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Risks and rewards: Defence R&D in Australia

by Gregor Ferguson

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Australia's defence budget is the fifth largest in the world per head of the population. In gross terms, it's the 14th largest in the world, commensurate with the size of the economy, which the World Bank rates 13th largest overall.

We spend a nationally significant amount on military hardware, software and related services. Over the next decade alone, the ADF plans to spend $150 billion acquiring and sustaining new and existing defence equipment; acquisition will account for over half of this expenditure. That spending attracts considerable scrutiny, but surprisingly little attention is devoted to Australia's defence research and development (R&D) and broader innovation activities.

In fact, the last ten years has seen a significant shift in the way that defence R&D is funded. The role of the Defence Science and Technology Organisation (DSTO)—once the primary provider of defence R&D to government and the originator of technologies such as over the horizon radar—has shifted away from fundamental research and has become more advisory in nature. This shift has occurred at the same time that the government's approach to defence acquisition has increasingly embraced the 'off-the-shelf' philosophy.

These changes have significant implications for Australia's defence industry. This paper examines trends in Australian defence R&D spending and what they mean for government and industry players. There is still a place for innovation and R&D, but it must be targeted differently. There is little appetite for long-term 'blue sky' research, but there is still a role for applied research and (especially) for rapid development of 'quick fix' solutions.

The shape of the R&D spend

The proportion of Australia's $27 billion defence budget that the Defence Materiel Organisation (DMO) will spend this year on goods and services for the ADF amounts to 0.9% of gross domestic product.[1] Defence invests around 2% of its budget or over $480 million a year on science and technology (S&T)—mostly through DSTO—to help it select, operate and sustain its equipment.

Counterintuitively, however, very little of the S&T spend goes towards developing new equipment. Most of DSTO's R&D effort underpins the advice it provides to the ADF on what to buy, how to use it as effectively as possible,

and how to keep it for as long as possible. The R&D to create new defence equipment and industry capabilities is mostly done outside DSTO, by industry or by a small number of specialist R&D organisations.

Table 1 shows Australia's overall R&D investment by government and industry. There are two striking contrasts here. While total government R&D expenditure has nearly doubled in dollar terms, the fast-growing economy means it has declined by more than a third as a percentage of GDP over the past decade. Meanwhile, industry's total R&D investment has grown sixfold to $16.8 billion, or 61% of the national total.

Table 1: Australian R&D Expenditure 1992 to 2009 (then-year A$ million)

	National	Total Government	Business	Business % of Total	Government R&D spend (% GDP)
1992–93	6,483	1,824	2,862	44.2	0.43
1996–97	8,792	2,064	4,234	48.2	0.39
2000–01	10,417	2,355	4,983	47.8	0.35
2004–05	15,968	2,486	8,676	54.3	0.27
2008–09	27,740	3,420	16,858	60.8	0.27

Source: Australian Bureau of Statistics, Research and experimental development, all sector summary, Australia, 2008–09, Canberra, October 2010.

In 2008–09, Australia invested 2.2% of its GDP in R&D, amounting to some $27.7 billion. Some 3% of that money ($800.8 million) was nominally spent on defence R&D. However, Defence emphatically does *not* mirror the rest of the economy, as Table 2 shows. Contrary to the overall national trend, attributed government defence R&D spending—in effect DSTO's budget—has more than doubled in dollar terms but has remained a relatively stable 2% of the defence budget, while industry's share of defence R&D has declined.

Table 2: Australian defence R&D expenditure 1992 to 2009 (then-year A$ million)

	Defence budget	Total defence R&D	Govt defence R&D	Gov't defence R&D (% Defence budget)	Business defence R&D	Business share of defence R&D (%)
1992–93	9,509	346.2	208.9	2.2	134.4	38.8
1996–97	10,611	437.0	234.0	2.2	195.8	44.8
2000–01	14,453	401.1	238.6	1.6	158.1	39.4
2004–05	20,569	616.6	309.3	1.5	278.0	45.1
2008–09	24,081	800.8	486.0	2.0	259.4	32.4

Sources: Australian Bureau of Statistics, Defence Portfolio Budget Statements and annual reports; ASPI Defence budget briefs 2003–2010; SIPRI Military Expenditure Database

DSTO's budget comes directly from Defence and therefore isn't subject to the same competition and funding pressures as other government R&D funds. But industry's declining share of defence R&D (despite nearly doubling in dollar terms) is surprising: the high-technology defence sector seems to be underinvesting in R&D compared with the rest of the private sector. This seems to 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 income.

