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Commercialising Defence R&D – Why, and Why Not?

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INTRODUCTION

There has been surprisingly little research into Australia's defence R&D activities and the success or otherwise of the commercialisation processes flowing from them. This is surprising because the Australian Defence Force (ADF), by virtue of its small size, depends on technology and training to offset its lack of numbers compared with other powers in the Asia-Pacific region.

Furthermore, thanks to its intimate relationships with both the USA and the UK, Australia enjoys unparalleled access to all but the very best, or most sensitive, technologies these countries along with other suppliers in Europe, Canada and Israel can offer. This requires a high level of technological and operational skill and understanding so that the ADF can operate this equipment effectively and perform credibly alongside its two major allies in future coalitions.

It also requires a high level of skill and understanding on the part of Australia's defence industry in order to 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.

Australia is overwhelmingly an importer of high-technology defence equipment. In the field of Electronic Warfare (EW) in particular, the majority of the ADF's EW equipment is sourced from overseas, though much of it is integrated with ADF platforms by local contractors and almost all of it is supported in-country by local industry and by the Joint Electronic Warfare Operational Support Unit (JEWOSU) at RAAF Base Edinburgh.

Given Australia's privileged access to high technology defence equipment, the training of its people and their deep and broad understanding of the technologies and operational techniques involved, it isn't surprising that for its size the ADF is a highly proficient, even potent, defence force.

What is surprising is that, given Australia's proficiency as an operator, and that fact that it is without doubt the biggest customer for sophisticated high-technology defence equipment in south-east Asia, Australia's defence industry is principally a service rather than a manufacturing industry. This is not a pattern that prevails in, for example, NATO Europe where technologically sophisticated defence forces sustain, and are sustained by, technologically sophisticated defence industries manufacturing a wide range of equipment.

Australia's defence industry has been shaped to a significant extent by policy guidance over the years from the Department of Defence on Defence's needs of industry. Even in the current Aerospace and Electronics Industry Sector Plans the emphasis remains on capabilities such as systems integration, maintenance and modification rather than equipment design and manufacture, except in critical niche areas. The result is that industry largely provides services rather than products. The majority of products integrated by Australian contractors into systems and platforms for the ADF are still imported.

This is not a problem in an operational or strategic sense: since the middle of the 20th 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 is unusual among middle ranking powers in not encouraging significant investment in major indigenous defence equipment design, development and manufacturing capabilities.

Nevertheless, Australia seems to spend about as much on defence-related R&D as many nations which have a much larger defence manufacturing base supporting both domestic and export markets.

Leaving aside the national and global politics of defence procurement and their effect on the market forces operating in the defence sector, it is axiomatic that a high technology defence industry manufacturing base must be sustained by significant levels of local R&D, or at least by unfettered access to appropriate IP sourced from elsewhere.

It is also clear that a high-technology defence force must invest a certain minimum amount in Science and Technology (S&T) studies simply in order to understand emerging defence technologies and their implications for future capability, operational employment, and equipment design and selection.

It is clear also from Australia's example that a significant R&D/S&T investment doesn't necessarily need a manufacturing base to justify its existence. Indeed the core mission of the Defence Science and Technology Organisation (DSTO) is to support the ADF with S&T and policy advice rather than do R&D to develop new products; its mandate to support Australia's defence industry is only a subset of this core mission.

However, Australian defence S&T/R&D, which is dominated by DSTO, has spawned a number of innovative and highly successful defence and civil products in the past.

Given the level of Australia's defence R&D expenditure and the quality of the IP it generates the author has been prompted to examine the reasons why Australia's track record in commercialising its defence R&D isn't better. Among other things, improving the commercialisation track record could lead to a stronger, more self-reliant ADF, a stronger defence industry manufacturing base, increased exports and a higher proportion of Australia's defence capital acquisition budget spent in Australia, all of which contribute to the broader national bottom line.

The author has begun studying the factors enabling or preventing successful commercialisation of defence-related Intellectual Property (IP) at the University of Adelaide's Education Centre for Innovation and Commercialisation (ECIC).

The purpose of this research is to measure Australia's total investment in defence-related R&D, the opportunity cost of failing to invest sufficiently in R&D and commercialise the resulting IP, and identify those technical, cultural and market factors which enable or prevent the successful exploitation and commercialisation of that IP. This research will take several years to complete, but a start has been made.

A pilot study completed in late-2005 set out to validate the Key Research Questions and refine the parameters that must be identified, measured and compared in order to answer these questions (Ferguson 2005). The study included a survey of 21 current or recent key players in the defence R&D and commercialisation arena, including officials from the DMO, past and present defence scientists, industry officials and senior officers of the ADF.

In short, the study resulted in a roadmap for a research program designed to answer five Key Research Questions:

1. What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?
2. Is Australia's public and private sector investment in defence R&D commensurate with the anticipated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from that R&D?
3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?
4. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?
5. Is it possible to define a model, or at least a more general set of pre-conditions, which is likely to result in successful commercialisation of defence-related IP?

The answers to Question 1 to 3 essentially provide the background, context and justification for the research; Questions 4 and 5 go to the heart of the topic.

While the research is nowhere near answering the five Key Questions at the time of writing, early studies have begun to address Questions 1-3 and provided some insights into Australia's commercial and defence R&D environment.

This paper focuses on Questions 1 to 3. It sets out to summarise some of the insights gleaned so far in this research and highlight future avenues for research.

Australia's R&D Environment

Defence seems to mirror the wider Australian R&D landscape - as a nation its R&D expenditure falls well short of the OECD average per head of population, dragged down by the private sector's under-investment in R&D.

The Australian Bureau of Statistics (ABS) reported Australia's Gross Expenditure on R&D (GERD) as a proportion of GDP was 1.62 per cent in 2002/03 (the last year for which ABS figures were available at the time of writing), amounting to some $12.25 billion (see Table 1) (ABS 2004). Of this, some 3.3 per cent or $404.25 million was spent on defence R&D. Business Expenditure on R&D (BERD) by the private sector was $5.987 billion, or 49 per cent of the total (ABS 2004); some $108 million of this was defence R&D - a figure which is unaccountably high and which is contradicted by more detailed figures, also based on ABS statistics, mentioned later in this paper.

