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DEFENCE R&D FUNDING IN CANADA

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ABSTRACT

In the decade following the end of the cold war, there has been a general trend throughout the western industrialised countries to reduce their defence spending to cash-in on the so-called peace dividends and defence Research & Development did not escape the reductions. During the same period, the Canadian government, plagued by a huge budget deficit and threatened by a national debt that was rapidly becoming out of control, decided to apply severe reductions throughout the civil service, federal agencies and the Canadian Forces. The Canadian Defence R&D Branch (now Defence R&D Canada, or DRDC), which was already modest in comparison of its international partners, was reduced even further, to a point where its ability to meet the R&D requirements of the Canadian Forces is questioned by many defence scientists in the organisation.

Ironically, it is also in the same period that the emergence of a Revolution in Military Affairs (the RMA), fuelled by an unprecedented rate of technological progress, became widely accepted, making R&D investment and technology awareness even more important for the military.

This paper presents a comparison of the funding levels and spending practices for defence R&D in Canada and some of its closest allies, and discusses alternative solutions to improve the financial situation of DRDC.

The paper also provides a short history of the evolution of Defence R&D in Canada and discusses two aspects of DRDC's funding and spending practices, revenue generation and the level of funding for external activities and spending policy. These two aspects are sometimes controversial within the scientific community, as well as with some of our military client base.

LIST OF ACRONYMS

ABCA:	Australia, Britain, Canada, America
ADM/S&T:	Assistant Deputy-Minister Science and Technology
ASD:	Alternate Service Delivery
CRAD:	Chief Research and Development
CRC:	Cooperative Research Centers
DARPA:	Defense Advanced Research Program Agency (US)
DERA:	Defence Evaluation and Research Agency (UK)
DND:	Department of National Defence
DOD:	Department of Defense
DRA:	Defence Research Agency (UK)
DRB:	Defence Research Board (Canada)
DREV:	Defence Research Establishment Valcartier
DRDC:	Defence Research and Development Canada
DSTL:	Defence Science and Technology Laboratory (UK)
DSTO:	Defence Science and Technology Organisation (Australia)
FFRDL:	Federally Funded Research and Development Laboratory (US)
FTE:	Full Time Equivalent
IP:	Intellectual Property
MoD:	Ministry of Defence
NATO:	North Atlantic Treaty Organisation
NRC:	National Research Council (Canada)
O&M:	Operation and Maintenance

R&D:	Research and Development
RMA:	Revolution in Military Affairs
S&T:	Science and Technology
SWE:	Salary Wage Envelope
TIS:	Technology Investment Strategy
TNO:	Netherlands Organisation for Applied Scientific Research
TTCP:	The Technical Cooperation Program
UK:	United Kingdom
USA:	United States of America

INTRODUCTION

Since the end of the cold war, there has been a general trend throughout the industrialised countries to reduce their defence spending to cash-in on the so called peace dividends, in the hope that the rest of the planet would follow the lead of the western democracies into a world of co-operation and economical growth, without exorbitant military expenditures. Defence R&D did not escape the reductions. Indeed, during the decade following the fall of the Berlin wall, the US reduced its Defence R&D spending by 30% between 1993 and 1999, and the Clinton administration was planning an additional reduction of 15% from 2000 to 2005[1]. In the UK, total reductions in the order of 45% were applied from 1992 to 2001[2] [3], Australia cut some 15% from 1997 to 1999 alone, and Canada, reduced its budget by 35% from 1991 to 1999 (41% in constant dollars and 40% in personnel)[4][5]. Ironically, it is in the same period that the emergence of a so-called Revolution in Military Affairs (the RMA) fuelled by new advances in technology became widely accepted.

Unfortunately, as it has ever been throughout history, the passage of one stable order to the next one did not happened overnight. The world instead entered a period of political instability, the much sought for orderly and peaceful world did not materialise, and regional enmities that had been contained for almost half a century

[1] "Innovation and Military R&D", Joseph I. Lieberman, JFQ, Summer 1999, p.14
[2] "Defence Research Agency Corporate Plan", 1994-1999, p. 13
[3] " DERA Annual Report 2000-2001", p. 52
[4] "Defence Research and Development: A Framework for the Future", Report by the DRDB ASD Team, April 1999
[5] htttp://www.dsto.defence.gov.au/corporate/publicity/smartedge/pro.html:

by the bi-polar static opposition of the cold war erupted in a score of localised conflicts that are threatening the new desired world order.

Concurrently, while Defence R&D was reduced, civilian R&D investments worldwide continued to increase and assumed a leadership that was previously the realm of the military. For example, the year 1998 was a record year for total R&D investment in the USA, and saw the largest yearly increase in R&D spending, despite the cuts in defence R&D[6]. This is especially true in the information technology sector, but also in other sectors such as nanotechnology, biotechnology, material science and many others. This situation has brought the Defence R&D communities in many countries to review their relationship with their civilian counterparts, as well as their business practices.

More recently however, a new trend has begun to emerge. In the USA, in reply to the threat posed to the country's security by the political instability in many regions of the world, the new Bush administration reversed the trend in defence reductions, and. whole-heartedly embraced the concept of the RMA and its implications: "*the Bush administration has stated that it will grow the S&T program to get the required revolutionary capability*"[7]. The same thing happened in Australia after the 1999 Defence Review that promoted a policy of self-reliance in defence matters. However, in Canada and the UK, the new investments are at best timid. The 21st century warfare will be technology driven, and since the Canadian Forces are expected to

[6] `Technology and its Relation to Peace Operations", PowerPoint presentation, Dr. D. Faubert, 1999

carry out most of their international endeavours as part of coalitions, most likely lead by the US Forces, they must keep abreast of this technology excellence, especially if they want to meet the challenge of "*fighting with the best against the best*". Otherwise, they run the risk of becoming a liability rather than an asset to future coalitions.