But why?

It's worth asking why Australia invests in defence R&D at all. Thanks to the privileged access we enjoy to the arsenals of our key allies, the US and the UK, there's very little the ADF needs that can't simply be bought off-the-shelf. Advocates of this 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 'military off-the-shelf' (MOTS) solutions. The result, it's 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 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 essentially bipartisan policy aimed at minimising or eliminating government interference in industry and the operation of markets, which ASPI examined in detail in 2009.[2])

There are several arguments against this economically dry outlook. First, there are some things judged to be 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.

Second, 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 to maintain and upgrade even imported equipment using local skills and resources. The ADF would become dependent on a handful of key foreign suppliers that are 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 operational capability.

Third, Australia depends on its alliances, which in turn depend on its 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 large areas and extending platform lives, provides the credible 'trade goods' that ensure its seat at the table alongside the US, Canada and the UK.

The opportunity cost to Australia of underinvesting in defence R&D was described to the author by a senior defence scientist:

> [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.

Finally, if Defence truly believes in a level economic playing field, Australian companies deserve the opportunity to show they can offer value for money in open competition, especially when Defence is spending a significant proportion of Australia's GDP on defence-related goods and services.

DSTO's role

It's a common misapprehension in the wider community that Defence seeks to shop locally and that DSTO's main purpose is to help local industry develop new equipment for the ADF. Nothing could be further from the truth.

That said, commercialisation of DSTO's R&D between 1990 and 2005 in projects such as JORN, Nulka and laser airborne depth sounding, and other work such as aircraft structural testing, generated direct income or defence budget savings equivalent to DSTO's own total budget for that period. DSTO effectively paid for itself, but it's not at all clear that it could claim similar results today. The long-term 'blue skies' R&D that led to those products no longer appears to be a feature of DSTO's approved program.

DSTO significantly reshaped itself during the 1990s to align more closely with the S&T needs of its principal 'client', the ADF. One of its key roles today is advising the DMO and Capability Development Group (CDG) on technology risk and conducting technology risk assessments in support of major capital equipment programs.

Given the massive asymmetry in defence spending, DSTO doesn't attempt to duplicate research that key allies such as the US, the UK and others are already doing, or to develop equipment others can produce more economically. It believes Defence's most pressing scientific need is advice on how best to select and use technologies developed by others.

Table 3 compares Australia's defence R&D with that of the US and UK—the imbalance is enormous.

DSTO is no longer (if it ever truly was) an R&D organisation. While its budget is counted towards government R&D spending (as reflected in Table 2), less than 15% of its budget is devoted to enabling research. Most of its investigative S&T work underpins its advisory function, and commercialisation of any resulting intellectual property (IP) is not a major priority[3]; indeed, its key performance indicators don't mention 'commercialisation.'[4] That said, much of DSTO's most important work for the ADF is classified and therefore unreported: DSTO has responded to the ADF's heightened operational tempo and the threats it faces in Afghanistan and elsewhere by increasing its enabling research in priority areas such as personnel protection, undersea warfare and cyber security.

Arguably, DSTO's 2% share of the 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 similar proportion of their budget to defence R&D.

Table 3: Comparative international R&D budgets

Country	Defence budget (A$ billion)[a]	Defence R&D budget (A$ billion)[a]	R&D (% of defence budget)
Australia	22.9	0.49	2.1
USA (FY 09)	523.5	80.4	15.4
UK*	61.24	3.16	5.16

Note: US total RDT&E budget is US$79.6 billion. Basic and applied R&D amounts to US$11 billion, or 2% of the defence budget

a Exchange rate calculated December 2010: A$1 = US$0.99 = UK£0.63
* The figures in this table for the UK are updated from the initial release of this paper and reflect the most recent publicly available information. Updated 21 January 2011.

Sources: UK Defence Statistics 2010, US Department of Defense 2009 financial year budget request, ASPI Defence budget brief 2010–11.