TABLE 1:

	Commonwealth	State/ territory	Higher education	Business	Private non-profit	Total
1996-97	1,266.6	797.7	2,307.6	4,234.7	185.8	8,792.4
1998-99	1,179.4	863.6	2,555.1	4,094.7	225.3	8,918.1
2000-01	1,404.8	951.0	2,789.8	4,982.6	289.0	10,417.1
2002-03	1,531.3	950.9	3,429.6	5,978.6	359.5	12,249.9

NB: Expenditure in AUD$ millions
Source: Australian Bureau of Statistics. "Research and Experimental Development, All Sector Summary, Australia, 2002-03", September 2004.

The ABS reports Australia's GERD/GDP ratio is low compared with other OECD countries. Australia is ranked 13th out of 19 countries, below countries such as Finland (top, with 3.46), Japan, the USA, Germany, Denmark, Norway, South Korea and France.

Australia's low ranking reflects the business sector's low R&D expenditure. However, where Government Expenditure on R&D (GOVERD) alone is counted, Australia's ratio of GOVERD to GDP ratio of 0.33 ranks it 7th out of 21, behind Iceland which is top with 0.76, and Korea (0.39), France (0.37) and Finland (0.36), but above Japan (0.3), the USA (0.24), Denmark (0.18) and the UK (0.17).

The ABS reports that Australia's BERD to GDP ratio of 0.79 places us 15th out of 21 OECD countries surveyed. The OECD average is 1.6 per cent with Finland again top with 2.41, followed by Japan (2.32), USA (1.87), Denmark (1.75), Canada (1.05), Netherlands (1.03) and Norway (0.96).

The Intellectual Property Research Institute of Australia (IPRIA), in its annual R&D and Intellectual Property Scoreboard 2005, paints a similar picture, although from a different statistical base. 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 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).

Does this matter? In short, yes – the IPRIA notes that between 2000 and 2004 some 30 of Australia's Top 50 R&D spenders invested 1.19 per cent of revenue on R&D, or more than four times the national BERD average of 0.26 per cent over that period. The Scorecard states that the weighted average return on shareholders' funds of these 30 companies, after tax, 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.

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.

On the IPRIA figures these companies spent $20.231 million in 2003/04 on R&D, or about 0.95 per cent of their combined turnover of $2,141.5 million. This is nearly three times the national BERD average, and is matched only by the Top 50 companies in the 2005 Scorecard.

The Department of Defence spent $292 million that year on R&D through DSTO, representing some 2.07 per cent of that year's $14.15 billion defence budget, compared with the wider Australian GOVERD to GDP ratio of 0.33 recorded by the ABS in 2002/03.

Relating these figures to Australian Defence Magazine's 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 were to spend 0.95 per cent of their revenue on R&D this would amount to a Top 40 defence sector BERD of $51.7 million. It is hard to see evidence of defence sector BERD on anything like this scale, hence the puzzlement of many observers at the figures for defence BERD presented by the ABS.

Nevertheless, by comparison with the rest of the economy, on the available figures Australia invests relatively heavily in defence R&D, both in the private sector and the public sector. But the ratio of GOVERD to BERD in the defence sector is very different from that in the wider economy. Why is this? And is this fact significant? If so, how? This is something which the author's research will examine.

Three factors which heavily influence Australia's defence R&D environment are the ADF's dependence on very high technology to offset its lack of numbers; its access to all but the most sensitive equipment produced by the United States and Europe; and its small size.

Except for a small but critical portion of ADF capability, Australia faces no overpowering strategic imperative to develop its own high-technology defence equipment. Indeed, it would be pointless and wasteful to try and duplicate within Australia much of what is freely available from overseas, especially if Australia were to be the sole customer – the ADF is too small a customer to offer any economies of scale.

In examining Australia's defence R&D and commercialisation performance, therefore, some fundamental things must be understood. One of the key operational challenges for the ADF is not that of obtaining the equipment it needs, 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.

Consequently, the November 2004 study, "A Profile of the Australian Defence Industry", by Canberra-based economists ACIL Tasman for the Australian Industry Group Defence Council (among other bodies) notes that much of DSTO's R&D is now directed at helping the ADF identify its technology needs and providing defence policy, smart buyer and smart user advice to the Department of Defence and the ADF.

According to reliable estimates (canvassed in the Pilot Study) less than 20 per cent of DSTO's budget is explicitly devoted to long-range or "blue sky" R&D aimed at developing all-new IP, technologies and capabilities. The remainder is devoted to S&T studies which underpin its advisory role. This appears to have been an important change in Australia's defence R&D landscape over the past two decades and reflects a tighter focus on the perceived science and technology needs of DSTO's principal customer, the ADF. It should be noted, however, that DSTO's budget has fallen over the years as the defence budget's share of GDP has shrunk. Therefore, DSTO has had to become more focussed on its R&D and S&T priorities.

Twenty and thirty years ago much more of DSTO's resources could be devoted to developing new IP, technologies and equipment such as Ikara, Jindalee, Nulka and LADS; as this proportion has fallen, the private sector appears not to have made up the shortfall.

Further research will establish whether this is actually the case, and if so, why.

Private sector R&D investment decisions are necessarily commercial decisions based on perceptions of risk and return. Anecdotal evidence appears to provide plenty of disincentives for significant private sector investment in local defence R&D or for the licensing and commercialisation of IP developed by bodies such as DSTO.

However, Australia's significant defence R&D success stories demonstrate that persistence, deep pockets and a prospective customer who is willing to keep faith with a good idea can all add up to commercial success. These are all issues which will be studied more closely as the research goes on: both Defence and Industry are ill-served by attitudes and policies based on incomplete or out-dated information, unchallenged urban myths and unsubstantiated anecdotes.

There is therefore plenty of scope for research into whether and how Australia could do better at commercialising its defence IP. The fundamental hypothesis of the author's research is that there are certain specific factors which enable or inhibit defence R&D commercialisation in Australia. These can be identified and their impact on the IP commercialisation process measured; and it should be possible to develop a model, or a

more general set of preconditions, which improve the chances of successful commercialisation.

The Pilot Study alluded to earlier set out a roadmap for the research which will prove or disprove that central hypothesis.

First, however, it is important to map Australia's current defence R&D environment and in particular challenge the misinformation, urban myths and legends which infest it. That is the thrust of this paper.

Is there actually a problem? Does Australia do as badly at defence R&D and subsequent commercialisation as the conventional wisdom suggests? How much do we spend on defence R&D and what sort of return do we get from it?

Secondly, does our defence R&D investment reflect the scale and diversity of the local and global defence markets open to Australian firms?

Thirdly, what do we stand to lose by under-investing in defence R&D and failing to commercialise?