Given the very substantial reductions imposed on Canada's defence R&D budget, which was already among the smallest of the industrialised countries, it is now reasonable to question the ability of DRDC to actually support the Science and Technology (S&T) needs of the Canadian Forces at the onset of the 21st century. Any attempt to determine the required investment in defence R&D for Canada, as well as the nature of that investment, is at best a subjective exercise. However, since DRDC is very much involved in international collaborations through The Technical Cooperation Program (TTCP), NATO, and several bi-lateral agreements, and relies heavily on such collaborations to leverage its efforts, a comparison with our closest allies can at least provide some reliable reference points.

The objective of this paper is therefore to review and compare the funding and spending levels and practices for defence R&D in Canada and some of its closest international defence R&D partners, Australia, the United Kingdom and the United States. The Netherlands was also reviewed as one of our NATO R&D partners that have chosen a different approach to defence R&D.

[7] "Report- NDIA Science and Engineering Technology Conference, Charleston SC, 5-7 FEB 02", Dr WL Macmillan CDLS(W), 20 Feb 2002

The paper will also provide a short history of the evolution of Defence R&D in Canada and discuss two aspects of DRDC's funding, revenue generation and the level of funding for external activities and spending policy. These two aspects are sometimes controversial within the scientific community, as well as with some of our military client base.

TYPES OF DEFENCE R&D ORGANISATIONS

With the exception of the Netherlands, all the countries studied have decided to maintain an in-house R&D capability within their respective department or ministry of defence. The Netherlands has opted long ago for non-government, not-for-profit organisation to carry out all nationally funded R&D, including defence. As indicated previously, all these organisations have seen their budget reduced, and most have been the subject of some reorganisation. The following paragraphs will attempt to present these organisations, their recent history and the evolution of their budget.

DEFENCE R&D IN THE NETHERLAND[8] [9]

The Netherlands represents an exception among the countries reviewed for this paper. Indeed, no Defence R&D is carried out within its Ministry of Defence or within government laboratories. Actually, there is no government laboratory per se, and all the government sponsored R&D is carried by an independent (not owned by the

[8] TNO Web site, http://www.do.tno.nl

government) not-for-profit organisation created in 1932 by an act of parliament, called the Nederlandse Organisatie voor toegepast-natuurvetenschappelijk onderzoek (TNO), in English, the Netherlands Organisation for Applied Scientific Research. TNO is a 5000-employee contract organisation dedicated to applied research, which provides services for the Netherlands government, supranational governments and the national and foreign private sector as well. It is constituted as a legal person in the Netherlands, and comprises fourteen research centres or institutes, three of which are dedicated to defence R&D under TNO Defence.

The mission of TNO Defence is to support the Netherlands Ministry of Defence and the Netherlands Armed Forces with applied Research and Development. The link with the Ministry of Defence is ensured through the National Defence Research Council, which is composed of representatives from the MoD, the Ministry of Education, Cultural affairs and science and a number of external experts. TNO's income is made of MoD program-directed financing, MoD contracts, other ministries and governments contracts and non-defence contracts. As an independent organisation, it is not bound by government regulations on the number of its employees, on minimum or maximum revenue generation neither from non-defence sources, nor on the way it spends its budget. For example, in 2001, for a total budget of 55,5 MEuros ($80M CAN)[10], its physics and electronics laboratory received 67% of its revenue from the MoD, 11% from other ministries, 13% from the private

[9] Private conversation, Dr Van Den Steen, Head Energetic Materials, TNO Prins Mauritz Laboratory, private conversation 1999

[10] Exchange rate used in this paper for all foreign currencies are those published on 8 June 2002 in Le Soleil, Quebec.

sectors and 5% from foreign sources. TNO Defence participates to international co-operation on behalf of the Netherlands MoD. The Netherlands expenditure on defence R&D represents approximately 2% of the ministry's budget.[11]

Besides TNO, there is also the National Aerospace Lab (NLR), which cover all the aerospace related aspects of the program.

DEFENCE R&D IN AUSTRALIA[12] [13]

In Australia, defence R&D is carried by a branch of the Department of Defence called Defence Science and Technology Organisation (DSTO) that has a lot of similarities with the former DND R&D branch (Chief Research and Development, CRAD) prior to its transformation into a Special Operating Agency. The mission of DSTO is to provide expert, impartial and innovative application of science and technology to the defence of Australia and its national interests. To achieve its mission DSTO:

a. Investigates the use of future technologies for defence applications
b. Ensures Australia is a smart buyer of defence equipment
c. Develops new defence capabilities
d. Enhances existing capabilities by increasing performance and safety, and reducing costs.