Table 4 shows that some of the countries from which Australia has bought significant amounts of high-technology defence materiel are wealthier nations that spend a greater share of their national wealth on defence R&D. Others, like Norway, Sweden and Denmark, spend less than Australia on defence but are prepared to make a greater overall R&D investment. In the defence sphere they are prepared to live with any resulting distortions of the free market and consequent cost premiums borne by their taxpayers.

Table 4: International defence R&D comparison - 2005

Country	% of GDP on R&D	% of total R&D spent on defence
USA	1.03	57.9
UK	0.72	31.0
France	0.93	22.3
Sweden	0.87	16.9
Spain	0.84	16.4
Australia	0.54	6.5
Germany	0.77	6.4
Norway	0.70	5.6
Canada	0.57	3.6
Netherlands	0.73	2.0
Denmark	0.76	0.6

Source: OECD, OECD in figures, 2007 edition

Industry's role

Defence needs industry—with very few exceptions, it buys every product and service it consumes from a commercial supplier—but it has no default preference for Australian suppliers. In some years, over 60% of the DMO's capital acquisition budget goes to foreign prime contractors. Defence's principal needs from Australian industry are maintenance, repair and upgrading of the ADF's equipment, most of which is imported. By some estimates, Australia's defence industry makes around 80% of its revenue from sustainment rather than manufacturing. (This makes industry's R&D figures look more impressive, notwithstanding that much of it is customer-funded rather than self-funded.)

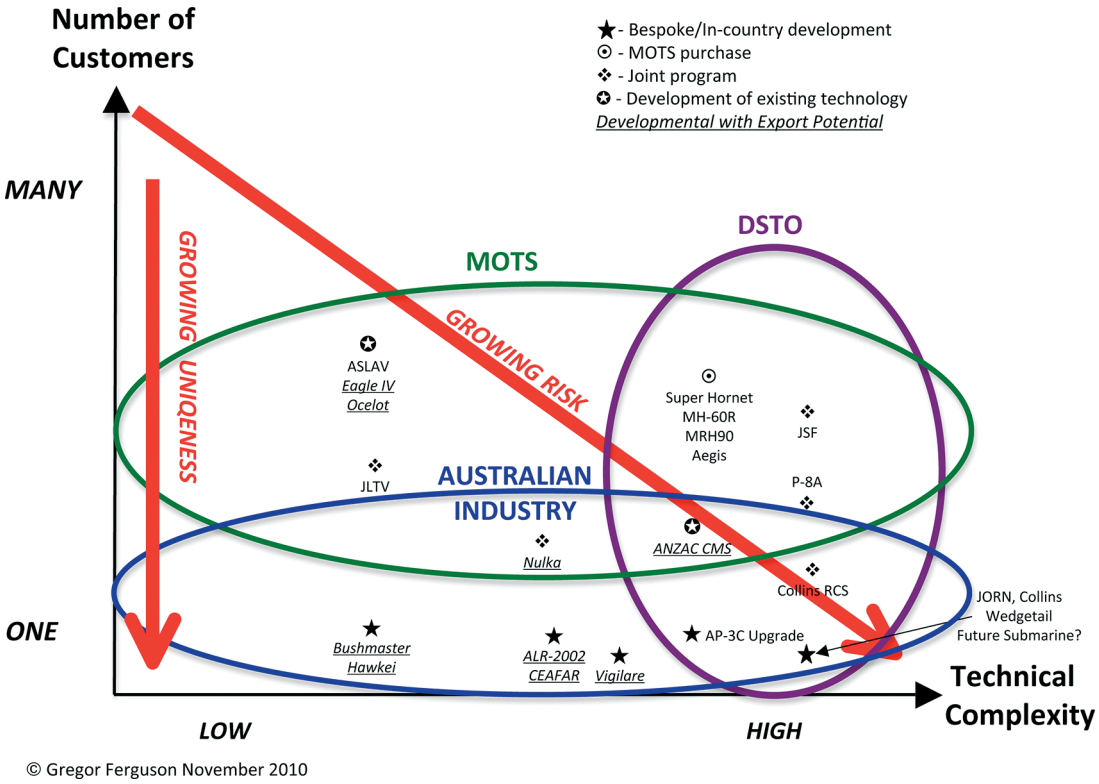
The CDG and DMO are risk-averse—and with good reason. Many complex (and even some relatively simple) Australian defence projects have encountered very visible technical difficulties and embarrassing delays. MOTS equipment is now the benchmark for assessing the utility, value for money and risk offered by a bespoke approach. However, the fundamental nature of the defence market is such that a defence product is rarely a MOTS solution in its own country. Before it can become a MOTS product it must go through the inevitable birth pains of a developmental project, which Australia seeks explicitly to avoid. This can place Australian firms at a disadvantage, as they usually don't get a chance to participate in R&D projects in other countries.