These are important questions on the way to addressing the two main hypotheses. The research has not produced definitive answers as yet, but this paper aims to provide an initial overview of Australia's defence R&D environment, with reference to the Electronic Warfare (EW) sector and to the first three Key Research Questions validated by my recent Pilot Study

One thing is abundantly clear from the Department of Defence's Electronics Industry Sector Plan (DMO 2004), however: if local companies cannot generate and sustain the technical expertise, skills and IP necessary to satisfy an increasingly demanding ADF as both an equipment provider/integrator and a dependable support base, they face the prospect of a long decline. Companies that do not carry out, or have access to, the R&D necessary to refresh and grow their IP, skills and capabilities will increasingly struggle to come to grips with the growing technological demands which the ADF will be making of it.

Is there a problem?

This is addressed in Key Research Question 1: What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?

Parts of the answers to both questions are in the open literature already; others will be sought through surveys of the defence industry. But gross figures tell only part of the story. Judgements as to whether or not Australia's performance is adequate – whether or not there is a problem, in other words - can only be made after comparing Australia with external benchmarks: the defence R&D and commercialisation performance of other countries, and broader non-defence R&D investment and commercialisation outcomes in Australia and elsewhere.

The Pilot Study found that this is a relevant question, though respondents warned that it is important to define terms such as “R&D”, “Defence” and "Commercialisation" unambiguously. Wherever possible I have used ABS and AusIndustry statistics because they have clear definitions of what is and what isn’t R&D – whether or not one disagrees with them, they provide a reasonable basis for comparison.

Beginning with DSTO, as noted earlier most of its budget is devoted to developing S&T advice that maintains and hones the ADF's capability edge. This generates a return that, while vital to the nation's defence, rarely shows on any corporate bottom line. DSTO’s equivalents overseas have similar advisory functions.

That capability edge drives Australia's high-technology defence marketplace, which is still the biggest and most sophisticated in the south east Asian region. It must be remembered also that the ADF depends absolutely on keeping that edge honed, so DSTO and the Australian defence industry are required to work close to or right on the leading edge of defence technology.

The former Chief Defence Scientist, Dr Richard Brabin-Smith, laid out the policy foundations for DSTO’s current operations during the mid-1990s: “ ‘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.” (Brabin-Smith 2005)

Brabin-Smith set out DSTO’s position in unambiguous terms: “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'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 may define 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 – but there haven't been many.

How does Australia compare with its two major allies? Table 2 shows what the UK and Australia invested in 2002/03, and the US in FY04, in their publicly funded defence R&D organisations. A broader comparison would be with smaller, second-tier powers whose economies, defence budgets and defence forces more closely match our own (Tables 3.1 and 3.2).

TABLE 2:

Country	**Defence Budget AUD Billion***	**Defence R&D Budget AUD Billion***	**R&D % of Defence Budget**
Australia^	14.7	0.288	2.18
USA (FY 04)#	507.6	82.4	16.2
UK	75.9	2.317	3.05

* Exchange rate calculated in January 2006. AUD$1 = US$0.75 = GBP0.43
# Source: US Dept of Defense budget papers for FY 2004
^ Source: Trenberth: "Review of DSTO's External Engagement", June 2004

TABLE 3.1 – GDP and R&D, 2003-04:

Country	**Pop - Millions**	**GDP AUD Billions***	**GDP per capita AUD**	**Exports % of GDP**	**GERD % of GDP#**
USA	293.0	16,487.9	57,753.3	10.6	2.67
UK	59.8	2,844.4	47,390.7	25.6	1.88
Canada	32.0	1,445.46	44,864.0	38.8	1.91
Australia	**20.2**	**892.0**	**43,853.0**	**19.0**	**1.62**
Netherlands	16.3	794.53	48,652.0	68.7	1.8
Sweden	9.0	510.53	56,417.3	47.9	4.0
Israel	6.8	170.26	24,576.0	45.2	5.0
Denmark	5.4	326.93	60,434.7	47.7	2.52
Finland	5.2	246.5	47,228.0	40.5	3.46
Norway	4.6	412.0	89,773.3	41.9	1.67
Singapore	4.2	155.06	36,240.0	224.7	2.1

* Exchange rate calculated in January 2006. AUD$1 = US$0.75
# Sources: Australian Bureau of Statistics. "Research and Experimental Development, All Sector Summary, Australia, 2002-03", September 2004. OECD Science, Technology and Industry Scoreboard 2005
Source: Dept of Foreign Affairs & Trade, September 2005

TABLE 3.2 – GDP, Defence Budget and R&D, 2003-04:

Country	**Pop -**	**GDP AUD**	**Defence Budget**	**Defence %**	**Defence**	**R&D % of**	**GERD**

	Millions	Billions*	AUD Billions*	of GDP	R&D Budget AUD Billion*	Defence Budget	% of GDP
USA	293.0	16,487.9	507.6	3.07	82.4	16.2	2.67
UK	59.8	2,844.4	75.9	2.67	2.317	3.05	1.88
Canada	32.0	1,445.46	14.98	1.03	0.283	1.89	1.91
Australia	**20.2**	**892.0**	**14.7**	**1.96**	**0.288**	**2.18**	**1.62**
Netherlands	16.3	794.53	12.2	1.54	N/A	N/A	1.8
Sweden	9.0	510.53	8.52	2.03	0.238	2.79	4.0
Israel	6.8	170.26	12.31	8.7	N/A	N/A	5.0
Denmark	5.4	326.93	3.98	1.23	N/A	N/A	2.52
Finland	5.2	246.5	3.32	1.34	N/A	N/A	3.46
Norway	4.6	412.0	6.06	1.47	0.095	1.5	1.67
Singapore	4.2	155.06	6.83	5.38	0.266	3.8	2.1

* Exchange rate calculated in January 2006. AUD$1 = US$0.75, €0.63, CAN$0.88, S$1.24, SKR5.87 GBP0.43
Sources: Dept of Foreign Affairs & Trade, September 2005, CIA World Fact Book, 2004, official national government web sites, Australian Strategic Policy Institute.
CIA World Fact Book – figures for FY 2003

Two points emerge here: with two exceptions – Israel and Singapore – companies with a higher GERD to GDP ratio than Australia also generate a higher GDP per capita. Singapore is one of the celebrated south east Asian 'Tiger economies' and is growing off a relatively low base back in the 1970s. Israel spends over 8 per cent of its GDP on defence – national survival often takes precedence over short-term prosperity.

It should be pointed out also that in many cases the R&D component of developmental defence acquisition programs can add significantly to the reported GOVERD and BERD in these countries.

