Defence R&D and the Management of Australia's Defence Technology

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ABSTRACT *Technological innovation for defence-related purposes has often facilitated major advances of socio-economic significance well beyond the defence sector. In the post-Cold War era, government spending on military research and development (R&D) is falling around the world but for Australia, the changing strategic environment presents challenges which imply there may be substantial benefits from maintaining existing, modest levels of domestic R&D effort. This paper examines the policy drivers in this area, embedding analysis of defence R&D spending in the broader processes of procuring R&D-intensive, hi-tech weapons systems. It concludes that if Australia is to reduce the inefficiencies often associated with defence procurement, it may need to have a core of defence-dedicated R&D undertaken by government itself.*

Keywords: defence and military R&D, defence procurement, defence science and technology, dual technology, government research agencies.

Introduction

One of the central features of the history of technology is the impact of innovations developed for the purposes of war-making or, more politely, defence. In the modern world, defence-related R&D has at times accounted for a large fraction of all national research expenditures by major military players such as the US, UK, France and the old Soviet Union (see the following section). The need for large scale defence spending, and with it defence-related R&D, is undergoing a major re-assessment in these countries in the post Cold War era.

Such re-thinking in the northern hemisphere is spilling over into policy debate on the organisation of defence-related R&D in Australia. On the other hand, the strategic thinking behind the debate reflects conditions in a medium-sized economy with unique geographical features, impediments to having specific technological needs met by allies, and the perceived value accruing to a home-grown and domestically sustained base of specialised knowledge.

Defence-related research and technological development takes various forms, from purely theoretical work on the physics of air and water turbulence, or radiation, to more experimental work designed to test materials and structures, to advanced technology demonstration construction, and, later in the life cycle of systems, work on detecting wear and fatigue with a view to extending the life of expensive weapons. In this paper we examine the efforts of efficiency-driven governments to extract maximum benefit from the R&D efforts of its defence science and industry—in a context where the notion of benefit itself is most elusive.

0810-9028/97/020223-29

In economic jargon, the final output of the department of Defence—national security—is usually recognised to be a public good. But the government's role in supplying a public good or a service is not equivalent to it producing the equipment or employing the labour required to provide the good. Like any other service supplier, it can make or buy (hire) any of the physical inputs it uses. It can also undertake its own R&D, or contract the work out, or just 'leave it to the market'.

Given the nature of Australia's geography (the continent of Australia and the Seas around her account for about 10% of the total surface of the planet), distances separating it from major regional military powers, and the inhospitable nature of much of its land mass, a sudden major military attack on Australia does not currently appear to be very probable. The most recent Defence White Paper does not identify any specific source of military threat to Australia but acknowledges the growing strategic potential of China, Japan and India and notes the large scale force modernisation programs being undertaken by many south-east Asian countries.[1] It notes that the end of the Cold War has brought about important new uncertainties relating to the future strategic situation in the region and that this may result in a deteriorating security environment for Australia.[2]

For most of this century, Australia's solution to her security problem has been to seek protection from powerful though distant allies. Whilst Australia's treaty relationship with the US continues to be a key element of its defence policy, Australia is also committed to the expansion of regional security 'partnerships' with the Association of South-East Asian Nations (ASEAN) countries—in particular Indonesia, Malaysia and Singapore. Most importantly, Australia is also committed to maintaining a degree of military independence. With its beginnings in the early 1970s, the concept of *self-reliance* has now evolved into the current strategic doctrine. Self-reliance does not equate to military self-sufficiency. It merely aims to permit Australia to conduct military operations in the event of credible low and medium level threats without depending immediately on potentially unreliable sources of military support and supply.[3] Australia also continues to support international constabulary activities aimed at peace keeping and the provision of humanitarian aid by multi- and inter-national agencies, particularly the UN.[4]

The main qualities required of Australia's defence effort are the adaptability and flexibility to meet diverse and rapidly changing demands. In part, the aim is to achieve these through using technological sophistication as a force multiplier.[5] Australian policy makers, however, have long had to balance demands for technological sophistication, based on imports of the state-of-the-art weapons systems, with self-reliance requirements calling for high local content in procurement of military materiel. This has been further complicated by an unwillingness to pay excessive premia for domestically-sourced equipment or to sustain obsolete industrial capabilities.

As self-reliance does not mean self-sufficiency, Defence must continue to rely on foreign sources for services including elements of intelligence and some products involving high technology innovations. On the other hand, even close allies do not share all the design and performance data (such as signature data) associated with state-of-the-art weapons-systems development. This points to the need for Australia to develop indigenous products and services in at least some areas. Self-reliance calls for a national capability to employ, maintain and modify advanced equipment so Australia does not have to depend on support from other powers to deal with the lower level threats it is likely to face. This all implies 'a significant level of Australian science, technology and industry support for capabilities considered vital for Australia's defence and where Australian needs are unique'.[6]

On the assumption that essential elements of defence capability cannot be simply purchased 'off the shelf' from overseas suppliers, the issue is how to develop them locally. Even in large industrialised countries, it cannot be taken for granted that private industry possesses all the R&D, design and production capability required to meet national defence needs. In a small-medium sized economy such as Australia, and one, moreover, with internationally low levels of technological innovation in manufacturing, private industry is certain to be deficient in meeting defence needs.

On the other hand, there are potentially good reasons for putting in place policies which encourage and enable local private industry to develop such capabilities. For one, having all elements of defence production undertaken in government factories has led to demonstrable inefficiency in the past. For another, private industry may be able to use more readily lessons learned in defence-related production for entering civilian markets than a government factory focused on a defence-specific mission. That said, private industry cannot be expected to invest in defence-specific R&D unless it is very sure of a good return. And even if it did undertake such R&D, Defence might justifiably worry about the level of effort, quality of work, and general issues of security. While there are several ways, potentially, of addressing these issues, one attractive division of tasks involves government in producing new knowledge for defence application and the private sector in using the knowledge to produce defence goods. In this context, whilst Defence does the research and some development and design work in-house, private industry may also undertake development and design work but specialises particularly in production. Of course, as innovation theory constantly reminds us, the innovation process is not a linear one. If a government wants the best from a Defence-industry relationship, both sides should be prepared to interact, to feed off each others' learning, throughout the life of a project.

Australia has gone a long way along the path of defence industry development. But Defence's demand for military goods and services has been and will continue to remain uneven and will most likely be too small to sustain an internationally competitive defence industry entirely dependent on domestic defence business. Poor Australian export performance in this area points up the difficult relationship with foreign primes—which have not only been unenthusiastic about using Australia as an export base but also have tended to own intellectual property (IP) in key elements of systems produced in Australia. On the other hand, undertaking domestically the R&D required to underpin innovations in defence technology may yield domestic ownership of the associated IP—but may well be neither a necessary nor sufficient condition for export success.

Challenges such as these motivated the recent Defence Efficiency Review (DER) into the overall management of Defence resources in Australia. The review—which gave rise to an ongoing Defence Reform Program—was conducted between September 1996 and March 1997 by Sir Malcolm McIntosh, CEO of Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and formerly Chief of Defence Procurement in the UK Ministry of Defence.

The following discussion consists of two parts. Part One looks at the general rationale for Defence procurement of R&D, management issues and international comparisons. In particular, we address recent international experience; the Australian context and also consider in-country formation of defence-related technological knowhow and associated aspects of defence technology management. In Part Two, we examine the evolution of specific institutions and policies for defence technology procurement and management in Australia, in particular: the Defence Science and Technology Organisation (DSTO); the Australian Industry Involvement (AII) programs;

the Defence Industry Development (DID) program; and the Commercial Support Program (CSP).

Part One: Defence Procurement of R&D

Global trends in Military R&D

Over the past 10 years, world expenditure on military research and development (R&D) has declined by some 50–55% in real terms, down to some US$55–60 billion per year of which US$39 billion is accounted for by the US, US$50 billion by NATO, and US$52 billion by member countries of the Organisation for Economic Co-operation and Development (OECD).[7] Of the major defence spenders (in absolute terms), only India, Japan and South Korea continue to increase their military R&D effort. Other countries have either reduced their R&D expenditure or have held it constant. The US, by far the largest spender, has reduced its military R&D expenditure by 25% since 1987.[8]

Table 1 shows government expenditure on military R&D in selected OECD countries. US expenditure exceeds that of the next largest spender—France—by a factor of eight and is more than three times that of all other countries listed in the table.

Of countries not included in the table, Russia and China appear to spend on defence R&D at similar levels to Germany, whilst India and South Korea lie somewhere between Italy and Sweden. Australian expenditure in 1994 was half Sweden's and twice that of the Netherlands'.

Table 2 shows 1988–95 expenditures on military R&D in selected OECD countries in constant 1990 US$. With the exception of Japan, all countries experienced significant decreases in real spending on military R&D. Australian real expenditure declined by 17% between 1988 and 1994.

Table 3 shows trends in expenditure on military R&D as a percentage share of expenditure on military equipment in the NATO countries, 1988–95. The table shows

Table 1. Official estimates (1991–95) of government expenditure on military R&D in selected OECD countries (Current US$m)

Country	OECD (year of expenditure)
USA	39 000 (1995)
France	4 600 (1993)
UK	3 900 (1994)
Germany	1 200 (1994)
Japan	770 (1994)
Italy	520 (1993)
Sweden	360 (1994)
Spain	270 (1994)
Canada	210 (1992)
Australia	170 (1994)
Switzerland	89 (1991)
Netherlands	76 (1994)

Source: E. Arnett, 'Military research and development', *SIPRI Yearbook 1996: Armaments, Disarmament and International Security*, Oxford University Press, Oxford, 1996, Table 9.1, p. 383.

Table 2. Trends in government expenditure on military R&D in OECD countries spending more than $20m annually, 1988–95 (1990 US$ million)

Country	1988	1989	1990	1991	1992	1993	1994	1995
USA	44 000	43 000	40 000	37 000	37 000	37 000	33 000	33 000
France	4 700	4 800	5 600	5 000	4 700	4 200	–	–
UK	3 600	3 600	3 600	3 400	3 200	3 200	3 400	–
Germany	1 400	1 500	1 600	1 400	1 400	1 200	1 100	–
Japan	–	500	530	580	630	680	680	–
Italy	740	680	420	560	550	470	–	–
Sweden	420	420	410	480	430	410	320	–
Spain	220	420	450	430	370	300	240	–
Canada	230	220	210	190	200	–	–	–
Australia	180	170	160	160	160	150	150	–
Switzerland	89	89	92	85	–	–	–	–
Netherlands	67	67	75	82	73	74	67	–
Norway	50	47	46	42	45	43	41	40

Source: E. Arnett, 'Military research and development', *SIPRI Yearbook 1996: Armaments, Disarmament and International Security*, Oxford University Press, Oxford, 1996, Table 9.5, p. 389.

that although R&D spending declined in absolute terms, spending on military equipment has also declined, in some cases even faster. There has been a tendency to develop demonstration technologies rather than to go into full production of new systems.