And, except where strategic circumstances demand, DSTO doesn't seek actively to develop its IP into a finished product. The author's recent research shows that DSTO isn't an important source of product-related IP for Australia's defence industry. In contrast with practices in other countries, local companies generate their own IP or work with other defence R&D organisations in Australia.

DSTO still actively seeks collaborative relationships with industry in order to foster information exchanges and shared awareness, but successful commercialisation is an increasingly rare outcome. Industry still seeks to collaborate with DSTO, not to gain access to IP that it can commercialise but for more strategic reasons.

Not surprisingly, the R&D priorities of industry and DSTO don't overlap much. Figure 1 maps the spaces within which industry, DSTO and the DMO operate. DSTO operates in (or at least has a watching brief on) the high end of the defence technology spectrum (the purple ellipse). 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, although understanding the technology behind them remains part of its core business.

Figure 1: DSTO, Defence and industry—the overlaps



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 product. As the technical complexity increases, it's increasingly likely that overseas partners of local firms will be involved. The risk-averse CDG and DMO prefer to shop higher up the graph where more mature, lower risk products are available, generally from overseas suppliers. In some cases (for example, 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.

These territories overlap imperfectly, and they contain interesting implications both for industry and defence researchers and for policymakers. Almost by definition, all brand new defence capabilities are developmental. However, the inherent risks in a developmental project can be mitigated by collaborating with a foreign ally—such as on Nulka and the *Collins* replacement combat system—or by joining an existing developmental program such as the JSF.

The future of defence R&D: Defence's innovation mechanisms

This analysis seems to suggest that Australian industry would need to spend more on R&D and risk mitigation to continue to survive as a relevant, competitive, independent high-tech manufacturing base. Alternatively, it needs to reposition itself 'up the graph' in the MOTS area so that it becomes a partner of, or supplier to, the mostly foreign companies that increasingly supply Australia's defence equipment.To the extent that Australian industry remains active in research, it's likely the most fertile ground will either be in those areas identified by government as being of strategic value, as articulated in the Priority Industry Capabilities (PIC) or in export markets where local firms enjoy access and some exploitable competitive advantage.

From the economically dry outlook now apparently prevailing within Defence, it's questionable whether DSTO needs a local defence industry to justify its existence. Therefore, most of the $486 million that Defence spent on S&T in 2008–09 has made little direct contribution to national wealth through the mechanism of industry development. 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 above, much of DSTO's best and most important work is unreported and therefore unexamined in this context.

However, it would take a ministerial or Cabinet-level judgment that the current situation is unsatisfactory to modify Defence's default arm's length policy towards industry. DSTO and Defence certainly feel no urgent need for change: when the Trenberth report on DSTO's external interactions recommended in 2005 that knowledge transfer and collaboration with industry should become an explicit part of DSTO's core business, Defence took no action.

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

- DSTO, whose S&T activities are vital but aren't focused on commercialisation
- the private sector, whose R&D risk appetite is conditioned by its commercial assessment of the defence marketplace 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 Defence's other mechanisms for conducting what might be termed 'applied R&D', or innovation, which are designed to help create new capabilities and equipment for the ADF.

The first is the Capability and Technology Demonstrator (CTD) program, funded by the DMO 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, but not to create a production-ready prototype. Of ninety-one projects funded to date, some fifty-five have been judged successful, but of those fewer than a dozen have generated sufficient user interest and development funding to transform them into finished products. The recently introduced CTD Extension Program will advance a handful of promising projects, but it's only funded through 2011–12.

The second mechanism is the Rapid Prototyping, Development and Evaluation (RPDE) program, established by CDG with an annual budget of $12 million to apply defence and industry expertise to pressing operational problems in the network centric warfare domain. Because RPDE actively involves the end users as well as CDG, DMO and DSTO, it's proven an effective mechanism for stimulating and then applying innovation right across the defence community.