It is interesting to compare Table 3.2 with Table 3.3 which lists the suppliers and integrators of most of the major Electronic Warfare equipments acquired by the ADF over the past decade or so. Many of these, of course, have been integrated aboard multiple platforms and in some cases these equipments have been an embedded sub-element of a new platform acquired by the ADF such as the Tiger and MRH90 helicopters.

Equipments in bold type have been acquired as a retrofit to an in-service platform. And the majority of the modern sensors and effectors acquired as retrofit equipment, as opposed to counter-measures dispensers, have been acquired from Israel.

TABLE 3.3 – ADF EW equipment suppliers and integrators

EW Equipment	Supplier	Country	Platform Integrator	Platform
Nulka Active Offboard Decoy	1. BAE Systems (air vehicle) 2. Lockheed Martin Sippican (EW payload)	1. Australia 2. USA	BAE Systems	FFG, Anzac (AWD in future)
PRISM ESM	BAE Systems	Australia	BAE Systems	Fremantle, Armidale, Huon class ships
ALR-2002 RWR	BAE Systems	Australia	Boeing/BAE Systems	Hornet, Black Hawk, Chinook, A330 tanker
SIIDAS suite controller	BAE Systems	Australia	BAE Systems	Wedgetail, Black Hawk
PIDS	Terma	Denmark	Boeing Australia	Hornet

TWE Radar/Laser Warner	Thales	France	EADS	Tiger, MRH90
SAPHIR CMDS	MBDA	France	EADS	Tiger, MRH90
AAR-60 MWS	EADS	Germany	EADS/Tenix	Orion, Tiger, MRH-90
C-Pearl ESM	Rafael	Israel	ADI Ltd	FFG
ALR-2001 ESM	IAI ELTA (via BAE Systems)	Israel	BAE Systems	Orion, Wedgetail
EL/L-8222 RF jammer	IAI ELTA (via Tenix Defence)	Israel	Tenix/Boeing	F-111
AES-210 ESM	Elisra	Israel	Tenix/Kaman	Seahawk, Super Seasprite
SPS-1000 RWR	Elisra	Israel	Tenix	Hercules
VICON CMDS	Thales	UK	BAE Systems	Wedgetail
ALE-47 CMDS	BAE Systems	USA	Various	Various
AAR-54(V) MWS	Northrop Grumman	USA	Tenix	Hercules
AAR-47 MWS	BAE Systems	USA	Tenix	Hercules
APR-39(V)1/3 RWR	BAE Systems	USA	Tenix	Hercules
AAQ-24 Nemesis DIRCM	Northrop Grumman	USA	BAE Systems	Wedgetail
ALE-50 towed RF decoy	Raytheon	USA	Boeing	Hornet

Source: Defense News, Australian Defence Magazine archives; 1995-2005

Much of the data and argument in this paper is 'general', but the Electronic Warfare sector in particular illustrates many of them for a number of reasons: it is a high-technology sector dominated by a small number of companies in an even smaller number of countries; EW, including EW Self-Protection (EWSP), is an absolutely critical force multiplier and so a key determinant of operational outcomes; and it is a technology domain where Australia has demonstrable, world-class skills and capabilities, and it is one of the few sectors with significant potential for domestic market growth.

The DMO's Electronic Systems Sector Plan is unambiguous about the importance of EW, stating: "It is… essential that the ADF maintain EW superiority over any potential adversary. This requires that Australia stay abreast of technological developments and ahead of threats and EW capabilities of anticipated adversaries."

The plan goes on to say: "The cost effectiveness of designing and developing EW suites themselves is presently being tested in Australia. It is nonetheless clear that strategic importance and deniability place electronic warfare as a high priority for industrial capabilities supporting military self-reliance. This is absolutely true in the case of capabilities required for the integration of EW suites into platforms and other systems, and, subject to cost-effectiveness, would be true in respect of system design and development as well" (DMO 2004; DMO 2004)

But except for BAE Systems Australia, which has developed a small portfolio of world-class products, the majority of Australia's EW industry capabilities are geared more towards delivering services than products: Test & Evaluation (T&E) systems such as Raytheon Australia's EW Training System, Tenix Defence's Generic Threat Simulator (GTS) and the in-service support capabilities established by Avalon Systems to support the Tiger and MRH90 helicopters.

However, the recent breakthrough in the ADF's selection of the Australian-manufactured ALR-2002 Radar Warning Receiver (RWR) for the Black Hawk and Chinook helicopters and Hornet fighter suggest acceptance within Canberra of locally developed EW solutions may be growing significantly. Proposals for indigenous EWSP solutions for platforms such as the Navy's forthcoming Air Warfare Destroyers and amphibious landing ships may land on fertile ground as may proposals to develop other EW sensors and effectors for the ADF's frontline combat platforms.

With that in mind, how do levels of R&D in the private sector compare with the public? According to ABS statistics cited in ACIL Tasman's 2004 defence industry study Australia's private sector spent only $31.9 million on defence R&D in 2001-02, compared with $238.6 million by the Federal government and $4.46 million by the Universities – this contrasts with the ABS's report that defence BERD amounted to $108 million, a figure which many within the broader defence community find unaccountably high.

Further research will be required to discover the cause of this discrepancy.

Industry's contribution to Australia's $274.9 million total defence R&D spend in that year was just 11.6 per cent. As a proportion of the $3 billion combined turnover of the Top 10 companies in the ADM TOP 40 listing of defence companies in December 2003, it amounts to 1.06 per cent. Averaged across the whole of the defence industry, of course, it amounts to considerably less - though it may still exceed that year's non-defence average BERD of 0.3 per cent of turnover.

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.

On the IPRIA figures these companies spent $20.231 million in 2003/04 on R&D, or about 0.95 per cent of their combined turnover of $2,141.5 million. The Department of Defence spent $292 million that year on R&D through DSTO, representing some 2.07 per cent of that year's $14.15 billion defence budget.