Table 4 shows trends in expenditure in military R&D as a percentage share of total military expenditure in the OECD countries, 1988–95. The table shows that in most OECD countries spending on military R&D remains a fairly constant proportion of all military expenditure. Some countries show small decreases and others small increases in their R&D shares. Australia belongs to the former category with a decline in the R&D share from 3% of all military expenditure in 1988 to 2.4% in 1994.

Table 5 shows 1988–95 trends in expenditures on military R&D as a percentage share of total government expenditure on R&D and total national R&D in OECD countries spending over US$100 million a year on military R&D. In most countries, and in the US in particular, military expenditure on R&D declined as a proportion of all government-financed R&D (note, however, the UK and Japan as the two outliers). Military R&D also declined as a share of all national R&D (with the notable exception

Table 3. Trends in expenditure on military R&D as a percentage of expenditure on military equipment in the NATO countries, 1988–95[a]

Country	1988	1989	1990	1991	1992	1993	1994	1995
USA	55.0	53.0	53.0	50.0	57.0	62.0	44.0	50.0
UK	35.0	40.0	51.0	43.0	48.0	34.0	39.0	–
Spain	11.0	24.0	39.0	38.0	42.0	25.0	25.0	–
Germany	18.0	20.0	21.0	23.0	28.0	32.0	32.0	–
Italy	15.0	14.0	10.0	15.0	16.0	12.0	–	–
Canada	9.9	10.0	11.0	10.0	10.0	–	–	–
Netherlands	4.3	5.0	5.6	7.3	7.2	8.0	6.3	–
Norway	8.1	5.6	6.0	5.8	5.2	4.7	4.1	4.7

[a]Includes only those reporting and spending more than US$10 million annually on military R&D.
Source: E. Arnett, 'Military research and development', *SIPRI Yearbook 1996: Armaments, Disarmament and International Security*, Oxford University Press, Oxford, 1996, Table 9.2, p. 386.

Table 4. Trends in expenditure on military R&D as a percentage of total military expenditure in the OECD countries, 1988–95[a]

Country	1988	1989	1990	1991	1992	1993	1994	1995
USA	14.0	13.0	13.0	14.0	13.0	14.0	13.0	14.0
France	11.0	11.0	13.0	12.0	11.0	10.0	–	–
UK	8.8	8.8	9.0	8.2	8.6	8.8	9.7	–
Sweden	7.5	7.3	6.9	8.7	8.0	7.8	6.1	–
Spain	2.3	4.3	5.0	4.9	4.6	3.4	2.9	–
Germany	3.5	3.7	3.8	3.6	3.7	3.6	3.5	–
Australia	3.0	2.9	2.7	2.7	2.6	2.4	2.4	–
Japan	–	1.8	1.9	2.0	2.1	2.3	2.3	–
Italy	3.1	2.8	1.8	2.4	2.4	2.0	–	–
Canada	2.0	1.9	1.8	1.8	1.9	–	–	–
Norway	1.5	1.4	1.4	1.3	1.2	1.3	1.2	1.2
Switzerland	1.2	1.1	1.1	1.0	–	–	–	–
Netherlands	0.89	0.88	1.0	1.1	1.0	1.1	1.1	–

[a]Includes only those reporting and spending more than $20m annually on military R&D.
Source: E. Arnett, 'Military research and development', *SIPRI Yearbook 1996: Armaments, Disarmament and International Security*, Oxford University Press, Oxford, 1996, Table 9.3, p. 387.

of Japan). However, the US still accounts for some 80% of all NATO R&D (military) expenditure—increasing its previous 3:1 lead to 4:1—and 75% of military R&D expenditure in OECD.[9]

The decline in defence spending which had begun in the late 1980s led to a widespread re-examination of defence policy with a view to providing national security against diffused threats at minimum cost. As Tables 1–5 show, technological knowledge, rather than weapons production *per se*, is becoming increasingly critical. Defence ministries often seek to insulate R&D funding from cuts while improving its effectiveness. Levels of defence R&D showed little tendency to fall, as a proportion of military spending, even in countries such as the US, UK and France in which defence R&D had often been seen as a barrier to technological performance in the civil sector.[10]

Germany, whose post-war levels of public investment in defence R&D have been low relative to countries such as the UK or France (see Table 5), has been the subject of growing interest to other nations. It has built major capabilities by outsourcing much of its R&D to industry and investing heavily in civil technologies. Though Germany remains well behind the US in military technology, it has reached a level comparable to that of France and the UK, each of whose investment in defence R&D is around three times as large.[11] From the German case it may be inferred that a nation which is at the forefront in civil technologies need not invest heavily in defence R&D.[12]

Governments have also embraced collaborative projects in order to control the rising costs and technical complexity of defence R&D. Ambitious projects dominated European collaboration in the 1980s and 1990s but resulted in a number of expensive failures.[13] Future initiatives are expected to be more modest undertakings involving fewer participants with compatible capabilities and system requirements.

Another recent trend has involved investment in R&D without associated production. Such a policy maintains the national knowledge base at greatly reduced cost.[14] Cooperative agreements between national defence research bodies are emerging 'partly to offset costs and partly to ensure access to markets'.[15] Smaller countries, including Australia, hope to promote technology transfer by partaking in such agreements. There has been a shift in the focus of defence R&D towards demonstrator technologies rather than

Table 5. Trends in government expenditure on military R&D as a percentage of total government expenditure on R&D and total national R&D in OECD countries spending more than $100m annually on military R&D, 1988–95[a]

Country	1988	1989	1990	1991	1992	1993	1994	1995
USA	67.8	65.5	62.6	59.7	58.6	59.0	55.3	54.8
	31.0	28.0	26.0	24.0	24.0	25.0	22.0	–
UK	42.7	43.6	43.7	44.2	40.9	42.5	44.5	–
	19.0	18.0	18.0	18.0	16.0	17.0	–	–
France	37.3	37.0	40.0	36.1	35.7	33.6	–	–
	22.0	21.0	24.0	21.0	19.0	17.0	–	–
Sweden	24.0	24.7	23.6	27.3	24.3	23.5	18.9	–
	–	9.8	–	12.0	–	9.4	–	–
Spain	12.6	19.1	18.4	16.8	14.6	12.5	10.6	–
	7.2	13.0	12.0	10.0	8.4	7.2	6.1	–
Germany	12.4	12.8	13.5	11.0	10.0	8.5	8.4	–
	4.7	4.6	5.0	4.2	4.0	3.5	3.3	–
Australia	11.3	11.2	10.6	9.7	8.9	8.5	7.8	–
	5.0	5.2	4.3	4.5	3.6	–	–	–
Italy	10.4	10.3	6.1	7.9	7.1	6.5	–	–
	6.8	6.0	3.5	4.5	4.3	3.9	–	–
Canada	8.3	7.5	7.1	6.4	6.2	–	–	–
	3.3	3.1	2.8	2.6	2.6	–	–	–
Japan	–	5.1	5.4	5.7	5.9	6.1	6.0	–
	–	0.79	0.79	0.84	0.91	1.0	–	–

[a]First row: Military R&D as a percentage of government R&D expenditure; second row: military R&D as a percentage of national R&D expenditure.

Source: E. Arnett, 'Military research and development', *SIPRI Yearbook 1996: Armaments, Disarmament and International Security*, Oxford University Press, Oxford, 1996, Table 9.6, p. 390.

products and maintaining the capability to evaluate procurement options. However preserving in-country capabilities to support and update weapons systems will remain a major priority, especially for smaller countries.[16]

Aiming to increase the efficiency of defence R&D and to support the national defence industrial base, some governments sought to commercialise defence R&D. In the UK, for example, the Defence Evaluation and Research Agency (DERA) was corporatised and extensively restructured so as to enhance its focus on performance. During this process the DERA increased the ratio of scientific to support staff and altered the balance of its research in favour of strategically important areas. Special emphasis was placed on the commercialisation of DERA technologies in both military and civil sectors.[17]

As the global arms market has contracted, the exploitation of dual technology has increasingly been promoted as a potential saviour of defence industries and a major goal for defence R&D policy. This attitude was exemplified by the establishment of Dual Use Technology Centres in the UK. Dual technologies are technologies which, while originating from the defence sector, have both defence and civil applications. Through the exploitation of dual technologies, defence firms, it is proposed, can maintain capabilities without public subsidies. Increasingly, though, defence technologies are lagging behind their civil counterparts, so that spin-offs tend to flow in the opposite direction from that traditionally suggested by the defence sector.[18]

Defence firms operate under conditions which differ significantly from those in civil markets: military standards and tendering processes increase the cost and risk of defence business and have contributed to the separation of defence and civil production. In the US, the DoD has abandoned many military standards in favour of commercial ones to promote the inclusion of civil technologies in defence systems.[19] The development of defence systems based on civil technologies, a process sometimes referred to as technological *integration* (as opposed to diversification or conversion) is the most likely medium term outcome of this policy initiative.[20] Such a process could eliminate the need for government sponsorship of defence dedicated R&D in areas where alternative civil technologies exist. There is also the distinct prospect of current US technological dominance being eroded by sophisticated Japanese and German civil firms, despite the considerable US lead in defence R&D.[21]

For small countries such as Australia, the implications of such trends for defence R&D may be quite serious. The entry of civil firms into the defence market should reduce the costs of advanced weapons systems significantly by introducing competition at the prime contractor level. Smaller nations are already struggling to remain in touch with the latest developments in a sector which is dominated by a declining number of large US based enterprises. Intensified competition would reduce opportunities for research in smaller countries to find new technological niches. Those nations already exploiting technological niches would find maintaining their position increasingly difficult.

Having long faced diffused threats, Australia began to adopt some of the now popular defence R&D strategies before its NATO counterparts. In addition, its small population did not permit a policy of self sufficiency in defence technology. The focus for defence R&D has therefore been on maintaining the technological capabilities required for in-country support and modification of defence equipment and for the provision of advice on procurement issues.