DSTO has close collaborative research links with the recently created Defence Science Institute at the University of Melbourne and a number of 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. The CRCs and DMTC are run by the Department of Innovation, Industry, Science and Research (DIISR), 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 from industry and academic participants, including DSTO and the Victorian Government.

These links generate expertise and insight into a variety of specialist technologies, which supports and strengthens DSTO's advisory function, ranging from biological and chemical threats, armour protection and lightweight aerostructures to submarine batteries. They also provide a low-risk, arm's length mechanism for the dissemination of IP and expertise to industry and thence to the Defence customer.

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 multinational prime contractors.

Conclusions

On the available evidence, the Australian defence R&D or innovation mechanisms best positioned to engage with industry in developing new equipment and capability for the ADF are the CTD program, RPDE and the CRCs (including the DMTC).

RPDE sets out to solve urgent, real-world problems by engaging the resources of a wide cross-section of players, while the CRCs tend to focus on relatively narrow technology domains. For example, DMTC's research goes directly to the heart of personnel and vehicle protection against contemporary threats such as improvised explosive devices, and is designed also to help position local companies to secure manufacturing and through life support opportunities in future DCP and export projects.

The CTD Extension Program, if continued, would also leverage a significantly greater return from DMO's investment in the CTD program. It's telling that the CTD, RPDE and DMTC programs, which between them cost just $29.4 million a year (or 6.5% of DSTO's 2009–10 budget), are largely funded by the DMO and CDG. Interestingly, the DMTC and the Defence Science Institute also receive Victorian state government funding, precisely because their research has the potential to deliver direct industry and therefore economic benefits.

It's also telling that the DMTC uses a modified CRC model developed outside of Defence (by DIISR) for reasons of governance and the delivery of measurable research results. Defence simply lacks the mechanisms, and seemingly also the appetite, for efficient commercialisation of its own IP.

DSTO will continue to meet Defence's need for expert advice but not, in the main, its need for smart equipment. Defence plans to spend $150 billion on capital equipment and sustainment in the coming decade. While DSTO's advice will help Defence spend that money wisely and use the equipment effectively, the relationship between what Australia nominally spends on defence R&D and its acquisition plans looks surprisingly tenuous.

For Australia's defence industry, R&D is closely linked to perceptions of market risk and reward. The business environment doesn't explicitly favour local manufacturers, although determination and 'smarts' can make Australian companies competitive and even world leaders. Short of a radical change of outlook within the Australian

Government, the environment won't adapt to industry—industry must adapt to the environment. If it can't, then the share of Defence's capital equipment acquisition program secured by locally designed and built products will continue to decline.

Endnotes

1. Stephen Gumley, *The changing shape of the DMO in Australia's defence and industry business environment*, address to the Australian Defence Magazine Congress, Canberra, February 2010.
2. Andrew Davies and Peter Layton, *We'll have six them and four of those: Off-the-shelf procurement and its strategic implications*, ASPI special report 25, November 2009, available at http://www.aspi.org.au/publications/publication_details.aspx?ContentID=231&pubtype=10.
3. RJ Trenberth, *Review of DSTO's External engagement and contribution to Australia's wealth*, Defence Science and Technology Organisation, 2004, Canberra.
4. Department of Defence, *Defence Annual Report 2009–10*, Department of Defence, Canberra.

Acronyms and abbreviations

ADF	Australian Defence Force
CDG	Capability Development Group
COTS	commercial off-the-shelf
CRC	cooperative research centre
CTD	Capability and Technology Demonstrator program
DMO	Defence Materiel Organisation
DMTC	Defence Materials Technology Centre
DSTO	Defence Science and Technology Organisation
GDP	gross domestic product
JSF	Joint Strike Fighter
JLTV	Joint Light Tactical Vehicle
MOTS	military off-the-shelf
R&D	research and development
RPDE	Rapid Prototyping, Development and Evaluation program
S&T	science and technology

About the author

Gregor Ferguson is Editor-at-Large of *Australian Defence Magazine* and currently researching defence industry innovation success factors at the University of Adelaide's Entrepreneurship, Innovation and Commercialisation Centre. He is also a former Defence Materials Technology Centre Research Fellow.

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Tel + 61 2 6270 5100
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