Table 4.1: Australian Defence Industry R&D

Company	Revenue 2003/04 - $M*	R&D Spend 2003/04 - $M^	R&D % of turnover
ADI Holdings Ltd	594.5	7.622	1.28
BAE Systems Australia Pty Ltd	475	1.759	0.37
Boeing Australia Ltd	284	0.1	0.03
Saab Systems Pty Ltd	123	1.975	1.6
Tenix Defence Pty Ltd	600	5.4	0.9
Thales Underwater Systems Pty Ltd	65	3.375	5.2
Group Total/Average	**2141.5**	**20.231**	**0.95**

* Source - Australian Defence Magazine Dec 2004-Jan 2005 - ADM Top 40 Defence Contractors 2004, pp27-47
^ Source - Intellectual Property Research Institute of Australia - R&D and Intellectual Property Scorecard 2005

Table 4.2: Defence Industry R&D – International comparisons

Company	2003/04 Revenue - AUD millions	R&D investment AUD millions	R&D % of Revenue
BAE Systems	30,697.67	2,790.7	0.91
Boeing	70,891.9	2,540.5	3.58
EADS	50,412.7	3,374.6	6.69
Elbit	1,270.13	90.33	7.1
Kongsberg Defence	1,286.25	139.8#	10.87
Lockheed Martin	47,972.97	1,300.00	2.7
Raytheon	27,364.86	663.51	2.42
Saab AB	3,087.9	67.13	2.17
Thales	16,333.33	579.36	3.55
Group Total/Average	**248,571.61**	**2,610**	**4.44**

Source – company web sites and annual reports
AUD$1 = US$0.74, €0.63, SEK5.78, £0.43,NKr 5.006
'Most' of Kongsberg's defence R&D, which accounts for over 50% of the total is customer funded, the company says

The Australian R&D average of 0.95 per cent of turnover is surprisingly close to the world best-practice all-sector BERD figure of 1.2 per cent recorded in Finland, and nearly three times better than Australia's non-defence average BERD. But it is still a very small dollar figure. Even so, the IPRIA figures suggest that the defence industry sector should be performing better overall than the rest of Australia's manufacturing industry – it should be recording faster growth, greater profitability and a higher return on shareholders' funds. No research has been undertaken yet to establish whether or not that is so, but the anecdotal evidence suggests this is not the case. If not, why not? More research is needed, but Table 4.2 points to a possible answer.

Figure 4.2 shows the R&D investment recorded in 2004 by a number of foreign defence manufacturers from whom Australia buys significant amounts or types of defence equipment. Even without Kongsberg's very high R&D investment, the group average would still be three times greater than Australia's. Although the list here is a very low-resolution and selective snapshot of a large and diverse industry, it is instructive that most of these overseas companies comfortably out-spend Australian companies in terms of R&D as a percentage of revenue.

This suggests another possible avenue for exploration: the level of R&D required to develop new defence equipment and maintain and refresh the very high technology skills which are essential for a technology-driven industry sector. While the Australian defence industry appears to spend considerably more on R&D than the non-defence sector, this is still low by comparison with the R&D spend by defence manufacturers in the countries from whom the ADF imports defence equipment.

The major difference between Australia's defence and non-defence R&D statistics is the relative size of BERD and GOVERD - in the non-defence sector in 2002/03 BERD amounted to 49 per cent of R&D expenditure while GOVERD amounted to 12.5 per cent. In the defence sector in 2001/02, however, GOVERD amounted to 86.8 per cent and BERD to just 11.6 per cent.

In 2002/03 it's interesting to note that GERD represented 2.28 per cent of Australia's defence budget, while it represented just 1.62 per cent of GDP. In that year 18.8 per cent of GOVERD went into DSTO; considering Defence accounts for less than 2 per cent of Australia's GDP, it attracts a disproportionate amount of GOVERD - though this is paid for directly from the defence budget and not from other Commonwealth sources, so is not subject to competition for resources from other fields of R&D.

Even though these statistics are from two different years, the relativities remain valid - and they tell an interesting story.

Although defence sector BERD appears significantly greater overall than in the non-defence sector, it is still massively outweighed by DSTO's budget. For the BERD:GOVERD ratio in defence to match that of the non-defence sector (roughly 4:1), in 2002/03 either Australian companies would have needed to be spending $1.152 billion, or roughly a quarter of their current total revenue, on R&D; or at current levels of BERD (assuming this is about 0.9 per cent of revenue - a very generous figure) industry would need to have a collective turnover of $128 billion a year rather than the $5.45 billion of the companies in this year's ADM TOP 40.

These figures highlight the technology-driven nature of the modern defence environment and the importance Defence places on S&T advice. They also throw up some questions which further research will aim to answer: in particular, because of the complete inversion of the ratio of BERD to GOVERD in the non-defence and defence sectors, what are the ratios of defence-related BERD to GOVERD in other countries, how much of the private sector's defence R&D is funded by the government, how well do companies in these countries commercialise IP developed in government laboratories, and what is the aggregate turnover of the defence industry in those countries?

The research will try to establish also whether gross R&D expenditure is the important issue, or the ability to commercialise successfully the IP flowing from that R&D.

Dr Steve Gumley, Chief Executive Officer of the DMO, provided an insight into the Department of Defence's view of private sector defence R&D investment in a speech to the Australian Strategic Policy Institute (ASPI) lunch on 3 March 2005 in Canberra. He said, "Defence is a high tech industry with some very exciting technologies. One of my biggest surprises since joining Defence has been the low levels of self funded R&D and innovation in industry, especially given the high profitability levels. I stress there are some notable and very laudable exceptions to this statement especially in the SME community. However, many companies only undertake significant R&D if funded by Government, and don't entrepreneurially invest their own shareholders' funds in innovation and markets even where they have substantial potential international market access at the product level through their parent companies.

"Or maybe its our fault. Just possibly, Defence has been so compliant in the past to pay for innovation, often dressed up as contract change proposals or funded studies that we have

taught the companies this is the way to do things. For the robustness of our industry, I would like to see more R&D being undertaken with export markets in mind."

Australia's defence industry is so small its R&D investment is relatively insignificant compared to that of the major European and US players in today's globalised, high-technology defence industry. This can be seen as a reflection of Australia's defence budget which is also small compared with the countries from whom the ADF imports most of its equipment. But does Australian industry properly exploit the IP generated by bodies such as DSTO and the Cooperative Research Centres (CRCs) and Universities who also carry out defence-related R&D?

Why doesn't more of this happen? And why don't Australian companies invest more in their own defence R&D? These questions go to the heart of the author's research.

In other countries government establishments similar to DSTO do S&T or R&D to underpin their policy, acquisition and operational advisory functions. Some of them have a more explicit role also in helping develop new defence technologies and equipment – indeed the R&D costs associated with many technology or product developments are too high to be borne by individual companies without significant support from the parent government. Kongsberg's development of the Naval Strike Missile (NSM) is a case in point: most of the R&D the company undertakes in support of this program is funded by the Norwegian Ministry of Defence.