Australian Defence Effort and Defence Market

The domestic context for defence R&D is Australia's overall defence effort. Australia is a medium size defence spender, with a defence budget of AU$10,027 million in 1996–97 (about 7.7% of Government budget outlays and 1.9% of Australia's Gross Domestic Product).[22] Nearly 90% of the defence budget is spent in Australia and nearly 70% of the budget is spent on procuring or maintaining capital equipment. In the mid-1990s, investment in equipment and facilities accounted for 28% of the defence budget, personnel 39%, and operating costs for the remaining 33%. Major capital assets in more recent years have included much more local content than in the 1970s, reflecting a Government determination to support domestic industry. Defence procurement has a relatively small impact on the Australian economy as a whole,[23] but it is important for particular industry sectors and individual firms.

Given its size, the Australian Defence Force (ADF) buys relatively small quantities of technologically-advanced equipment and consumables by world standards. For most defence-specific products, the domestic requirement is too small to sustain dedicated production lines at and above the minimum efficient scale (MES) and, thus, to exhaust the economies of scale.[24] Even though domestic demand for defence equipment has not been strong enough to sustain, in peacetime, more than one viable producer for most products types (e.g., one defence shipbuilder)—and in many areas even a single, defence-oriented producer would require some form of assistance—for various historic and political reasons, most defence-related industry sectors contain two or more producers (e.g., three significant shipbuilders). Many of these firms have operated at scaleswell below the MES and with a great deal of spare capacity and have been kept viable by various forms of assistance and 'demand manipulation'.[25]

Defence has identified a number of broad capabilities 'critical to ADF self-reliance': command, control, communications, intelligence and information technology; surveillance; weapons platforms; weapons systems; munitions; and logistics support.[26] This listing suggests the following industries are of particular importance to defence: electronics/optics; communications and information technology; aerospace; shipbuilding and repair; munitions; and land vehicles. Strategically important goods and services are largely supplied by five industrial sectors (although they also involve assembly of components supplied by several other sectors): Information Technology, Electronics and Communications; Shipbuilding and Repair; Aerospace; Ordnance, and Vehicles.[27] The value of these goods and services is estimated at AU$2–2.5 billion annually, or about half of the DoD's annual expenditure on locally sourced goods and services. This was approximately four per cent of Australia's total manufacturing output.

In the mid-1990s about 70% of defence procurement expenditure was spent in Australia-New Zealand.[28] About 25% of procurement expenditure went to the shipbuilding industry, with another seven industries receiving between 2 and 8% each. The remaining 40% was spread widely across the economy. Many of Australia's defence industries (perhaps with the exception of surface shipbuilding) are dominated by subsidiaries of foreign firms, including some of the world largest arms producers (e.g., Lockheed-Martin or British Aerospace).

By and large, Australia imports its defence-related technological knowhow. A large part of the imported knowhow comes in the form of product technologies embodied in imported weapons systems. A significant proportion of technological imports takes the form of: overseas training of Australian defence personnel (in particular in the US and the UK); direct imports of production and logistic support facilities embodying new process technologies; (disembodied) technology transfers (e.g., production licences, blueprints and intellectual property rights); and in-country training of Australian technical personnel by foreign contractors in the application of imported new technologies. Technological imports are further necessitated by demands of interoperability in the use of defence equipment between Australia and her allies.

Although the most advanced technologies are still embodied in imported sub-systems, the desire to achieve a high degree of self-reliance has led to a preference for the in-country production of platforms and (weapons) system integration. This, in turn, has resulted in the substitution of technologies embodied in imported final defence products (complete systems) by technologies embodied in intermediate products, production and through life support facilities and by transfers of knowhow in the form of blueprints, intellectual property and skill formation. While the focus was traditionally upon the technology of the platform (a ship, an aircraft, a tank), the emphasis has now shifted to the electronic and IT systems controlling delivery of its weapons.

Even though Australia was a very significant producer and exporter of military equipment during and immediately after World War II, domestic defence-related industry has long been inward-oriented. (In 1992–3, Australia's total defence exports amounted to AU$46 million or 0.08% of Australia's total exports.) Advanced industrial countries with comparable defence budgets, such as Sweden or Switzerland, have been much more (defence) export-oriented and geared to the development of technology-based competitive advantages in various niches of the global weapons market. As noted by the DER:

> Exports of defence goods and services can significantly bolster or sustain indigenous industrial capabilities, thereby increasing self-reliance and reducing costs for local orders. Not surprisingly then, the Defence departments of most nations actively

> support their industry's defence exports except when there is a real chance they will be turned against their own forces.

... but ...

> Export markets, the alternative source of defence work, are extremely competitive and our domestic base is such that we should regard export orders as windfalls rather than reliable income sources in most areas.[29]

However, there is now a growing emphasis on scale—and scope-related efficiencies and *regional collaboration* in defence industry, and the policy focus is shifting to export promotion in the form of joint development of requirements and co-production of defence equipment.[30]

As in other countries, the domestic market for defence goods and services is government regulated. This gives government influence over such things as the performance and quality requirements of defence systems and hence product-related technological change; process-related technological change; and the extent of in-country availability of defence-specific technological knowhow. Australian Defence (like DoDs elsewhere) also has a degree of monopsony power. This applies in particular to the smaller defence-dependent domestic contractors and defence-dedicated subsidiaries of large multinational firms. To the extent Defence can use its monopsony power, it can influence the rate of technical change by selecting particular technologies, exposing domestic producers to the threat of import competition or by arranging (disembodied) technology transfers.

To date, some 60% of in-country defence-specific R&D has been undertaken in-house, mainly through the DSTO (see Table 6). Most of the residual R&D investment has been undertaken by industry. (The observed variation in industry defence R&D spending may be related to the data collection problems).

Since the late 1980s there have been significant changes in the manner in which Australian defence R&D is carried out. Essentially, there has been a shift towards greater private sector involvement and a streamlining of DSTO, the backbone of defence R&D (see Part Two).[31] Government funding for defence R&D has remained quite stable over this period, both in constant dollar terms and as a proportion of national R&D expenditure, experience consistent with international trends.

Table 6. Defence-related R&D expenditure in Australia 1990–91 and 1994–95 in constant 1989–90 prices, AU$ million

	Source of Defence R&D Expenditure (in brackets as a percentage of total defence R&D expenditure)			
	Business	**Government**	**Higher Education**	**Total Defence R&D Expenditure**
1990–91	–	226.13	1.89	–
1991–92	17.98	–	–	–
1992–93	126.74 (40)	189.38 (59)	2.75 (1)	318.87 (100)
1993–94	92.77	–	–	–
1994–95	127.71 (38)	203.56 (61)	4.42 (1)	335.87 (100)

Sources: ABS cats. 8104, 8112 and 8114, various issues

Issues in Defence Technology Management and Procurement

To the extent the ADF is involved in the formation and maintenance of in-country defence capabilities, it must not only secure the provision and readiness of defence-related assets (i.e., military personnel and equipment, defence-related civil infrastructure) but also ensure the in-country availability of those product and process technologies that are critical to the operational effectiveness of the ADF in war time and to the cost-effectiveness of the national defence effort in peace time.[32] Hence the ADF is not only the key driver of technological change in in-house military activities but also the major influence on defence-related technological change in industry. Its technology management task embraces both the in-house management of military technologies and outsourcing activities aimed at fostering the appropriate defence-related technologies in industry. The ADF is also the key driver of defence-related technological imports. It selects technologies embodied in imported military products, arranges for the overseas training of Australian military personnel and in-country training of Australians by foreign personnel, and secures disembodied imports of technology in the form of blueprints, information and intellectual property rights.

In this section, we consider processes leading to the in-country formation of defence-related technological knowhow. The latter can be envisaged as a product of two types of activity: indigenous research, development and design activities, and the transfer and diffusion of technologies developed overseas. Defence must determine the extent to which it wants to be directly involved in domestic R&D activities as against the transfer of foreign technologies.

Defence technology management is a challenging task. The range of options varies from 'doing nothing' in the belief that certain defence-related technologies will become available as a result of 'normal' civil activities, to doing it all in-house for reasons of 'national security' or 'public interest' or because of the civil sector's unwillingness to engage in such tasks. Since different types of goods and services acquired by Defence present different technology management problems, technology management issues are reviewed below by reference to a particular typology of defence acquisitions. Four groups of goods and services purchased by the ADF are distinguished here:

(1) military products in relation to which the ADF has little or no buying (monopsony) power to extract relatively advantageous terms from suppliers. Here, Defence is a minor buyer in the world market. Moreover, it does not wish to establish new and more easily influenced sources of supply because the products may either not be important enough to Australia's security or it is too costly to make them in-country. This group of products includes mostly imports but it may also include some export-oriented, domestic production of military materiel where the domestic demand is of little significance to the producer;
(2) volume-produced civilian products, such as civilian-line vehicles or commercial fuels, where the ADF is a relatively minor buyer—just another customer—with no significant market power, and where the criticality of supplies is not high enough to make it develop/acquire more market power or set up an in-house production of substitutes;
(3) military and civilian products where the ADF is a significant but not a dominant buyer. It has a degree of monopsony power but is not a sole or dominant source of demand. (Dual technology products, such as off-the-road vehicles, where Defence may account for a significant share of domestic market demand may also fall into this category); and
(4) military and civilian products where the ADF is either the sole source of demand (a monopsonist) or the dominant buyer exercising a very considerable degree of monopsony power. This product group includes goods and services supplied by most

large domestic defence producers, i.e., the dominant part of the defence-related industry, as well as the in-house production of defence inputs. It may also include small manufacturing and through-life support services, where local providers depend on Defence for business and, in particular, when as a result of their past investments, they have acquired defence-specific assets (e.g., secure facilities, dedicated test equipment).

The first product group. With regard to this group, the ADF has no influence on technological decisions made by suppliers and, thus, can only choose products from the available technological menu—'off the shelf', as it were. In this case, the ADF's technological requirements are not important enough to enter into the strategic product-process considerations of suppliers, although most off-the-shelf products can be tailored to customer specific technological requirements, if the buyer is prepared to pay the price.[33]

Here the ADF's technology management task is restricted to being a 'wise and prudent buyer', ensuring that its acquisitions meet its technological requirements and that it is sufficiently well informed to avoid buying 'technological lemons' or failing to assess and discriminate between technologies available in the world market. The ADF must thus ensure that it either has appropriate in-house technological expertise or access to unbiased (external) technological advice.[34] The most difficult procurement problems are posed by complex, knowledge-based systems, such as intelligence, command, control and communication (IC^3) equipment. It is these so-called 'smarts' that determine the operational effectiveness and dependability of modern weaponry. And it is in the context of IT acquisitions that the asymmetry of knowledge between the buyer and the seller is particularly significant, especially where technology is proprietary and well protected by intellectual property rights.