During the 1990's, DSTO like most other Defence R&D organisation in the world was subjected to reduction. In 1997-98, its budget was about $230M AU ($209M

[11] "Defence Research and Development, A Concept Study", CRAD internal memorandum, 1996
[12] DSTO web site, http://www.dsto.defence.gov.au

CAN), for a staff of 2400 employees. Following the 98-99 Defence Reform Program, it budget shrunk to $210M AU ($191M CAN) and its staff was reduced to 2100. It also proceeded to a rationalisation of its installations, closing some laboratories and consolidating the activities in a partially renewed infrastructure. Today DSTO comprises 10 scientific divisions housed in two major laboratories, the Aeronautical & Maritime Research Laboratory, near Melbourne, and the Electronics & Surveillance Research Laboratory, near Adelaide. Smaller facilities are maintained in Sydney, Perth, Canberra, Innisfail and Scottsdale. Its staff has grown back to about 2200[14], mostly scientists, engineers and technicians, and its annual budget is now $250M AU ($227M CAN)[15]. Although DSTO is encouraged to commercialise its intellectual property, its salary wage envelope if fully funded and approximately 90% of its budget is spent in-house.[16]

DSTO is also expected to contribute to Australian national wealth by supporting the Australian industry and universities[17]. This is achieved through:

a. Alliances with industry

b. Licensing of intellectual property to industry

c. Contracting work to industry and universities

d. Participating in Co-operative Research Centres (CRC's)

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[13] Australian Parliament web site, http://aph.gov.au-search
[14] DSTO web site, http://www.dsto.defence.gov.au
[15] "The world according to … Ian Chessel", Selina Mitchell, The Australian, edition 1, 6 Feb 2001. Dr Ian Chessel is the Australian Chief Defence Scientist and the Head of DSTO.
[16] Private conversation, Dr Sook Yin Ho, Australian National Leader, TTCP WTP-4, April 2000
[17] "DSTO: Engaging with Australia's Industry, Science & Technology Community", DSTO web site, http://www.dsto.defence.gov.au

e. Contract services through which DSTO conducts independent research for industry or provides access to unique facilities.

In 1999-2000, DSTO spent approximately $24M AU or 10.6% of its budget outsourcing research, development and support services. Of this, $20M bought services from universities and industry, the rest being spent in co-operative ventures, including $2.5M in direct funding to Co-operative Research Centres. When staff and facilities provided by DSTO are added, the total contribution of DSTO to CRC's goes up to $6.8M.[18] Over the last 5 years, DSTO's budget represented between 2.1 and 2.2% of the overall Australian defence budget, and the secretary of defence has expressed the desire to bring it to 3%[19].

Table 1. presents the evolution of DSTO's budget and staff since 1997.

Fiscal Year	97-98[20]	98-99[21]	99-00[22]	00-01[23]	01-02[24]
Budget M$ AU	230	210	239.1	234.9	250
Staff	2400	2100	2183	2206	2200

Table 1. Evolution of DSTO's budget and staff since 1997.

[18] Ibid
[19] [19] "Australian National Overview, TTCP WTP-4 annual meeting, April 1999, ARL, USA
[20] "DSTO Profile", DSTO web site, http://www.dsto.defence.gov.au
[21] Ibid
[22] "Australian National Overview", TTCP WTP-4 annual meeting, April 2000, Adelaide, Australia
[23] Ibid
[24] "The world according to … Ian Chessel", Selina Mitchell, The Australian, edition 1, 6 Feb 2001. Dr Ian Chessel is the Australian Chief Defence Scientist and the Head of DSTO.

DEFENCE R&D IN THE UNITED KINGDOM

The UK is probably the country where defence R&D saw the most dramatic (and frequent) changes since the end of the cold war. From 1991 to this day, it went to a reorgani

was £169.2M ($378M CAN), research and non-research. It had a total staff of 11 656.[28] In total, the UK defence R&D budget was cut by 45% between 1992 and 2001. These figures do not take into account R&D carried out under other organisations such as the Ordnance Board.

This was not the end of transformation for defence R&D in the UK. Immediately after DERA's creation, there were talks about its possible privatisation. DERA was a very business like organisation, and the idea of its privatisation brought some concerns among UK's international partners. The US in particular was concerned about the use of its intellectual property provided to the UK under government-to-government agreements such as the TTCP. Nevertheless, in 1998-99, the MoD launched its Public Private Partnership (PPP) initiative for DERA, which led to the separation of DERA into two distinct entities, the Defence Science and Technology Laboratory, and one outside the MoD, now known as QinetiQ. The Central Scientific Staff of the MoD was also reorganized to cope with this change.

The Central Scientific Staff acts as an executive management body, consisting of Capability Research Directors and Technology Research Directors responsible for formulating the research program and determining science procurement strategies, and of commercial staff to let the resulting contracts. The research funding (called Research Building Block) is about £450M ($1,006M CAN). It is divided into the

[28] " DERA Annual Report 2000-2001", p. 52, 54

Applied Research Program (£300M), the Corporate Research Program (£110M), the Technology Demonstration Program (£28M) and the international collaboration and joint grant (£12M). The Central Scientific Staff is responsible to apportion this budget between DSTL and non-MoD suppliers, including QinetiQ.

DSTL is the MoD retained portion of DERA. The elements of the R&D program to be carried out by DSTL will be based on a policy decision about what needs to be done in-house, and will not be subject to competition[29]. While DERA had an arms length relationship with the MoD technology customers, DSTL will play an integral role with the Central Scientific Staff in assisting program formulation, managing contracts and integrating results.[30] These management activities will be the subject of a separate agreement between DSTL and the central staff under the Term of Business agreement (TOBA).