So another line of enquiry to be pursued in this research is this: how far is the publicly-funded defence R&D in other countries geared towards subsequent commercialisation by the defence industry, by comparison with Australia? And how do ratios of defence BERD to GERD in those countries differs from Australia?

Obviously size matters - the US and UK have 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.

However, smaller countries such as Canada, Finland, Israel, the Netherlands, Singapore and Sweden are also considerable exporters of defence equipment and services, in some case off a smaller domestic market base and defence budget than Australia.

But it could be argued that much of the private sector defence R&D conducted in some these countries supports an industry base whose products are inferior to the top-end equipment from the US, UK and the major European NATO powers among whom Australia shops for its high-end defence equipment.

Nevertheless, where DSTO and industry have worked together with the ADF there have been significant Australian success stories. The classified second volume of the 2004 Trenberth Report on DSTO's external interactions included six case studies of technologies developed by DSTO and successfully commercialised by Australian industry. DSTO invested some $245.4 million developing these technologies during the 1970s, '80s and early '90s; while some of them don't lend themselves to a simple calculation of their commercial return, the author estimates that domestic and export sales of these technologies so far amount to roughly $4.6 billion.

But the aggregate contribution these technologies have made to Australia's national wealth, including industry and scientific skills development, import replacement, enhanced defence capability and non-defence commercialisation amounts to some $12.08 billion. That figure was derived for Trenberth by ACIL Tasman and is based on a complex matrix of cost and value estimates and supports DSTO's argument that the organisation has more than paid its way without having to focus on a commercial bottom line.

These successes haven't been matched by achievements on a similar scale developed solely from the private sector, with perhaps three exceptions: The CEA-MOUNT and CEA-FAR radar systems developed by CEA technologies in Canberra, which appear on the verge of significant domestic and international success; the Bushmaster Infantry Mobility vehicle (IMV) developed by ADI Ltd; and the Metal Storm ballistics technology developed by Metal Storm Ltd in Brisbane. Metal Storm is a disruptive new technology which has attracted huge interest and R&D funding from the US government and private sector and in parallel (but only after much initial self-funded R&D) by DSTO.

These examples illustrate the point made earlier: under Brabin-Smith's guidelines DSTO could probably never have justified investing R&D resources in these technology areas, but three Australian companies bore the considerable risks involved and have developed world-leading and very valuable technologies and products with potential to deliver a very significant commercial return.

It should be noted that DSTO's success stories have taken decades to generate the sales figures quoted above. Last year the companies listed in the ADM Top 40 had a collective revenue of $5.45 billion. In other words, the commercial return from DSTO's (and therefore, so far, Australia's) biggest defence R&D success stories still amounts to less than a year's total revenue for the Top 40 Australian defence manufacturers.

What's the market?

Or, to address the second Key Research Question: Is Australia's public and private sector investment in defence R&D commensurate with the anticipated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from that R&D?

And is there a circular argument here? For example, is demand for Australian goods and services (which may or may not be an accurate indicator of the accessible market) shrinking

because Australia (and especially Australian industry) isn't investing enough in developing new defence goods and services?

It's arguable that Australia's defence industry spends less on R&D than its rivals and peers overseas, and pays the price - further research will test that hypothesis. If that is indeed the case, then why? Is it because the domestic market is too small or too inaccessible? Cause and effect in this case remain to be explored in detail.

However, the widely-shared gut feeling that the domestic market for Australia's defence industry is small and shrinking was articulated by ADI Ltd's managing director, Lucio di Bartolomeo, at the 2005 D+I Conference in Canberra.

He stated then: "During the next decade and beyond, I estimate that the addressable market value for Australian industry in major capital equipment will fall to around 30-40 per cent of the $3Bn allocated in today's dollars. That's about $1 to 1.2Bn annually." The head of the DMO, Dr Steve Gumley, concurred with di Bartolomeo's analysis.

By di Bartolomeo's estimate, the 2004-14 Defence Capability Plan is worth about 30-40 per cent of its $54 billion value to Australian companies, or about $16 billion to $22 billion over the life of the projects contained in it. (Bartolomeo 2005)

The remainder of the money will go to overseas prime contractors in programs such as Joint Strike Fighter, Follow-On Stand-Off Weapon, Air Warfare Destroyer, Maritime Patrol and Response capability, and so on.

Furthermore, Australia's defence acquisition policy means that where they do have access to the domestic market Australian companies are still competing against foreign companies for domestic sales. Other countries are not always so open to overseas competition.

So, to partly answer the original question - arguably, the current level of private sector defence R&D probably reflects industry's perceptions of the scale of the accessible domestic defence market, the perceived risks inherent in tackling it and the consequent difficulty in leveraging domestic sales successes in export markets. Arguably also, it barely reflects the need to maintain and enhance skills and capabilities, and to fuel or sustain industry growth in the future.

As noted earlier there is a widespread industry belief, sustained by anecdotal evidence and the testimony of at least one senior DSTO scientist, that the "not invented there" syndrome applies within the DMO and Capability Development Group, that Canberra is reluctant to trust local suppliers and, by a lazy default, favours imported equipment and solutions over local solutions.

Furthermore, Defence's slow processes, and the costs these inflict on industry, compound the perceived risk associated with developing new indigenous IP and product specifically for the local defence market. However, as Australia's defence industry is predominantly a service industry, the companies listed in the ADM TOP 40 can still turn over $5.45 billion

between them despite having access to only 30-40 percent of a $3 billion capital equipment market.

Therefore, estimates of the size of the defence market, both domestically and overseas, can appear to industry to be a theoretical abstraction because gaining access to those markets can be difficult. Further research will examine whether or not barriers to entry are as high as the anecdotal evidence would suggest, and whether and how they differ between the domestic and export markets.

What about the export market? Growth is essential for any industry. But it can be safely assumed that the Defence budget, and the proportion of it realistically accessible by Australian companies, won't increase dramatically in the next decade or so. If the industry wants to grow without diversifying hugely into non-defence areas, it can only do so through exporting.

However, this implies a significant change in much of the industry's business model. As noted earlier Australia's defence industry is mainly a service rather than manufacturing industry. This is in large part because the Department of Defence's stated need is for a local industry base specialising mainly in maintenance, upgrade and systems integration, not manufacturing.

