2	3	7	6
Collaborative research arrangements	1	5	5	4	2
Acquisition or merger	3	1	1	1	0
Other* (please specify)					
RPDE; Mergers with like-minded organisations.....					

\* denotes respondent did not ascribe a level of importance to this IP source. 1 respondent skipped this question

**\*9** Please estimate the proportion (%) of your business's total defence R&D expenditure allocated to each of the following areas of research **between 2006-07 and 2008-09**:

RESPONDENT*	Physical, chemical or earth sciences %	Information, computing and communication sciences %	Engineering and technology %	Other (please specify) %
1			100	
2		80	20	
3			100	
4	50		50	
5			100	
6	40	50	50	
7			60	
8			100	
9		20	80	
10			100	
11		20	30	50 (Manufacturing)
12			100	
13		10	90	
14		40	60	
15		20	80	
16			100	
17			100	
18	6	67	27	

\* Denotes 1 survey respondent skipped this question



\*10. Defence suppliers undertake R&D or innovation activities for many reasons, such as meeting new defence requirements or making the existing defence business more profitable. Please estimate the proportion (%) of your business's R&D/innovation expenditure between 2006-07 and 2008-09 that was undertaken for the following reasons:

RESPONDENT*	To develop in-house new proprietary IP or technology for sale to Australian or overseas defence customers %	To adapt IP or technology generated elsewhere (eg by a university, overseas parent, or technology partner) for sale to Australian or overseas defence customers %	To improve profits by developing and introducing more efficient arrangements to supply defence-related goods and services %	Under contracts with Australian or overseas defence agencies %	Other reasons (please specify) %
1			100		
2	1	80	20		
3	100				
4	50	20	20	10	
5	100				
6		100			
7	15		45		40 (defence-related but not front-line)
8	50	45	5		
9	60	30	10		
10	60	20	10	10	
11	50	25	25		
12	80			20	
13	80	5	15		
14	100				
15	40	30	20	10	
16	50	50			
17	10				90 (Consumer markets)
18	11	6	3	80	
	49.81	37.4	22.1	26	

\* Denotes 1 survey respondent skipped this question

**11. Do you wish to add any further comment on your business's R&D and Innovation activities, or on Australia's defence R&D environment more generally?**

<b>Respondent</b>	<b>Comment</b>
<b>1</b>	[Company X's] R&D is principally commercially focused on a global basis. R&D in the Defence & Aerospace sector is performed as part of our industry segments approach. This may find it's way into embedded functionality in any of our COTS hardware or software product lines or may be developed for tailoring, adoption and integration of COTS hardware and software for Defence-specific purposes.
<b>2</b>	DMO's obsessive need to ensure there is no competitive advantage to local SMEs is harming local capability in Australia. There is no longer an advantage to bid from a local capability and sometimes it appears that being a local capability in the eyes of DMO is actually detrimental.
<b>3</b>	The information in this survey refers to my company's R&D division only
<b>4</b>	The key driver of successful innovation is market demand. In the Australian defence space this is solely determined by the policies surrounding defence capability development and acquisition. Unless there is a clear path to a contracting mechanism to procure a capability, the likelihood that innovation investments will lead to successful commercial outcomes is very low.

**Many thanks for taking part in this survey. Don't forget to email Gregor Ferguson after logging off to request your copy of the aggregated survey results, and also to help ensure that you are the only authorised respondent on behalf of your company.**

**[gregor@rumourcontrol.com.au](mailto:gregor@rumourcontrol.com.au)**

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