DSTL mission is to create "*the winning edge for UK Forces and Government through the best use of science and technology*"[31] by providing:Trusted in-house analysis and advice

b. Science and Systems Research in
   i) sensitive areas or and
   ii) where deep understanding or breakthroughs are needed
c. Knowledge integration

[29] "Science and Technology Review", Ministry of Defence (UK), 15 June 2001, p. 45

d. Focus on government to government international research collaboration[32]

Its main client and raison d'etre is to serve the MoD. DSTL is also expected to exploit its intellectual property rights with vigour and to serve other G/Span /MCID 1 BD05252

QinetiQ will be treated by MoD like any other company and will have to compete for MoD's business. Therefore DSTL will not offer any advantage or disadvantage to QinetiQ compared with any other contractor. DSTL and QinetiQ will share sites, at least initially, but will be physically separate.[36]

Finally, the MoD recently announced a new initiative, the creation of Defence Technology Centres (DTC). A DTC is defined as *"a formal collaborative arrangement between industry and academic experts in a particular technology, funded jointly by participants and MoD. The participants will work together to generate and enhance the technology vital to the delivery of future UK Defence capabilities."* MoD will fund each DTC up to a maximum of£5M ($11M CAN) per year for between 3 to 6 years. DTCs will be created at the initiative of the MOD through requests for declaration of interests. The winning consortium will be expected to provide a significant (up to 50%) contribution. MOD intends to state funding 3 DTCs in fiscal year 2002-03.[37] However, these are now running into difficulty, as industry will only invest if they have exclusive rights to any IP generated. MoD is considering to (initially) provide 100% funding to get around this IP issue. Funding would come out of the corporate research program putting additional pressure on the DSTL/QinetiQ programs.[38]

DEFENCE R&D IN THE UNITED STATES[39]

[36] "DSTL is part of the Ministry of Defence", PowerPoint presentation, [DSTL], April 2002, slide 78
[36] Ibid, slide 8
[37] http://www.mod.uk/dtc/contracts.htm
[38] Private communication, Michael Clark, CDLS London, 6 June 2002
[39] "Report- NDIA Science and Engineering Technology Conference, Charleston SC, 5-7 FEB 02", Dr WL Macmillan CDLS(W), 20 Feb 2002

In the US the trend to cut the defence R&D spending saw a dramatic reversal with the advent of the new Republican government. The last Clinton budget (FY02) allocated $7.8B for S&T. The Bush administration increased it by $1B and requested $9.9B for FY03 (for the sake of comparison, total DND budget in US$ is around $7.5B). The FY03 budget will be divided as follows: Basic Research, $1.4B; Applied Research, $3.3B; Advanced Development, $4.7B. When divided by services and agencies: Army, $1.6B (1.8% of the Army budget); Navy, $1.8B (1.6%); Air Force, $1.6B (1.5%); DARPA, $2.6B; Others, OSD, $2.3B.

From FY02 to FY03, the US defence R&D budget that was already in a class of itself, saw an actual increase of 25% over two years. In addition, over the last two years, Congress added $0.5B to $1B more than what was asked by the president! While the present R&D spending level represents between 1.5 to 1.8% of the total US defence budget, the new administration has stated that it wants to grow the S&T program to 3% of the defence budget by 2010, with the objective of developing the required revolutionary capabilities. Such an increase would represent an additional growth of 30%, an idea that is supported by Pentagon officials[40].

The three main issues identified for the defence R&D in the US by the Director Development, Research and Engineering, Dr R. Sega are: the need for S&T to enable transformation; the need to accelerate specific technologies needed for

[40] "DOD to spend more on S&T", Peter Grier, Air Force Magazine, Aug 2001

transformation; the concern about the state of the national S&T workforce and laboratories.

Defence R&D in the US is carried out in a variety of organisations and establishments. These includes in-house, services owned R&D establishments, Federally Funded R&D Centres (FFRDC, private R&D centres operated on behalf of DOD), University Affiliated Research Centres, as well as contracts, grants and partnerships with industry and universities. The time available to write this paper did not permit to review them in depth, or to investigate their relative levels of funding.

The importance of US government defence R&D funding to the science in the US is remarkable. Over the last fifty years, it contributed financially to 58% and 43% respectively of the US Nobel prizes in chemistry and physics. Close to 75% of the papers cited in industrial patents applications draw on federally funded R&D programs.[41] According to US senator Lieberman, both industry and the military rely on government-sponsored research, as US industry does not engage in long-term research and concentrates its efforts (84%) on the more lucrative final stages of product development. Industry also has a tendency to focus on low-risk legacy systems, as substantial losses may be encountered if DOD does not acquire newly developed products.[42] This is an opinion shared by Mr M. O'Neil, Chief Technical Officer for Lockheed Martin, who believes that governments should support

[41] "Innovation and Military R&D", Joseph I. Lieberman, JFQ, Summer 1999, p. 13-14
[42] Ibid, p. 14

revolutionary development, as stockholders will not allow companies to invest for something 20 years away[43].

DEFENCE RESEARCH AND DEVELOPMENT CANADA (DRDC)

The birth of Defence R&D in Canada can be traced back to the Second World War, when the National Research Council did assumed de facto the role in the absence of a dedicated defence R&D organisation. At the end of the war however, the NRC management, while convinced of the necessity of a strong defence oriented organisation, did not wish to assume the role anymore. The Defence Research Board was therefore created in April 1947. In the words of its first chairman, Dr O. M. Solandt,

> *"Its aspiration was to ensure that the Canadian Armed Forces were known as the most scientifically and technically alert and best equipped in the world. The aim was to ensure that the best science and technology from all parts of the world were available to and used by the Canadian forces".* [44]

The DRB could not however *"cover the waterfront"* and was to *"pursue a highly selective program…. [45]* DRB was a separate employer (i.e. it was not part of the public service nor of the Department of National Defence), it operated under the