But the export market is overwhelmingly product-based. Robert Salteri, CEO of Tenix Defence, made this point in an interview published in Australian Defence Magazine in February 2005: "Why do I do [R&D]? Obviously so that at the end of the day I have products to sell… in the export market. In Australia I can sell my project management skills and related capabilities… but when you go offshore you… need product as well…something that is tangible. I need to have… products to sell in export markets." (Ferguson 2005)

Developing high-quality products in turn means either doing high-quality R&D to develop them, or exploiting somebody else's R&D. It may also mean establishing new manufacturing capabilities or enhancing existing ones – a major investment in infrastructure and industry capability beyond that explicitly sought by Defence.

This opens up a possible line of enquiry: do Defence's stated needs of the Australian defence industry, which focus largely on skills rather than products, inhibit investment in the development of new products for both the home and export markets? Are Australian companies put off? Does the Department of Defence say in effect, "We don't believe you should be building this so we simply won't buy it?" There are undoubtedly aggrieved Australian business executives who believe that is the case, but this may simply be another urban myth. Again, further research is necessary to establish whether this is the case or not.

Quantifying the accessible export market is difficult. To summarize the views of many Pilot Study interviewees, access by Australian companies to the export market is constrained artificially by a number of factors: first of all, some Australian technologies or products may be too sensitive to receive Australian Federal government export approval; secondly,

some products and technologies developed jointly with allies such as the United States may be subject to those allies' export controls; thirdly, access to and success in an export market are to a considerable extent determined by political and strategic factors outside the control of most private sector exporters; and finally, it is the accepted rule throughout the global defence industry that to have any chance of winning an export sale to a foreign government the product or service in question must first have been sold successfully to the exporter's own government.

In assessing the scale of the market opportunities open to Australian industry there is a circular argument which goes like this: Australian companies shouldn't try to compete at home or abroad against imported products developed by overseas manufacturers who enjoy natural advantages in, for example, the benefits of scale afforded by the size of their domestic market (and relative lack of access by foreign competitors) and the amount of money available for R&D, either privately funded or from government sources.

In that case, the argument runs, Australian firms should target niche markets of direct benefit to the ADF; products and services developed for these niche markets should be attractive to export customers operating in similar physical and operational environments, and Australian firms would face few, if any, direct competitors.

This argument, though logical and entirely consistent with both Brabin-Smith's guidelines for DSTO's R&D investment and Defence's needs of industry, is also limiting. It excludes Australian companies from the majority of the domestic market and therefore from the export market as well. But the skill base resident within Australia's defence industry means that local firms, using either DSTO's IP or their own, can and often do compete or collaborate with foreign companies in the development, manufacture and delivery of high-technology goods and services.

It must be remembered that the ADF shops in the same store as the UK and US armed forces and the Pentagon – it seeks the best. And the Australian defence market is one of the most open in the world, so local manufacturers compete with and are judged against the biggest and best suppliers in the world.

The corollary to this is that locally developed equipment that is good enough for the ADF is good enough for most customers, but may be too good to be exported widely. Its export markets may be confined to countries such as the USA, UK and Canada where competition is toughest, and its market potential may be affected still further by factors such as high barriers to entry and Australia's small domestic market which offers no economies of scale.

One emerging pathway to the export market is through Global Supply Chains (GSC). These are a mechanism whereby an overseas prime contractor sources components and sub-assemblies on a best-value basis from a global network of suppliers and sub-contractors.

The best-known example of this is the F-35 Joint Strike Fighter (JSF) program which has seen companies in nine different countries develop products, processes, services and expertise to support the System Development and Demonstration (SDD) phase of the F-35

fighter. When the aircraft enters low-rate and then full-rate production, most of these companies will supply components and sub-assemblies to prime contractor Lockheed Martin in Ft Worth, Texas.

Instead of building a relatively small number of components under some kind of negotiated industrial offsets deal, or assembling a handful of aircraft locally for their own air force, these companies (including nearly 20 Australian firms) will design and manufacture equipment for the entire production run of F-35 aircraft – potentially 6,000 aircraft over 30 years. But they will only secure this work if they are globally competitive in both technical and cost terms.

As the cost of defence technology and the level of R&D required to harness it continue to rise, it isn't hard to imagine scenarios in which JSF-type Global Supply Chains become established for both new and legacy products. Obvious examples include the Eurotorp MU90 Impact lightweight torpedo, for which Thales Underwater Systems manufactures components on a sole-source basis; the Evolved Sea Sparrow Missile (ESSM), whose thrust vectoring control system is manufactured in Australia by BAE Systems; Nulka, another BAE Systems product derived from DSTO's original IP; and possibly future variants of the Aegis air warfare system.

One Pilot Study interviewee stated: "Where Global Supply Chains (GSC) are concerned, it can be presumed that local firms will achieve greatest leverage where there is an implicit or explicit commitment by the ADF to acquire the equipment in question. While breaking into GSCs is much harder without the promise of a local sale, price, quality and unique technology can open doors – see, for example, Austal's role in the General Dynamics-led proposal for the Littoral Combat Ship (LCS) program for the US Navy: the RAN is highly unlikely to acquire the LCS."

So, rather than try to "guesstimate" the export market for goods and services resulting from Australian defence R&D it may be more helpful to focus on potential GSC opportunities where the prospects for Australian participation may be enhanced by the leverage of a potential ADF purchase of the equipment in question. Indeed, entering the Global Supply Chain for some overseas primes might be the easiest way to sell to Canberra.

This isn't to negate the efforts of Australian exporters who have performed well and continue to open up potential export markets in the traditional manner. ADI's AMAS mine warfare system (derived from DSTO's original IP) has achieved global sales worth around $50 million; Tenix Datagate's Interactive Link (also developed from DSTO's IP) has enormous potential; and, after a troubled gestation, ADI's Bushmaster Infantry Mobility Vehicle has performed well in Iraq and has caught the eye of several potential export customers.

So there is a large, as yet unquantified (and possibly unquantifiable) market among our allies for sophisticated equipment and sub-assemblies which also form part of major equipments and platforms we buy from, or in partnership with, those allies.

But accessing large, sophisticated and competitive markets such as the US and Europe requires quality product, which in turn demands quality R&D - this is a lesson which many Australian firms have learned the hard way from unsuccessful early tenders for work on the JSF System Design and Demonstration (SDD) program. And if the IP isn't available through DSTO, it must be derived from R&D by the companies themselves.

What's the cost of not doing it right?

This is the third Key Research Question: What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?

This question has its roots in the assumption that defence R&D can and does deliver a measurable benefit to Australia and, by implication, that Australia therefore pays a penalty if it fails to invest sufficiently in defence R&D. It therefore addresses the question of why defence R&D is necessary in the first place; this in turn addresses both strategic (national) and commercial or business motives.