The 'clever buyer' approach adopted by the ADF is to maintain in-house technological expertise in the DSTO and seek further technological advice from external sources either through DSTO collaborative arrangements or using vehicles such as the DID program (see Part Two). National security considerations tend to restrict the scope for outsourcing the technological advice needed to buy security products most critical to Australia's defence.

The second product group. Presents a simpler technology management task. That is, whether the products under consideration are made in-country or imported, they are not important enough to induce the ADF to attempt to secure better offers from vendors. In most cases, the ADF buyer must accept the existing product specification and 'list price'. However, to be a wise buyer of such 'staple' civil products, Defence has little need in this case to develop specialist product and process knowledge. In line with other public and private buyers, it can access the general pool of market knowledge (e.g., information provided by consumer advisory bodies), use external sources of expertise (e.g., public sector purchasing advice, commercial consultants, academics), and/or develop in-house procurement expertise. In short, this is an area where Defence relies on the existing civil infrastructure to provide appropriate incentives to efficiency, most likely by means of market competition.

The third product group. Since this group comprises civil and military goods and services where Defence has some degree of monopsony power, the technology management requirements for these products present additional challenges. As in all previous cases, Defence must continue to ensure that it is sufficiently well informed to make 'wise' procurement decisions. To achieve that, it may elect to develop the relevant expertise in-house or it may out-source its pool of expert advice. However, in this case, the application of market leverage is important. As the ADF is now perceived to be a significant buyer of these products, its purchasing requirements are likely to be taken into account by suppliers investing in new technologies and capacities. In that sense, the ADF has *ex ante* influence on the nature and rate of technological change in industry (including those overseas suppliers that consider the Australian DoD to be a significant customer).[35] Providing that 'normal' technological investments made by commercial suppliers in anticipation of buyer requirements provide the ADF with the kind of technology it wants, there is no need to do much more but adopt the 'wise buyer' stance and use the available degree of monopsony power to negotiate price concessions and 'package' enhancements.

However, the market may fail to produce desirable technological outcomes. Insofar as product and/or process differentiation is required to win Defence orders, firms may have to make some ADF-specific investments in assets and knowhow, which could only be recovered through successful ADF orders. Their willingness to sink resources into such dedicated investments depend on the prospect of cost recovery through future sales. In some cases, even a modest degree of monopsony power applied by the ADF to negotiate lower prices and/or 'package enhancements' could reduce suppliers' return on their ADF-specific technological investments and, thus, deter firms from undertaking ADF-specific R&D activities. Also, for a given size of (anticipated) Defence order, an increase in the number of potential suppliers reduces each competitor's chance of winning the tender. Hence the supplier's awareness of market fragmentation may itself become a deterrent to investing in ADF-specific technologies. Ultimately, firms may decide to decline the ADF's invitations to tender as they perceive their chances of winning defence orders to be strongly unfavourable.[36]

Thus, to achieve its objective of fostering dependable, competitive and technologically innovative supplies, Defence must provide contractors with sufficient incentives to engage in anticipatory investments in ADF-relevant product and process technologies. This can be achieved by means of restricted tendering, to improve each tender's chances of winning Defence business, and/or by making contracts more lucrative to win.[37] However, if such incentives fail to secure adequate levels of technology, Defence may have to consider other more radical options, such as sole sourcing its technological requirements, or performing R&D in-house. Defence may also seek to develop international defence buyer consortia capable of exerting market leverage.

The fourth product group. Finally, this group poses the greatest challenge for defence technology management. This group of goods and services includes all those domestic suppliers that are critically dependent on Defence for business so that the ADF is the sole (or the dominant) driver of technological change. 'Smart buying' in this case requires a very proactive stance since Defence must ensure that those technological and production capabilities that are critical, in its assessment, to national security are available in-country. This presents the ADF with a dilemma. On the one hand, for most of these products, Defence is the sole source of demand which could easily result in abuse of its monopsony power. For example, the extraction of monopsony rents might deter firms from making ADF specific investments and, in the longer term, induce exits. On the other hand, given the small size of domestic market, sole source suppliers should also dominate. To maintain some semblance of competition, whilst protecting the industry from genuine international challenges, domestic dual and treble sources of supply have often been created (e.g., shipbuilding). This in turn diminishes technological investments by industry, as each supplier is well aware of its own vulnerability. Thus, the combination of Defence monopsony with the fragmented supply (induced by the monopsonist) increases cost premia needed to sustain domestic (industry) capability.

The DER, following the two most recent White Papers of 1997 and 1994, recognises this problem by acknowledging that 'there is, however, a narrow sector in which Defence is the major, and in some cases, the only customer. As far as possible, we should discourage such specialisation'.[38]

It is not clear how 'narrow' the sector of industry is that critically depends on Defence business. The DER provides no information on the proportion of all acquisitions that fall into this category. This is, however, a problem area in relations between the government and industry as the latter tends to claim, not surprisingly and often for self-serving reasons, that the degree of dependence on defence business is very high for firms specialising in major platform assembly, where, high levels of local content are required for reasons of national security or due to political imperatives.[39] Inspired by the British privatisation experience of the 1980s and 1990s, the DER argues against public ownership of defence-specific industry assets in the form of government-owned defence industries. The DER Report is rather vague, however, as to how Defence should ensure contestability in dealing with the 'narrow sector' suppliers for whom it is the major and often the only customer. Its notion of 'demand manipulation', combined with exhortations to invoke 'market competition' (in markets which by definition are inherently uncompetitive), and references to the British experience (which one would think is not easily portable to small countries such as Australia) are not very helpful in addressing the sole sourcing problem.

Partnering (bilateral monopoly) arrangements between the Defence buyer and a single industry supplier present obvious challenges to contestability and, in particular, call for mechanisms to ensure that new entrants could challenge incumbent suppliers. On the other hand, the experience of government-owned industries may also need further examination, notwithstanding the current sentiment for privatising, outsourcing and contracting out public sector activities. As the DER notes, the experience of countries such as France and to some extent the US (with its government-owned arsenals) suggests that successful weapon production and technological innovation could be combined with public ownership, especially where the private sector is unable or unwilling to take up the challenge. The advantages of private sector production are easier to demonstrate in areas where market competition is feasible. They are far less clear in the case of sole source arrangements where the supplier is also expected to invest in buyer-specific assets and undertake buyer-specific R&D investment and when the buyer is a monopsonist.

Part Two: Institutional Arrangements

Defence Science and Technology Organisation

Mission

The Defence Science and Technology Organisation (DSTO) is part of the Department of Defence. Its overarching goal is 'to give advice ... on the application of science and technology ... best suited to Australia's defence and security needs'.[40]

This goal is supported by four subsidiary objectives:

(1) to position Australia to take advantage of future technological developments potentially relevant for defence use;
(2) to ensure Australia is an informed buyer in markets for capital equipment;

(3) to develop new capabilities as circumstances require; and
(4) to support existing capabilities by increasing operational performance and reducing costs.[41]

In addition, DSTO has the task of transferring in a timely fashion the results of defence research to industry, and provide access for industry to its research facilities, expertise and intellectual property.[42]

Although the four sub-objectives have the potential to be mutually self-reinforcing, they also have distinctive flavours and implications. The first objective, for example, is addressed by the relatively small fraction (about 10%) of DSTO resources devoted to *enabling* R&D. Such work includes developing skills and expertise to position the organisation to understand, exploit and counter advances in S&T which could be turned to defence use; to avoid unpleasant surprises from future developments in new technology; and to advise the DoD on developing policy which anticipates the S&T advances of other countries.[43] The idea is that by undertaking enabling research, DSTO can identify S&T trends and so give advice informed by expert knowledge on tomorrow's emerging alternatives. In this context, DSTO has the role of providing a counter to the short term view which, in the military, may be reinforced by a posting system that leaves decision-makers with only two or three years to make a mark. Enabling R&D, however, also allows DSTO expertise to be maintained at a level that effectively permits it to make the DoD a 'wise buyer' of highly complex systems in an environment of rapid technological change (objective (2)), and to help create new capabilities ready to meet Service demands as they emerge (objective (3)).

To assist the DoD to be an informed buyer, in the current period, DSTO conducts studies on system alternatives, assesses the suitability of systems developed elsewhere for the peculiarities of Australian field conditions, assists in tender evaluation, can act as a watchdog and problem solver during the development and construction stages of major projects, and offers test and evaluation services.

Objective (4) is particularly important in periods, like now, of increasing budgetary pressures. At a time when, also, new systems are doubling in real price about once every 7 or 8 years, there is increasing advantage to be gained from prolonging the working life of existing platforms without sacrificing safety or operational availability.[44] At their planned year of withdrawal Australia's F-18 fighters will be 30 years old, P-3C maritime patrol aircraft 37 years old, Iroquois helicopters 40 years old, and its F-111 strike reconnaissance aircraft 47 years old.[45] While such craft will be quite able, if in good order, to provide the service for which they were purchased, research is required to ensure wear, fatigue and faults are identified and dealt with early, that the processes of ageing are well understood, and that long term costs of operation are kept under control.[46] If research like this can show that the expected life of a component exceeds (or can be made to exceed) that indicated by an initial supplier, the costs of component replacement over a system's life cycle can be substantially reduced.

History and Current Organisational Structure

The Defence Science and Technology Organisation came into existence in 1974 but comprises elements which had been in operation for much longer. As early as 1910, explosives-research began at Melbourne's Victoria Barracks and as the work spread to encompass materials and protective science, it came to be housed in the complex now known as the Materials Research Laboratory at Maribyrnong. Aeronautical research to meet RAAF, civil aviation and industry needs started in 1939 and the Aeronautical Research Laboratory was set up in 1940 at Fisherman's Bend.

These two Melbourne sites in recent times have formed the largest elements of what became the Aeronautical and Maritime Research Laboratory (AMRL).[47] Its work today covers airframes and engines, air operations, ship structures and materials, maritime operations and weapons systems.

The other major arm of DSTO is the Electronics and Surveillance Research Laboratory (ESRL). This grew from the Long Range Weapons Establishment formed in 1947 at Salisbury in the Adelaide suburbs to support the rocket range at Woomera, under a joint project agreement with the UK. In subsequent decades, the laboratories became involved in international space programs, and built and launched Australia's first satellite. Today Salisbury is the home of ESRL, and undertakes work on communications; electronic warfare; high frequency radar; information technology; land, space and optoelectronics and microwave radar.