[43] "Report- NDIA Science and Engineering Technology Conference, Charleston SC, 5-7 FEB 02", Dr WL Macmillan CDLS(W), 20 Feb 2002
[44] "The Defence Research Board's untimely end: what it means for military science", O. M. Solandt, Science Forum, No. 47, Oct 75

mandate of the National Defence Act, with executive, management, advisory and administrative responsibilities, was funded from a separate parliamentary vote and was responsible and accountable to the minister of National defence. The DRB was governed by a board comprising the chiefs of staff of the three force elements, the president of the NRC and representatives from the universities and industries, and its chairman was sitting on the Chiefs of Staff Committee.[46]

In April 1974, following the major reorganisation of the Department of National Defence in 1972, the DRB laboratories were integrated to the department under a new Chief of Research and Development (CRAD), reporting to the assistant-deputy minister materiel (ADM-Mat). The DRB remained as a small advisory group to the minister, and has since faded away, like the proverbial old soldier, the role of scientific advisor being discharged by CRAD. The dismemberment of the Defence Research Board met even less agreement from its scientists than the CF integration did with the military in the previous years. In 1975, Dr Solandt, then retired from the DRB, wrote: "*The Defence Research Board has recently been dismembered in a thoughtless act of mayhem committed in the name of administrative tidiness".*[47] Many of the scientists concerned specially those in management, considered the change "*to be both unreasonable and detrimental to the future of Canadian science".*[48] Even today, some of the players of the day still resent the decision as demonstrated by this

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[45] Ibid
[46] "Why the bureaucrats secretly carved up the DRB: it worked to well", Gordon D Watson, Science Forum No 47, Oct 75
[47] "The Defence Research Board's untimely end: what it means for military science", O. M. Solandt, Science Forum, No. 47, Oct 75
[48] "Why the bureaucrats secretly carved up the DRB: it worked to well", Gordon D Watson, Science Forum No 47, Oct 75

comment by the Honourable Paul T. Hellyer, former minister of national defence, in his recent book, Goodbye Canada:

> "*When Canada eliminated the Defence Research Board (DRB) in 1974, it virtually abandoned the kind of military research that inevitably produces subsidised civil spin-offs for industrial production.*"

Defence R&D nevertheless survived within DND. The mission of the new R&D Branch was defined as follows[49]

1) To provide Science &Technology advice to the CF and Department
2) To provide and sponsors a broad spectrum of defence R&D
3) To leverage technology by national and international collaborationTo help create and maintain the Canadian defence industrial base

From 1974 to 1990, the R&D Branch size was slowly and mostly painlessly reduced from 2100 to 1500 employees, through regular attrition, and at a rate that still allowed a continuous renewal of the expertise, although some areas of research had to abandoned and many others were already getting close to their critical mass. During most of that period, the R&D branch budget was based on 5% of the department's capital budget, a formula that provided a reasonable level of stability and predictability. Starting in 1995, however, following the 1994 budget, severe reductions were implemented, and the organisation lost approximately a third of its resources.

DRDC Budget Summary (K$)	1993-94 Before reductions	1997-98 After reductions	2001-02 Today
Salaries	75,749	53,864	59,158
TOTAL	247,376	173,430	194,056
% of DND Budget to R&D	2.08%	1.75%	1.65%
Staff	1500	1100	1248

Table 2. Evolution of CRAD/DRDC resources since 1993-94

Moreover, to limit additional loss of personnel that could have lead to establishments closure (which was considered politically unacceptable), CRAD had to find a way to offset a additional Salary Wage Envelope (SWE) reduction of 10,2 M$ representing approximately 190 Full Time Equivalent (FTE) employees[50]. During the following months, CRAD sponsored several studies, in-house and with consultants, to assist in the design of an operating model more suitable for the new reality. All these studies concluded that the business practices of the day needed serious improvements if CRAD was to achieve its mandate, that there was a need for a strong in-house S&T capability within DND, and that efficient collaboration with industry and universities was essential. A study conducted by Navatar[51] on behalf of CRAD in 1997 identified two main problems facing the organisation:

1) *How to deal with the increasing demand for R&D within reducing funding envelopes; and*

[49] "R&D Branch: DREV-CRAD Overview", R. S. Walker, PowerPoint presentation, 1995
[50] "Report on the Development of the R&D) (CRAD) Branch Operational Flexibility and Future Model", Navatar Ltd., 1997

2) *How to work with the private sector in new ways that allow for effective technology transfer and development to achieve a growth in wealth and knowledge.*

Navatar also identified several shortcomings that impose a cost premium to CRAD at its disadvantage:

1) The true return on investment for our contracted out activities: *"A sizeable amount of contracting out is done with CRAD being treated more as a cash cow by firms in the private sectors than as a true collaborator. Little or no monetary or intellectual advantage accrues to CRAD as a result of these activities."*
2) Its total reliance on a single client and source of funding
3) Lack of a marketing and business development capability
4) Lack of leveraging through economic association with commercial or private sector for collaborative cost sharing R&D.
5) Lack of control of its own Intellectual Property (IP, 95% of DND's)
6) Inappropriate financial practices such as the constrictive vote-netting of DND, inability to retain revenue generated, lack of a revolving fund
7) Consequences of government policies and imposed resources decision such as mandatory SWE reduction

[51] "Report on the Development of the R&D) (CRAD) Branch Operational Flexibility and Future Model", Navatar Ltd, 1997