It also suggests an obvious corollary – that it is possible to over-invest in defence R&D and suffer an opportunity cost from resources diverted wastefully to this area which could have been put to more productive use elsewhere.

One Pilot Study interviewee put forward the provocative suggestion that it wouldn't make much difference to Australia's defence capability if the country doesn't do defence R&D and try to commercialise it.

He argued that, with its unparalleled access to the best defence equipment the US and UK can produce, it would be cheaper for Australia to invest scarce R&D resources in areas that contribute directly to the national economy and stop wasting money on defence R&D and on trying to manufacture defence equipment in Australia. The resulting increase in national wealth could then be used to simply buy defence capability off the shelf.

This argument is countered by several defence R&D, industry and ADF voices. The arguments are summarised thus: "We 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."

The Pilot Study suggested the opportunity cost of under-investing in defence R&D and commercialisation can be measured a variety of ways: aside from revenue and profit foregone by the companies themselves, and the wider economic benefits which flow from these, Australian companies and public sector R&D organisations risk losing core skills and knowledge which are stimulated and refreshed by R&D. These bestow the ability to evaluate others' R&D and products and actually support those products in service; they also

underwrite the companies' credibility as sub-contractors, suppliers and industrial partners in new ventures, both domestically and overseas.

A declining defence industry base will struggle to attract young engineers who will increasingly flow to other industry sectors, or even overseas, in pursuit of attractive career opportunities. Australian companies will gradually become uncompetitive and therefore unable to innovate, and so become irrelevant both to the ADF and to customers and partners overseas.

It would be difficult, if not impossible, to answer this question without establishing some sort of benchmark against which to measure Australia's performance. Benchmarking against other countries or market sectors where strategic circumstances and defence market conditions may be quite different is naturally problematic. But there seems little alternative to seeking external benchmarks for national defence capability and defence industry revenue and profitability to assess Australia's defence R&D and commercialisation performance.

Why is this question important? For two reasons: firstly, it attempts to quantify (however imperfectly) the benefits of conducting defence R&D in Australia and the costs of not carrying out such R&D. This in turn may help improve the basis on which defence R&D and subsequent commercialisation investment decisions are made, in both the private and public sectors. It may also help provide an answer to a subordinate question – how much R&D is enough?

Secondly, because the answer to this question is likely to be derived (at least in part) by inference and from comparison with other countries and other industry sectors, it may also provide a valid basis for comparing the national and private sector resources devoted to defence R&D and commercialisation with those devoted to R&D and commercialisation in other sectors and in other countries. And it may show whether or not Australia's defence IP commercialisation outcomes are commensurate with the S&T and R&D investment.

The financial benefits of defence R&D and commercialisation may be relatively easy to measure. Non-financial benefits may be very much harder to measure. They generally include (in no particular order) things like recruitment and retention of suitably skilled personnel; commercial leverage in negotiating with technology and equipment suppliers and partners; and confidence that the correct purchase and policy decisions are being taken with regard to defence equipment and technology investment.

These can be described loosely as contributing to "competitiveness", which is measured in many ways and is affected by many factors outside the scope of this research. However, a very simple measure of competitiveness does exist: IPRIA's figures show a very strong correlation between R&D investment and a company's financial performance.

The same may be true on a larger scale of those countries which make a significant commitment to defence R&D which in turn supports a nationally and internationally competitive defence industry. However, the research must take into account strategic

imperatives which distort classical market mechanisms: most European countries, for example, have quite large defence industries which are major employers and contribute significantly to the national economy as well as to the nation's technical sophistication.

In many such cases public and private sector R&D is directed at supporting this industry base and successful commercialisation, either nationally or in a multi-national partnership, is almost a 'given'. This type of situation can result in some inferior products being favoured by national governments over superior or more cost-effective products developed elsewhere. It can therefore distort assessments of commercialisation models and outcomes, as well as comparisons with Australia's performance, and so the validity of some statistics may need careful scrutiny.

However, the defence R&D and commercialisation performance of other countries over the past few years will undoubtedly illustrate the consequences of failure as well as the rewards for success.

CONCLUSION

To summarise briefly – Australia spends less than the OECD average on R&D; paradoxically, Australia's defence sector spends well above the national average on R&D. But much of Australia's defence R&D or S&T investment is designed to underpin DSTO's critical advisory function. The gross level of private sector defence R&D in Australia appears very low, considering defence is such a technology-dependent environment. And it is by no means certain that Australia's levels of private sector defence R&D are commensurate with the accessible market.

Much work remains to be done to refine the statistics, analysis and arguments which will answer the five Key Research Questions. In particular, any consequences to Australia's defence industry of failing to invest sufficiently in defence R&D, and then to commercialise the resulting IP, will probably need to be demonstrated by inference.

But several important questions have emerged from the research so far and further research will attempt to answer them:

- Does Australia do enough defence R&D?
- Have DSTO's S&T/R&D investment priorities changed significantly, and if so has industry made up any shortfalls?
- Is the ratio of defence GOVERD to BERD significant?
- How does Australia's defence GOVERD to BERD ratio compare with other countries?
- How does Australia's BERD to defence budget ratio compare with other countries?
- How does Australian industry's defence R&D investment compare with the defence industries of other countries?
- Does Australian industry invest sufficiently in its own R&D or in commercialising the IP developed by DSTO and other agencies?
- Given its generally higher R&D investment, does Australia's defence industry perform better than the non-defence sector?

- How do DSTO's IP commercialisation policy and mechanism compare with those of its peers overseas?
- What are the factors (real or perceived) in the Australian defence market which inhibit private sector defence R&D?
- For example, do Defence's stated needs of Australian industry inhibit or actively discourage investment in new products?
- Is the market simply too small to sustain an industry base with the skills the ADF needs to support it?

DSTO has a critical role in the nation's defence. Only part of that role relates to the traditional definition of R&D. Increasingly, it seems responsibility for product-related R&D is falling on the private sector. Operating in the open market, private companies tend to act from self-interest. If the benefits of investing in R&D aren't clear then two possibilities exist: first, for whatever reason, the market is unable to deliver a benefit commensurate with the investment; or secondly, the company concerned is blind to those benefits. In the case of the Australian defence market a considerable amount of research may be required before it can be said with certainty whether either possibility applies here.

Identifying the specific factors that enable or inhibit successful commercialisation of Australian defence IP will be a long-term project. But Australia's defence community needs hard data and a systematic approach to gathering it in order to identify clearly what needs to be done to enable the industry to remain relevant and to grow through the first half of this century.

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