The current structure of DSTO reflects, in some ways, an important aspect of modern military technology. The modern battlefield is increasingly characterised by information dominance, stand-off (disengaged) combat, precision weapons and joint operations.[48] The Aeronautical and Maritime Research Laboratory, broadly speaking, deals with platforms and the physical and chemical characteristics of explosives; ESRL, also broadly speaking focuses on the information technology which facilitates command in contemporary warfare and controls the platforms and their weaponry.

In the recent evolution of DSTO, the policy emphasis has been on demonstrating responsiveness to customer/client requirements and simultaneously raising supply side cost efficiency.

The need to show relevance to the Defence Organisation at large might usefully be seen in the context of views reported in an early 1990s program evaluation of the then Materials Research Laboratory by the Inspector-General.[49] Despite enjoying praise for work on particular tasks or projects, DSTO was said to be suffering criticism from within Defence, in part because it was perceived to be 'pursuing its own interests rather than that of Defence', and partly because it was viewed as lacking a 'coherent and transparent policy framework'.[50] The evaluation cites the suggestion in a consultant's report, that 'very rarely is the organisation, in its entirety, referred to as having a critical value to Defence'.[51]

At about the same time as these views were being voiced (1992), the Chief Defence Scientist commissioned a Program Improvement Group (PIG) to 'examine the process by which DSTO plans, reports and evaluates its R&D activities'. Bearing in mind that up to 90% of DSTO's R&D expenditure focuses on work sponsored by its clients in Defence, this was a timely move in a period when competitive tendering for government work was increasingly being proposed as an option. DSTO stood to lose if other R&D providers could be found. The PIG recommended a structure for the DoD S&T program (to all intents and purposes, DSTO) which was customer-focused rather than technology- or laboratory-focused. The initiative aimed to bring Defence users more formally into planning and review processes, and assist DSTO in refining customers' strategic priorities, planning its R&D program, and communicating its performance.

'Customer focus' in itself was by this time widely understood by innovation-driven private-sector business as an essential element in effective strategy. It was increasingly being discussed in connection with public sector research providers, such as CSIRO. But whereas actual potential 'customers' are sometimes hard to identify for business, and possibly more so for providers of 'public good research' in general, DSTO has much less difficulty in this respect. Its customers are the ADF's Maritime, Land and Air

Forces, along with a wider base associated with strategy and intelligence, and general defence policy development (the contentious issue of industry as another potential 'customer' is addressed below). Following the PIG's recommendations, a Force Research Area (FRA) was set-up for each of the three forces and one more for policy and command. Each FRA was to address nominated Defence capabilities (such as submarines, patrol boats and mine countermeasures under Maritime), and within each FRA capability (FRAC), there was to be a list of 'thrusts', such as propulsion systems and electronic warfare under submarines.[52]

Outcomes and Efficiency

In reporting on its performance these days, DSTO focuses almost exclusively on results achieved for its clients. Performance is assessed by client surveys, internal and external reviews, joint DSTO/client R&D review committees, and direct contact with clients.[53]

The organisation has also concentrated on efficiency on the supply side. From a structure formerly based on scientific divisions, such as physical and inorganic chemistry, DSTO was reorganised (as noted above) into programs to meet air, land and maritime needs. In terms of employment, DSTO staff fell from 4400 in 1983 to 2555 in 1996. Its expenditures declined from about 3% of the Defence budget in 1983 to about 2.3% in 1996. And as a proportion of the overall DSTO budget, R&D spending has risen steadily, from 59% in 1989 to 70% in 1996.

Nevertheless, concern with efficiency gains of all kinds was at the centre of the 1996–7 DER. The DER observed that in some other countries like the UK, a 'user pays' approach had been adopted which, translated into the Australian Defence context, would mean giving DSTO's service and other customers the funds currently given to DSTO itself. DSTO's customers would then task the research organisation through contracts and pay on milestones or delivery. The Review recommended user-pays 'at the margins' and commended a closer look at the approach to see if it might be introduced in a simpler form than in large scale applications elsewhere. The tool, said the Review, brought with it accounting and other management overheads which would be difficult to absorb within the small scale (by international standards) of Australian activity. It added that DSTO was not just a research service provider to the Defence organization, it was also key component of that organization. Any application of 'user pays' would have to take account of this special relationship.

Relationships with Industry

While much of the concern about DSTO's performance has been focused on how well it serves its service customers, there has been a long-running debate too on the relationship of the organization and its work to private sector industry. Abstracting from strategic considerations, one set of issues surrounds the general problem of successfully transferring technology at an early stage of development from the public sector to the private. The public sector scientists who supplied and did the pioneering development work on a new idea might not be available or able to provide effective input at a later stage or in a private sector context. On the other hand, the private sector might lack the financial capital, managerial expertise or support networks to carry an early-stage technological development to the point of commercialisation or full-scale production. On the first of these, DSTO has said in the past: "Special DSTO skills or facilities not available elsewhere in Australia can be used by the non-defence community *if priorities of Defence tasks permit*" (Italics the authors').[54] On the second, there is ample evidence that

Australia's private sector takes up only a small fraction of the new technological ideas generated in publicly funded research agencies though Australia can hardly be viewed as a special case in that respect.

It should be a matter of general concern to facilitate interaction between the generators, developers, commercialisers and users of new technology within any nation's innovation system and at least as importantly, internationally. But in the particular case of defence-related technological innovation, specific strategic issues influence priorities, imperatives and implementation.

Policy development for DSTO's relationship with industry dates back to an Australian Science and Technology Council (ASTEC) review of 1986 and in the following year the Minister for Defence Science and Personnel started talking about commercial exploitation of DSTO research—emphasising opportunities for joint ventures and commercial links. But it was another 4 years before the Defence Science and Technology Committee produced a comprehensive statement of policy on the conduct of DSTO commercial activity. Throughout that period and subsequently, Defence continued to assert that "DSTO exists principally to serve the needs of the Australian Defence organisation and any commercial effort must be managed so as not to detract from that primary role".[55]

As of 1993, the Inspector General felt able to pass the judgement that clearer policy and guidance was needed to frame DSTO-industry relationships and that, in the absence of such a framework DSTO had tended to apply its efforts 'in a relatively narrow sense'.[56] The Inspector General's report goes on:

> There is clearly scope for development of a Defence policy framework which sees DSTO as a more active player in the development of a self-reliant industrial infrastructure. There has been, however, a general hesitance by DSTO to take up this challenge. This hesitance arises partly because its service customers are sensitive to competition for S&T resources, and partly because the S&T program has not indicated ... that resources should be diverted away from the ADF and towards industry.[57]

By 1994, however, the White Paper *Defending Australia* was noting that DSTO's interaction with industry would grow, especially since developments in commercial markets were driving technological advance in fields of particular interest to defence—such as communications and information technology. As an indication of what was being achieved, DSTO in South Australia was by then involved with 26 companies and four universities. Spanning 45 technologies, the DSTO-industry/university interaction took the form of agreements to research applications, commercialise technologies, develop new products and establish start-up companies.[58]

Extended references to DSTO interaction with industry began to appear in Defence Annual Reports as recently as 1994–5, although briefer accounts relating to technology transfer could be found in earlier years. In the 1995–6 report, the relevant section covered contracting out, licensing of DSTO-developed IP, DSTO-industry alliances and Co-operative Research Centres.

DSTO set a target in 1993/4 to achieve by 1998 a level of *external contracting out* amounting to 8–10% of its budget.[59] In 1992, it had attempted to contract out scientific and engineering support services and information systems and telecommunications work worth AU$63 million, and work in property services, materials distribution and media services worth AU$17 million. The Defence Science and Technology Organisation in-house bidders won the first group of contracts; outsiders the remainder.[60] External suppliers at the time were apparently felt to lack the specialist expertise required for high-level S&T work. By 1995–6, AU$17 million R&D and technical support contracts were being placed with industry and tertiary institutions—7.2% of DSTO's budget. These included contracts in the areas of electro-optic modulators, photonics, and acousto-optic technology.[61]

The Industry Commission noted that, even on most recent evidence, "DSTO appears to contract out a much smaller proportion of its defence research than the UK and US".[62] While Australia's defence requirements and its industry capability to undertake defence R&D were different, the reason for the internationally low level of external contracting of R&D was "not wholly clear".[63] The upward trend is, however, marked and set to continue. The latest development is the idea, floated in the DER, that testing and evaluating Defence-supplier products might be contracted out to commercial facilities on an extended and accelerated basis.

Examples of *licence agreements* used to transfer DSTO-developed IP and technology to industry include anechoic tiles for submarines (to the Australian Submarine Corporation), an infra-red jamming system (to British Aerospace Australia), and a diode pumped slab laser for use in eye-surgery (to Taracan Pty. Ltd).[64]

While the licencing mechanism has the advantage of generating a revenue flow to DSTO, it may or may not offer the context for an ongoing close research-development-production relationship. In this context, a major industry group (the Association of Australian Aerospace Industries (AAAI)) has argued that long-term *strategic alliances* are the best mechanism for allowing DSTO to provide the generic technology base on which Australian-based industry might grow.[65] Such alliances facilitate, among other things, two-way briefings, collaborative R&D, commercial transactions and support for export ventures. Currently ESRL alone has well over a dozen formal industry alliances, and examples from the organization at large include arrangements with the shipbuilder Transfield Defence Systems (in relation to naval platforms and systems), Celsius Tech Australia (command and control, and weapons systems) and Vision Abell (signal processing and systems integration). The logical extension of alliances is integrated product teams involving a partnership between government and contractor personnel at all levels. DSTO is beginning to participate in these sorts of approaches.

Elsewhere in this volume, Turpin explores the role and impact of *Cooperative Research Centres* (CRCs). The Defence Science and Technology Organisation contributes to eight CRCs in all, an involvement which allows it to engage in pre-competitive R&D collaboration with industry. As an example of what can be achieved, alternative fabrication methods for fibre-reinforced composite structures have been developed as part of DSTO's involvement with the Aerospace Structures CRC.

In line with all of these developments, the DER argued that there was scope for carefully targeted development programs in industry to which DSTO might contribute. Part of such work could involve serious investment in a program of concept or technology demonstrators, especially in the fast-moving, high-technology areas. This would call for committed involvement by DSTO and could include leveraging off similar programs overseas—such as the advanced concept development program in the USA.