Both an in-house study[52] based on a series of interview with several stake holders, including industry representatives and a study by A. E. Collin Associates[53] reported that "…*industry makes a strong case for the continuation of active applied research in DND in close collaboration with the defence industry of Canada*". The in-house study also concluded: "…*it is not assumed that the private sector is able or willing to accept increased responsibility for defence research and development at competitive cost.*" The Collin study add:"…*with a few exceptions, Canadian companies are not large enough to undertake an adequate program of applied research to maintain a competitive product development activity over the long term".*

All these findings were in line with a previous study of the National Advisory Board on Science and Technology's Federal Science and Technology Expenditures Committee[54] which had concluded that: "…*fundamental changes are required in the organisation of federal intramural S&T activities and ... a new management regime, one better suited to the unique nature of science and technology, needs to be established."* The recommendations included the creation of more efficient, less bureaucratic separate R&D entities with the authority to enter in contracts with other clients, own and exploit intellectual property and retain earnings.

Needless to say that when DND launched its Alternative Service Delivery (ASD) initiative, unlike many other organisations that perceived it as a threat, CRAD saw an

[52] "Defence Research and Development, A Concept Study", CRAD internal memorandum, 1996
[53] "An Examination of the Role of Research and Development in the Department of National Defence", A. E. Collin Associates, December 20 1996

opportunity to achieve a different status that would allow it to proceed to reforms desperately needed to maximise the value of the Canadian defence R&D investment. The CRAD ASD team identified some additional areas of concern such as

a. a rust-out, neglected infrastructure in great need of repair or renewal, a situation mostly caused by insufficient O&M and Capital funds over an extended period, and
b. an ageing workforce in which the 20-29 years of age represented less than 1%. (28-37% of DRDC's S&T workforce will be eligible for retirement by 2006[55])

After studying various options ranging from status quo to full privatisation (typical of all ASD studies), the ASD study group[56] recommended the creation of a statutory agency, which, interestingly enough, would have included many of the features of the DRB:

a. Head reports to Minister or delegate
b. Advisory Board (clients, S&T representatives)
c. Single operating budget, including salaries, O&M and minor capital
d. Multi-year non-lapsing budget authority and a revolving fund
e. Separate employer status for human resources

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[54] "Revitalizing Science and Technology in the Government of Canada: The Report of the Committee on federal Science and Technology Expenditures", 1990
[55] 'Synopsis for the DRDC Advisory Board", S. McIntyre, May 2002
[56] "Defence Research and Development: A Framework for the Future", Report by the DRDB ASD Team, April 1999

f. Authority for contracting and for revenue generation and retention

g. Authority for public affairs

In the end, the department decided to adopt a different option, and the R&D branch became a special operating agency within DND, called Defence R&D Canada (DRDC), and CRAD became the assistant deputy minister for science and technology (ADM-S&T). DRDC remained part of DND and the public service. It now has a single operating, is allowed to carry over a part of its budget from one fiscal year to the next and was delegated additional authorities in managing personnel. It has also gained authority for public affairs, the authority to generate and retain revenue, and in a sense, an obligation to do so, since its salary wage envelope is still not entirely covered by DND. The annual revenue generation objective was set to 10M$ to be achieved by 2004, but shall not exceed 10% of the overall budget. DRDC did not obtain authority for contracting out and is still subject to Public Work and Government Services Canada, nor did it obtain a multi-year non-lapsing budget authority and a revolving fund. In that regard, the retained solution did not provide all of the much-needed financial flexibility that was sought for. R&D is a long-term endeavour which outcome is often unpredictable, and in which even the time required for the acquisition of specialized equipment can exceed 12 months. It is therefore more difficult to manage within the present constraints.

ADM/S&T has provided the following vision for the agency: *"To be known world wide as the best in defence R&D"* [57]and its mission was defined as follows[58]:

1) Facilitate and enhance the ability of decision makers to make informed decisions on defence policy, force generation, and procurement by providing expert scientific and technological (S&T);
2) Contribute to the success of military operations by pursuing Research and Development (R&D) activities that provide improved support, knowledge, protection, and response to potential threats;
3) Enhance the preparedness of the Canadian Forces by assessing technology trends, threats and opportunities, and by exploiting emerging technologies;
4) Contribute to the creation and maintenance of a Canadian defence S&T industrial capability that is internationally competitive, by contracting-out to industry, by transferring technology to industry and by entering into partnerships in which cost and risk are shared; and
5) Conduct S&T projects for clients external to DND, in order to assist the Agency in developing and maintaining its defence-related technological capabilities

OUTSOURCING POLICY

[57] "Looking Forward, Staying ahead", DRDC, 2002 edition

Since the creation of CRAD in 1974, it has been an internal policy to spend approximately 50% of the overall budget on external R&D sources, mostly industry. Part of the CRAD budget for SWE, operation & maintenance (O&M) and minor capital was provided by ADM/Mat, while capital and R&D funding, all of which was destined to contracts, was provided by the VCDS. This general policy is still applied today by DRDC, even after the 1994 budget reductions; between 1996 and 2002, this percentage varied from 46 to 54 %. However, as mentioned in the Navatar study quoted previously[59], there were little advantages accrued to CRAD as a result of these activities. True collaboration, that is CRAD and a private company both investing in a project and sharing the results seldom occurred, and what most of the time passed for collaboration was companies accepting to fund a part of the R&D they were performing for CRAD. In the past, prior to the severe budget and personnel reduction of the 1990's, the policy had less consequences on CRAD's ability to function and meet the requirements of its mandate towards the CF and DND. In many instances, it helped maintained industrial R&D capabilities where the Canadian market would not have supported it. So, although it may not have been optimal in terms of technology exploitation, it was beneficial to the overall defence R&D availability. Some projects were very successful, like the development of the CRV7 Rocket Weapon System which was an essentially a DRB-CRAD funded development. By the time CRAD terminated its in-house effort, the manufacturer, Bristol Aerospace Ltd, had