International Co-operation

In the international arena, there is also benefit to be had from information and staff exchange arrangements with defence R&D organisations overseas, as noted earlier in relation to reforms in the British DERA. In defence as much as elsewhere, a small country like Australia stands to gain greatly from cultivating international research networks. As vehicles for facilitating such exchanges, Australia relies, among other things, on the Technical Co-operation Program with US, UK, Canada and New Zealand, and collaborates bilaterally with the UK under the Anglo-Australian Memorandum of Understanding on Research.

The Australian Industry Involvement Program and Offsets

Industry Involvement and Offsets Policies

Australian Industry Involvement (AII) refers to the program of activities for capital equipment and major logistics projects in which Australian (mainly private sector) firms supply equipment and related services to Defence. The AII program is operated alongside the government's general industry policy for an internationally competitive and efficient Australian industry. An industry involvement program has, in one form or another, been in existence since the early 1970s.[66] One of the purposes of the program has been to provide a mechanism to obtain, through offsets against Australian purchases of defence systems, access to proprietary knowledge underlying innovative and sophisticated technology.

By the mid-1980s, international arms suppliers were competing increasingly intensely with each other and becoming more willing to offer technological 'adds-on' to sales of weaponry. Small countries attempted to exploit this through offsets and, in Australia, priority was given to offsets incorporating direct transfers of advanced technology and training, R&D conducted by Australian industry or research institutions, and the participation of local enterprise in design work. There was a strong emphasis on the long term viability and international competitiveness of offsets-related activities. New production kick-started by offsets was expected to be sustained after offsets obligations were all met. The Program also stipulated that primary contracts subject to offset obligations should not be 'padded' in anticipation of offsets requirements.

The AII Program of the later 1980s departed from the 'best endeavours' approach for offsets compliance used in earlier years and adopted instead mandatory offsets arrangements for all Government purchases which exceeded AU$2.5 million in value. The offsets obligation of foreign companies was set at 30% of the imported content of contracts. To be eligible for inclusion, activities were required to have technological significance to manufacturing, software development, research and development, design, technology transfer and certain types of training. *Multiplier* incentives were used to encourage the provision of offsets in the form of R&D and approved training expenditures. This apparently somewhat clumsy arrangement reflected a growing understanding of the vital importance to small economies of drawing on foreign technology and of the growing dependence of North American and European arms suppliers on exports. However, it also implied a lack of confidence in negotiators' skills—leaving it to an administrative formula to ensure inflows of technological offsets.

Following the Review of Defence Policy for Industry (the Price Review) in 1992, Defence decided to reduce 'its reliance on less focused mechanisms such as offsets in support of Australian industry involvement'. Specific AII objectives were now to be generally achieved by more focused provisions within contracts, with the aim of ensuring continuing capabilities in areas of importance. Defence offsets remained as a 'last resort' but only to address high priority capability requirements set out in industry capability planning statements.[67] As this implies, the creation of new offset obligations has not been mandatory since. On the other hand, the most recent (1997) guidelines allow Defence negotiators to seek 'package enhancements' (offsets) as well as to bargain for price discounts. Australian Defence appears therefore to have entered an era of flexible and 'market-wise' procurement in which government negotiators may seek offsets when it is to the greatest advantage of Defence to do so.

Benefits and Costs

The percentage of AII in all Defence contracts rose from about 26% in 1986 to over 70% in 1990 but has since declined and will continue to do so as major submarine and frigate projects move towards completion. Over the same period, defence offsets fell from about 24% of total contract value to less than 10%.

From the point of view of this paper the most interesting statistic is that, in the two decades to 1995, only 2% of the value of all offsets achievements related directly to R&D, though technology transfer accounted for another 18%. None of the other offsets categories relate in any direct way to R&D.[68] The scheme would thus seem to have achieved rather less than might have been hoped for in terms of its initial drivers.

The evaluation of social benefits is a qualitatively more difficult exercise than the measurement of 'achievements'. It is, however, a most necessary part of judging whether an offsets policy has been worth having. To see why 'achievements' and social benefits may differ widely, consider a case of technology transfer, in which it might be imagined that a supplier 'achieves' its offsets obligations by providing access to blueprints of a manufacturing process. A high dollar value might be placed on such blueprints on the grounds that they convey technological knowledge formerly held closely by the supplier. But the benefit to a recipient nation from access to the blueprints depends critically on whether it already has the experience, know-how, tacit understanding and other complementary inputs required to absorb and make effective use of the documentary knowledge in the blueprints. In general, such absorptive capacity cannot be taken for granted, and in the case of small countries like Australia, the potential for absorption is likely to be limited.

The annual cost of administering defence offsets has been about one per cent of the average annual level of offsets obligations negotiated. But to this should also be added the costs of compliance incurred by Australian firms in connection with the scheme and costs which the public choice literature characterises as 'rent-seeking' (i.e., lobbying by Australian firms in relation to benefits generated by the scheme). No direct evidence on either of these is available but a government inquiry into defence procurement generally found evidence of substantial costs associated with tendering and negotiation, and it is inevitable that some of these should be related to offsets claims.

Analysis of the Australian offsets database suggests that the scheme also imposed substantial managerial demands because of the large number of small obligations and claims it involved. The burden of offset administration is associated with claims, i.e., goods and services claimed to be eligible as achievements against offsets obligated. The Australian experience shows that, by value, the bulk of offsets claimed accrued to a small number of firms whilst the bulk of claim processing effort was directed at small claimants.[69]

Defence Industry Development Program

At a cost of around AU$10–12 million per annum, the DID program was designed to develop industry capabilities of strategic value falling outside the domain of other Defence programs. After a life of just over two decades, the program seems likely to be reorganised out of existence as a result of the DER. Its role has been to develop significant local industry capabilities of a generic nature, and of value to more than one of the services. Among criteria applied to funding DID projects, strategic benefits had to justify the costs incurred and have a high probability of achievement. Proposals could be made either from within the DoD or by industry.[70]

The program in an earlier form came into existence in 1976 as the Australian Industry Assistance (AIA) Minors Program.[71] This program was established to fund industry and technological support projects with limited lead times. It funded projects from small batch manufacturing to studies of industry capability and R&D, many of relevance to only a single Service. Guidelines allowed funding for activities which were of limited strategic benefit. Restructuring in 1987 led to the AIA and the Machinery and Plant Program being merged to form the DID. Proposals were now restricted to activities providing generic benefits the development of which could not be justified within the confines of any single project. DID initiatives were intended to produce long term benefits through the development of industry capabilities.

In 1993, the Price Report recommended changes to DID guidelines to align the program more closely with DoD policy. While the program had established important capabilities in industry, funds had not been specifically directed towards strategic objectives. For example, the program had been strongly biased towards product development rather than equipment modification and support. Under the revised guidelines, only projects providing strategic benefits were to be acceptable, with economic benefits being of secondary importance. The program was also to move towards a 'user pays' system to encourage ADF customer involvement in DID projects. There seems to have been widespread confusion in both industry and defence about the aims of the program, but suggestions that DID functions should be performed by DSTO were rejected on the basis that these programs were sufficiently different in focus to justify separation.[72]

By contrast, in 1994 the Industry Commission recommended that the DID be dismantled and its role performed by other programs: procurement related capability development through the capital equipment program and the development of generic technologies and capabilities through DSTO. Possible duplication of functions between the DID, DSTO and the procurement authorities, along with high administrative costs, were the main factors behind this recommendation. Maintenance of the DID as a separate program had resulted in funding considerations (rather than the inherent potential of proposals) dominating the evaluation process, and a bias towards smaller projects. Funding, it was pointed out, should ideally be determined following an examination of the proposals received.[73] Although some changes were made to DID guidelines, the government postponed deciding on the future of the scheme.

With the recent release of the DER, change seems inevitable. The review referred to the DID as 'remote' and 'loosely coupled to future military needs'. It endorsed the Industry Commission recommendations that DID functions be performed by the acquisition authorities and DSTO. Moreover, the DER recommended that only development projects and requirement studies should continue to receive funding support, implying that other DID activities would be discontinued. This suggests that the DID program will effectively cease to exist, and that its funding will be retained by Defence to serve more focused objectives.[74]

Commercial Support Program

The Commercial Support Program (CSP) is a DoD initiative started in 1991 for testing non-core defence activities by opening them up to commercial tender. Core activities are essentially combat-related and other critical defence activities; non-core activities are 'civilian' in nature and provided to support the combat elements of the ADF (e.g., transport, warehousing, IT and communications support, and engineering and scientific services). There are three steps in determining if an activity is to be reviewed under CSP. First, will the function under consideration be needed in future? Second, is it inherently core or non-core? Third, for those activities determined to be non-core, should any part of the activity be quarantined from CSP to maintain suitable positions for essential uniformed and civilian Defence personnel? In other words, non-core activities may be contracted out when it is operationally feasible, practicable and cost effective.

As in-house bids are encouraged, CSP is not necessarily a contracting-out programme.[75] As of May 1996, over 70 activities involving 5490 positions with a baseline cost of some AU$300 million were commercially tested. Thirty-two prime contractors and more than 100 sub-contractors had shared in the award of new work to industry worth AU$539 million over the life of the contracts. In-house bids have successfully competed for work valued at AU$320 million. At the time of writing, some further 5850 positions are scheduled to be tested under CSP.[76] As of mid-1996 the projected, recurring annual savings from CSP were estimated at AU$117 million.

The relevance of CSP to technology management is two-fold. First, non-core DSTO activities have been market tested under CSP, leading to savings in areas such as cleaning. Support staff numbers were reduced and laboratories amalgamated so as to raise the fraction of outlays devoted to R&D from 59% in 1991–92 to 70% in 1995–96. Between 1992 and 1997 the DSTO is aiming to double the value of R&D outsourced to industry and tertiary institutions through the CSP process in order to achieve results at lower cost (see DSTO, *op. cit.* Ref. 31).

Second, there are concerns that contracted out defence activities—in areas such as engineering and scientific services, repair and maintenance of sophisticated activities or IT and communications support—may suffer in the longer term from the lack of investment in R&D by contractors. It is often argued that technological competencies acquired by contractors are provided by skilled, ex-DoD personnel who have moved jobs. If Defence ceases to train its technical personnel to the same extent as in the past, small and medium size firms are unlikely to fill the skill-formation void whilst civilian secondary and tertiary educational institutions may not develop defence-specific skills and competencies. Consequently, industry's capability to support-maintain and adapt/modify new military equipment may deteriorate in the long term. We are not aware, however, of any Australian or overseas evidence of the adverse effects of market testing and contracting out on long term skills formation and technological capabilities in industry.