[58] "Welcome to DREV", G. Bérubé, PowerPoint presentation, Oct 01
[59] "Report on the Development of the R&D) (CRAD) Branch Operational Flexibility and Future Model", Navatar Ltd, 1997

established a solid national and international market that allowed the company to take over the R&D aspects and to further develop the system on its own. BAL celebrated last year its first billion dollar sales of DRB-CRAD developed rockets (Black Brant research rockets and CRV7). It is worth noting that the Black Brant development and technology transfer was entirely completed and that the CRV7 was already well underway when the DRB was disbanded in 1974, and that by the mid 1980's, it had become obvious that successes like the CRV7 were no longer affordable by the organization.

Others initiatives remained entirely dependent on CRAD's financial support and disappeared as soon as the government money stopped flowing. A good example of this is the attempt made by the DREV Armament Division to develop a defence industrial capability in finite elements and hydrocode in the 1980's. When priorities changed and contract money was redirected to other technologies, the industry personnel was laid off or reassigned and within two years the capability was gone, as there was no market for it.

It is interesting to compare our 50% outsourcing policy with our international partners policy or practices. In the US, where the R&D capabilities of the private defence industry are much more developed than in Canada, the policy is "*that the government shall rely to a large degree on the private sector to supply its needs*.[59] At the same time, it is recognized that to maintain an efficient relationship with the private sector, a solid in-house expertise is essential: "*The complexities of acquisition decisions,*

which require the application of sound scientific and technical judgments, dictate that the government maintain a strong internal competence in research and development."[60] In other words, the US DOD needs internal capabilities to be a smart buyer. As far as the level and the nature of internal vs. external expertise is concerned, "(this) *must remain matters of executive management judgment, to be exercised within the bounds of the agency's duly established responsibilities and the public resources provided to meet those responsibilities.*"[61]

In Australia, where the defence industry is not as developed as in the US and much more comparable to Canada, there is a clear intent to develop the industrial capabilities by exploiting the technologies developed by DSTO, through transfer of technology. This is, however accomplished through cooperative ventures and licensing, and DSTO spends only about 10% of its budget on out-sourcing. Last year, it has nineteen cooperative agreements in place with industries. This approach allows DSTO to maintain a staff of 2100 employees (twice that of DRDC) with a budget just 20% larger than the DRDC budget ($227M CAN for DSTO vs. $187M CAN for RDDC). By participating to joint ventures instead of contracting out, DSTO supports industrial capabilities while augmenting its own knowledge base by leveraging industries investments. Moreover, the risk of becoming a milking cow for body-shop companies is virtually eliminated and the value of the Australian government investment is maximized.

[60] "Required in-house capabilities for department of defence research, development, test and evaluation", Research Office, Office of the Under Secretary of Defence for Research and Engineering, 1 Oct 1980
[61] Ibid

The case of the UK is probably more difficult to interpret as the fate of its defence R&D is still pretty much an experiment for the moment, following the division of DERA into DSTL and QinetiQ. However, if the situation develops as planned, DSTL will be funded to carry out in-house the portion that is deemed necessary to retain within the MoD, while the contracted out part will be issued by the central staff with DSTL acting as an advisor. In its first year of existence, DSTL receives 56% of the MoD research budget (approximately $565M CAN), for a staff of 3000 employees. The UK has a relatively strong defence industry, and traditionally, 75% of its defence systems were built by UK industry or by consortium involving at least one UK industries.

In the Netherlands, the defence R&D being entirely contracted out to TNO, an organization that is somewhere between a US Federally Funded RD Center and the Canadian NRC, there is no government policy for TNO to "sub-contract-out".

REVENUE GENERATION POLICY

Since 1999, DRDC has a revenue generation policy to cover a portion of its salary wage envelope not funded under its Service Level Agreement (SLA) with DND. Its main revenue sources are:

a. Exploitation of its intellectual properties through patenting, licensing and technology transfer.
b. Renting of facilities excess capacities to other legitimate users
c. The provision of R&D services to clients external to DND, or to DND clients for activities not covered under the SLA (contracting-in)

In achieving its revenue generation objectives, DRDC:

a. is not expected to exceed 10% of its budget in revenues
b. shall not compete in any manner with Canadian industries
c. shall not accept work outside its mandate, i.e., shall avoid mission drift
d. shall not compromise its ability to act as an independent advisor to DND.

Since its introduction, revenue generation has been one of the most controversial topics among the DRDC scientific community, especially in the beginning. The first reason for this is undoubtedly a cultural one: the civil service with all its rules and regulations does not foster entrepreneurship. However, the circumstances under which it was introduced was probably also responsible for a good part of the

reluctance demonstrated by many of DRDC's employees. Indeed, because revenue generation was introduced in a staff and budget reduction context, even if it was to avoid even more drastic reductions, it was perceived by many as a kind of penalty, a breach of confidence between DND and its scientists, or as some scientists did put it, that the government was trying to have its cake and eat it. Moreover, the negative reaction of many of our military clients when they were charged for services not covered by the service level agreement between DRDC and DND exacerbated the problem. It took some time to pass the message that DND was not paying the whole salary wage envelope of the DRDC anymore, and that DRDC was not trying to get a "double-pay" for its services. These negative reactions from the employees and the military clients were mostly directed at the "contracting-in" aspect of revenue generation, as there were little or no objection to the exploitation of intellectual property and the excess capacity of the facilities. There were no noticeable objection from industry, and many of them actually began to use DRDC's services.