Conclusions

The peacetime mission of the Australian Defence Organisation is to invest in the formation of capabilities which, in the event of particular military and civilian contingencies actually occuring, could be used to generate specific security responses. The typical defence capability is that embodied in a weapons system. A defining characteristic of these defence investments is 'the constant pursuit of improved performance and capabilities through technological advance. Thus, innovation is at least as important a product of the defence sector as the physical products that embody the new ideas'.[77] A problem particularly relevant to smaller countries like Australia concerns the relatively small quantities of most defence systems purchased. Potentially there are significant scale and scope economies to be reaped in the production, acquisition and through-life support of most defence systems. However, the insistence of Defence on military specifications and standards has usually prevented such economies being realised. As a result the user's insistence of defence-specific product differentiation has resulted in large cost penalties. With currently declining military budgets and the growing technological strength of civil IT industries, the application of military specifications has become more selective and the use of dual technologies has increased. Faced in addition with the rapid rate of technological change, and the equally rapid rate of technological obsolescence of existing equipment, the ADF has become more concerned with the durability and adaptability of systems over time.

Another defining characteristic of defence procurement is the insistence on in-country availability of technologies and industry capabilities. This *jointness* between in-house investments in weapons systems (military capabilities) and industry investments in production and through-life support facilities (industry preparedness) poses particular problems for the acquisiton of technologically sophisticated defence systems and for source selection. In particular, insisting on in-country supply sources, that is, by imposing restrictions on permissible sources of supply to foster domestic industry preparedness or to create jobs, Defence has nested many of its relationships with suppliers in a very uncompetitive environment.

As noted earlier, there are many products for which Defence is just one customer among many and where it is reasonable to assume that normal commercial investments will provide the levels and types of technology needed by Defence—whether in peace- or war-time. There are, however, goods and services for which Defence is the only, or the dominant purchaser, and where the production economies do not justify more than one in-country supplier. In so far as the provision of these goods and services requires the acquisition of defence-specific assets and skills by commercial firms, with associated high sunk costs, Defence must provide sufficient commercial inducements or subsidies to encourage domestic industry to invest in assets and skills critical to the integrity of the national defence effort.

Thus, firms which, in a competitive environment open to overseas competitors would never consider becoming Defence suppliers, are encouraged by government to invest in defence-specific assets and skills, including R&D. However, to induce them to undertake such investments they must be offered subsidies or granted a *de facto* status of sole source or guaranteed a certain volume of work. Since such arrangements are inherently uncompetitive, Defence must find ways of making them more contestable, that is, to expose incumbent firms at least to potential competition. This poses a major challenge to those responsible for the in-country procurement of technology-rich defence systems. On the one hand, firms have to be encouraged to make long term strategic commitments to defence-related production and invest in defence-specific assets, skills and knowhow. On the other, they are to be 'kept on their toes', to prevent them from taking advantage of their sole source status. To date, Defence does not appear to have been entirely successful in meeting this challenge. And as noted, the DER failed to supply the policy makers with many new ideas.

One way of avoiding the problem is for Defence itself to undertake the most risky and costly investments, including R&D, in-house. This may offer the advantage that specialist R&D activities might feed into other in-house activities (e.g., acquisitions). 'On tap' R&D may also shorten procurement cycles. In fact, most defence-related R&D has been undertaken in-house by DSTO. Over the past few years, however, there has been considerable pressure to outsource many in-house R&D activities, especially the more 'downstream' forms of technology application and demonstration. There has also been a tendency to make R&D more user-focused. Insofar as these initiatives result in higher levels of customer service and enhanced cost-effectiveness through the more efficient division of labour between public and private sectors, they should clearly be encouraged.

However, there is also a risk that activities may be outsourced for ideological, as opposed to economic, reasons. There are those who believe that public sector agencies, including Defence, are inherently less cost-effective and user-focused than demand-oriented private enterprise and should therefore avoid producing anything that could possibly be sourced commercially (see the DER Report, for example). It goes without saying that in an economy such as Australia's, dominated by private sector activity, public sector activities should be restricted to those areas where the private sector is unwilling and/or unable to deliver the product and where it is clearly demonstrated that a public sector agency is capable of improving on private enterprise. Similar standards should apply to public sector outsourcing decisions in areas such as defence-specific R&D. Private enterprise must be shown to be capable of 'delivering the goods', i.e., of providing a dependable, long term source of supply that is also free from monopolistic excesses and rent seeking. This is the intent behind Defence's approach to market testing—the CSP. It is important that the integrity of the CSP outsourcing methodology is not sacrificed as Defence intensifies its contracting out activities.

Notes and References

1. The White Paper, *Defending* Australia, (AGPS, Canberra), was published in 1994, i.e., after the end of the Cold War. Whilst the ending of the Cold War has produced reductions in military spending, production and arms trade in most NATO and the former WTO countries, there appears to be a significant arms buildup occuring in East Asia. ('East Asia' is defined here as comprising the following countries: Brunei, Cambodia, China, Indonesia, Japan, North and South Korea, Laos, Malaysia, Myanmar, Philippines, Singapore, Taiwan, Thailand and Viet Nam.) This growth in military spending power reflects a major improvement in the economic circumstances of East Asian countries, often combined with very healthy external balances (e.g., Taiwan) and increasing public revenues. Also, with the exception of Japan, most of the existing sea and air capabilities in the region have become quite (technologically) obsolete and require extensive modernisation. In South-East Asia, only the Philippines appears to be severely restricted in its military spending by budgetary constraints. Not surprisingly, concerns have been raised as to whether this increased defence spending in the region represents an incipient arms race (SIPRI, *SIPRI Yearbook 1995*, Stockholm International Peace Research Institute, Oxford University Press, Oxford, 1995).
2. The reasoning here is that rapid economic growth will increase the power of Asian nations whilst political change is making their policies less predictable. In addition, the US strategic role is changing as the US reassesses its global military commitments. In the circumstances, the concept of a 'peace dividend' in the form of defence budgetary cuts seems somewhat implausible in Australia.
3. The policy of self-reliance was one of three pillars of overall strategic policy outlined in the 1987 White Paper, *The Defence of Australia* (A Policy Information Paper, Department of Defence, AGPS, Canberra, 1987)—the remaining two being Australia's alliance with the US and the commitment to devote a certain level of resources to meet planned objectives.
4. The 1990s have already seen significant Australian deployments in the Gulf, Namibia, Cambodia, Somalia, Rwanda and the South Pacific.
5. The technology-based force multiplier is defined here as the contribution of defence technology to the effectiveness of the defence force after numbers of personnel and equipment (labour and capital) are taken into account, e.g., an increase in firepower achieved with given personnel and equipment numbers when technology is upgraded.
6. Ken Anderson and Paul Dibb, *Strategic Guidelines for Enabling Research and Development to Support Australian Defence*, Strategic and Defence Studies Centre, Australian National University, Canberra, 1996.

7. E. Arnett, 'Military research and development', in *SIPRI Yearbook 1996: World Armaments and Disarmament*, Oxford University Press, Oxford, 1966, pp. 381–409, a particularly valuable and up-to-date review of world military R&D expenditure. Figures provided by the OECD are likely to be most reliable as they follow a common standard of data collection and presentation.
8. *Ibid.*, p. 381.
9. *Ibid.*, p. 391.
10. *Ibid.*, especially Table 9.3. The costs of heavy investment in defence R&D are examined, inter alia, by D. Buck and K. Hartley, 'The Political Economy of Defence R&D: Burden or Benefit?' in R. Coopey *et al.*, *Defence Science and Technology: Adjusting to Change*, Harwood, UK, 1993, pp. 13–44.
11. See Arnett, *op. cit.*, Ref. 7.
12. This is suggested, for example, in P. Gummett and W. Walker, 'Science, technology and the peace dividend', in M. Brzoska and P. Lock (eds), *Restructuring of Arms Production in Western Europe*, SIPRI/Oxford University Press, 1992, and M. Edmonds, 'Technology Dependence: the Hidden side of Defence Research and Development', in Coopey *et al.*, *op. cit.*, Ref. 10.
13. See M. Lorell, *Pros and cons of international weapons procurement collaboration*, NDRI, RAND, Santa Monica, 1995, for an analysis of the features of successful collaborative projects and Arnett, *op. cit.*, Ref. 7, for likely future tendencies.
14. See E. Arnett and R. Kokoski, 'Military technology and international security: the case of the USA', in *SIPRI Yearbook 1993; World Armaments and Disarmament*, Oxford University Press, Oxford, 1993, pp. 307–34.
15. *Ibid.*, p. 388.
16. Also see Arnett and Kokoski, *op. cit.*, Ref. 14.
17. See *DERA Annual Report 1993–94*, HMSO, London, 1994 and the 1994–5 edition of this report.
18. Arnett and Kokoski, *op. cit.*, Ref. 14, label this as the 'spin-on' process.
19. See the memorandum by Defense Secretary Perry, *Specifications & Standards. A New Way of Doing Business* at http:;sh;shbbs.itsi.disa.mil:5580/E2925T3045. For an analysis of the implications of the use of civil technology in defence systems see J. Petrovic and K. Kogler, *Assessment of COTS technology impact on weapons system support*, Internet, 1996 and B. Eisenstein and K. Adamchak, *Dual-use COTS Technology: The Key to U.S. Military Leadership in the 90s and Beyond*, Internet, 1996, and J. Ericson, *Life Cycle Support for Military Systems: The Public versus Private Debate*, Internet, 1996, These Internet publications may be found at: http:;sh;shcots-ndi-conf.kpt.nuwc.navy.mil/infopapers.htm (available in Word format).
20. See J. Gansler, 'The Future of the Defence Firm: Integrating Civil and Military Technologies', in A. Latham and N. Hooper (eds), *The Future of the Defence Firm: New Challenges, New Directions*, Kluwer, Dordrecht, 1995, pp. 89–95.
21. See Arnett, *op. cit.*, Ref. 7, and Gummett and Walker, *op. cit.*, Ref. 12.
22. DER, *Future Directions for the Management of Australia's Defence*, the Report of the Defence Efficiency Review and Addendum (Secretariat Papers), Department of Defence, Canberra, 1997.
23. Referring to the Government-owned and designated sole sources, the DER further notes that: "The state invested heavily in these firms' defence facilities, often giving them quite advanced capabilities and, at least as often, incipient excess capacity for any possible peacetime needs and most wartime needs short of a World War II replay. They become demonstrably uncompetitive in price and often delivery time, and less often in equipment capabilities and advanced technologies when they are finally produced". (DER, *op. cit.*, Ref. 22, p. 31). The DER comments also apply to some of private (sector) 'designated sole sources' not exposed to market contestability and kept in business by preferential procurement and 'demand manipulation'.
24. The Minimum Efficient Scale refers to the minimum scale of production that ensures the cost-competitiveness of the producer through economies of scale.
25. As the DER observes, "The Australian defence market is too small to provide continuity of production, let alone sufficient new design and development work, for such firms to remain viable without subsidisation in most areas". (DER, *op. cit.*, Ref. 22, p. 30).
26. Submission by the Department of Defence to the Industry Commission's Inquiry into Defence Procurement (see Ref. 28).

27. The strengths in Australia's defence industry include: a substantial shipbuilding capability developed in relation to the frigate and submarine projects; design and development skills in aerospace and a significant capability in component manufacture; an IT sector which offers the potential for reliable, and technologically state-of-the-art supply to the DoD; and an electronics/communications industry capable of undertaking defence-related R&D. The principal weakness of many defence-related industries is the extent to which they depend on Australia's DoD for business. Main opportunities in the defence industry appear to be limited to import replacement in niche markets and an ability to develop products, including maintenance services, largely dedicated to the ADF requirements or to adapt and customise imported systems. There may also be some opportunities in international networking with other countries in the region, especially if Australian companies are prepared to operate as equity partners rather than sub-contractors. There are also expectations that general systems integration and project management skills acquired during major defence projects could be internationally marketable, in both defence and civilian contexts. As for threats, once the present shipbuilding projects are complete, the future of the shipbuilding industry may be in doubt, partly because of a world-wide excess supply of construction facilities but also because national governments tend to adopt mercantilist attitudes to defence industries and favour indigenous companies. Another threat concerns the maintenance of technological capabilities acquired in the 1980s and the early 1990s. Technologies acquired during that period may be difficult to retain and develop in the 1990s and beyond unless substantial non-defence or export-related demand materialises (for further details see Stefan Markowski and Peter Hall, 'Defence Industry and Local Content Requirements', in G. Cheeseman, (ed.), *Fostering Indigenous Defence Industry?*, Defence Industry Policy after Price Review, Australian Defence Studies Centre, Canberra, 1994, pp. 51–76).
28. IC (1994), *Defence Procurement*, Report No. 41, August, Industry Commission, AGPS, Canberra, 1994.
29. DER, *op. cit.*, Ref. 22, pp. 31 and 37.
30. See the Hon Bronwyn Bishop MP, Minister for Defence Industry, Science and Personnel in Stefan Markowski and Peter Hall, Best Practice Defence Procurement, *Learning from International Experience*, Special Report, December, Australian Defence Studies Centre, Canberra, (1996).
31. See DSTO, *The future Role of DSTO in Enhancing Australian Defence Industry Capability*, DSTO, Canberra, 1992.
32. The capability focus should not be confused with business entities that provide 'organisational envelopes' for defence-related capabilities. Defence is clearly not concerned with the latter as long as the needed defence-relevant assets and skills are available in peace- and war-time in-country (see also DER, *op. cit.*, Ref. 22, pp. 29–33).
33. For many (most?) defence products, there is no such thing as the 'going' market price. Specifications vary as weapons systems are 'packaged' to user specification. However, an off-the-shelf buyer has no market power in that its specific requirements had not been considered beforehand and the volumes concerned are not significant enough to induce the vendor to offer special price inducements or package 'enhancements' (at the list price).
34. Since defence products are highly specialised, the buyer cannot rely on some general pool of market knowledge which is easy and inexpensive to access. Buying weapons that other nations are buying is unlikely to be very 'wise' since their operational effectiveness and reliability tend to be user-specific.
35. To achieve and/or sustain their competitive advantage in the broader market, firms must engage in R&D to compete on product specification (differentiation, quality) as well as price. The cost of R&D investments can only be recovered through the subsequent production and sale of products which in turn depend on success in attracting orders. Insofar as the product innovation results in R&D-based rents, or increased sales are achieved by means of cost-reducing process innovations, firms are likely to invest in innovative activities. On the other hand, inability to secure proprietary rights in innovation deters commercial investments in R&D. Since the ADF is not the sole (or even dominant) buyer of the product, the producer's willingness to engage in product- and process-related R&D is driven by the broader civil or, in the case of imports, global defence market considerations. Nevertheless, large international suppliers embarking on the development of a new

weapons system are likely to consider specific (product-variant) requirements of a number of countries and select product and process specifications that maximise their total expected sales. If Australia is considered to be a credible future buyer of such products, its specific requirements are likely to be incorporated in the menu of options and modules to be offered by the supplier. Thus, the extent of an upfront, country-specific investment undertaken by the supplier will depend on the *expected* sales revenue, that is, the country's likely expenditure on the weapons system under development weighted by the probability of winning the order.

36. The prospect of winning a very large order may induce firms to invest even if the probability of success is small whilst a large requirement may also allow Defence to split its orders between two or more providers, and thus to increase the number of successful contestants. In Australia, given the small size of requirements, such opportunities are rather restricted.
37. On the other hand, to draw an initial list of preferred bidders, Defence requires a great deal of technological and firm-specific information. It must also be reasonably specific about its own user requirements. Such information may not be available to Defence in the early stages of procurement. More information may become available when in-house activities are to be market tested or when a particular requirement is recontracted and the experience of previous tenders is retained in the corporate memory.
38. DER, *op. cit.*, Ref. 22, p. 30.
39. See, for example, industry submissions to the Industry Commission's Inquiry into Defence Procurement in IC *op. cit.*, Ref. 28.
40. Department of Defence, *Defence Annual Report*, 1995–6, AGPS, Canberra, 1996, p. 163.
41. *Ibid.*
42. DSTO, *Providing Australian Defence with the Smart Edge*, Department of Defence, Canberra, 1994, p. 3.
43. Anderson and Dibb, *op. cit.*, Ref. 6.
44. Sandler and Hartley, *op. cit.*, Ref. 10, p. 116.
45. Anderson and Dibb, *op. cit.*, Ref. 6, Annex B.
46. A good example of this is 'crack patching' which uses a composite bonded repair technique to reinforce aircraft components. The bonded reinforcement field kit designed by DSTO can cut conventional repair time from six days to half a day and gives a more durable repair than conventional riveted repair patches.
47. AMRL also has operations at Pyrmont (NSW), Salisbury (SA), Innisfail (QLD), Scottsdale (Tas) and Garden Island (WA).
48. M.A. Ablong, 'The revolution in military affairs—implications for the ADF', *Journal of the Royal United Services Institute of Australia*, 16, 1, 1995.
49. Department of Defence, Inspector-General Division, *Materials Research in Defence Science and Technology: Program Evaluation*, Department of Defence, Canberra, 1993.
50. *Ibid*, pp. 3–7.
51. Woolcott Research Pty Ltd, *An Evaluation of Attitudes Towards the Organisation Amongst its Key Stakeholders*, 1992. Report written on the basis of research conducted for the DSTO Public Relations Unit and cited in the Inspector-General's program evaluation, pp. 3–8.
52. Department of Defence, Inspector-General Division, *op. cit.*, Ref. 49, pp. 5/3–5/4.
53. Department of Defence, *op. cit.*, Ref. 40, p. 164.
54. Department of Defence, *Defence Science and Technology Organisation*, AGPS, Canberra, 1983, p. 3.
55. Australian National Audit Office, *Audit Report No. 2, 1992–3. Efficiency Audit, Department of Defence. Commercial Activity in the Defence Science and Technology Organisation*, AGPS, Canberra, 1992, p. 5.
56. Inspector General, *op. cit.*, Ref. 49, pp. 4–10, 4–11.
57. *Ibid*, pp. 4–11.
58. Industry Commission, *Research and Development: Report No. 44*, AGPS, Canberra, 1995, p. 329.
59. *Ibid.*, p. 325.
60. Industry Commission, *op. cit.*, Ref. 28, p. 71.
61. Department of Defence, *op. cit.*, Ref. 40, p. 168.
62. Industry Commission, *op. cit.*, Ref. 58, p. 324.
63. *Ibid*, p. 324.

64. Department of Defence, *op. cit.*, Ref. 40, p. 168.
65. Industry Commission, *op. cit.*, Ref. 58, p. 329.
66. For details, see Stefan Markowski and Peter Hall (1995), 'The Defence Offsets Policy in Australia', in S. Martin (ed.), *The Economics of Offsets: Issues, Policies and Prospects*, Harwood Academic Publishers, Amsterdam, and Peter Hall and Stefan Markowski (1996) 'Some Lessons from the Australian Defence Offsets Experience', *Defence Analysis*, 12, 3, December.
67. DoD, 1992, Ref. 72, p. 24.
68. Hall and Markowski, *op. cit.*, Ref. 66.
69. Hall and Markowski, *op. cit.*, Ref. 66.
70. For an overview of the DID guidelines see Defence, Development of a Defence Capability in Australian Industry, Chapter 3 of *Selling to Defence—A Guide for Industry*, http://www.cc.adfa.oz.au/DoD/al/iic/sell2defence/sell_ch3.htm, as at 6 February 1996. Further details may be found in Defence (1992), *Review of Defence Industry Development Program*, Exports and International Programs Branch, AGPS, Canberra, 1992.
71. See Defence, Exports and International Programs Branch (1992), *op. cit.*, Ref. 70, pp. 3–7.
72. See Defence, *Defence Policy and Industry*, Report to the Minister for Defence, Department of Defence, Canberra, November 1992, (Price Report), pp. 31–33, and Defence, Exports and International Programs Branch, (1992), *op. cit.*, Ref. 70.
73. Refer to IC, *op. cit.*, Ref. 28, pp. 59–63.
74. See DER, *op. cit.*, Ref. 22, p. 36 and Recommendation 26.
75. The Defence Restructuring Agreement 1993 allows the civilian workforce to exercise its right to develop an In-house Option (IHO) when a particular activity is market tested under the CSP (DER, *op. cit.*, Ref. 22, p. 200).
76. DER, *op. cit.*, Ref. 22, p. 18.
77. W.P. Rogerson, 'Incentive models of the Defense procurement process', in Keith Hartley and Todd Sandler (eds), *Handbook of Defence Economics*; Handbooks in Economics 12, Elsevier, Amsterdam, 1995.