Most of the foreign defence R&D organizations reviewed for this paper are now encouraged to generate revenue from the exploitation of their intellectual properties and the sale of their facilities excess capacities to their national industry. In that regard, DRDC is not different from DSTO, DERA-DSTL or the US laboratories. All of them, like DRDC also have an obligation to avoid competing with their national industries. Where DRDC is different, though, is in the fact that it has an obligation to generate a portion of its SWE from revenue generation, while the number of its employees is still controlled by the department. In Australia, DSTO also conducts

independent research for industry, although to the knowledge of the author at the time of writing this paper, it has no revenue generation target. In the UK, while DERA had a significant external revenue generation objective (£165M out of a £1032M budget in 2001)[62], after the split of DERA into DSTL and QinetiQ, DSTL, as the MoD-retained part of DERA is not expected to accept contract from the private sector. In fact, it must now obtain an authorization from the MoD to do so[63].

DISCUSSION/RECOMMANDATIONS

To achieve this mission, DRDC has the smallest budget of the ABCA countries, no matter how it is presented and the smallest R&D organisation. While the result of the ASD review has left DRDC a much-improved organisation, it still must confront serious challenges in the coming years. Indeed, DRDC faces a situation where its functioning budget is insufficient to adequately support its workforce and an infrastructure that is rusting out at a disquieting pace. Moreover, staff reduction have brought several of its technologies dangerously close to the critical mass threshold, and unless immediate action is taken to correct the situation, valuable expertise will soon be lost when our ageing workforce retires. In the absence of recruitment during the last decade, because of hiring freeze and staff reduction, “la relève” does not exist within the agency.

[62] “DERA Annual Report 2001”
[63] “DSTL is part of the Ministry of Defence”, PowerPoint presentation, [DSTL], April 2002, slide 77

In the recent years, DRDC has not been inactive and has done its homework in preparing to face these challenges. First, in developing its Technology Investment Strategy[64] (TIS) in accordance to Defence Strategy 2020, it has defined the various technologies that will be needed by DND over the next decade to meet the technology challenges of the 2020's and beyond. The TIS also identifies those technologies that will require additional investments (growth technologies) and those in which the investment is considered adequate. A recruitment strategy based on various growth scenarios was also developed by the agency. The scope of the growth scenarios goes from the status quo with 60 positions being reassigned from overhead to R&D through reorganization, to an additional 300 employees. The agency has also created a rejuvenation fund to allow the anticipated replacement of those scientists close to retirement. So far, the agency has been awarded 82 new positions by DND, to be staffed by April 2002. In addition, DRDC has reviewed the state of its infrastructure and submitted a number of projects to renew it. The required funding is estimated at $200M. The state of the infrastructure may also have a detrimental effect on our ability to recruit and retain scientific personnel. Indeed, it is recognised that an above average environment would help attract the much-needed young scientists, while obsolete equipment and buildings in constant need of repair is a most frequently mentioned demotivator amongst scientists[65].

However, the best strategy will be totally useless if proper resources are not provided to RDDC. Even the most optimistic presented in the TIS, i.e. 300 additional

[64] "Technology Investment Strategy, For the next two decades", Defence R&D Canada

employees, would still leave us with a relatively small workforce compared to our most important international partners. So, while increased funding is absolutely essential to improve DRDC's situation, additional initiatives must also be considered.

First, it is time for DRDC to reconsider its 50% out-sourcing policy, as it cannot alone support the Canadian defence industrial R&D with its limited resources. DRDC being a knowledge-based organisation needs to put a priority on developing its in-house expertise if it wants to maintain the wide technology base required by DND and the Canadian Forces. By developing outside expertise at the expense of its own workforce and infrastructure, ADM S&T risks to compromise its ability to act as a knowledgeable and independent advisor to the Department of National Defence. In the 1999 CRAD ASD study report, it is concluded:

"*The R&D organisation can no longer rely solely on contracting-out to industry, universities and other government departments as a mean of supplementing its in-house capabilities. Not only has the contracting budget decreased, but there are no longer sufficient resources to manage and apply the work conducted externally. The R&D Branch must now forge new relationships with its partners, especially industry.*"[66]

[65] "R&D Productivity, an investigation in ways to improve productivity in technology-based organizations", second edition, Hughes Aircraft Company, 1978, p. 8, and 9.
[66] "Defence Research and Development: A Framework for the Future", Report by the DRDB ASD Team, April 1999, p. 6

A true cooperation approach, as the one adopted by Australia, would be much more suitable for the Canadian situation. First, like Australia, Canada does not have a very large defence industry and many of our defence systems are bought outside Canada. Secondly, this might help to reverse a trend that Prof. Andrew Richter, a defence expert from the University of Windsor (quoted in the Toronto Star[67]) sees as a fundamental problem in Canada, that is *"the puny research and development effort by Canadian industry*". A few Canadian defence industries have expressed an interest to increase their R&D investment and to enter into joint projects with DRDC. This is however conditional to the existence of a market, i.e., a commitment by DND to acquire the end products if they meet the stated requirements. Recent examples of success are the pyrophoric flare and the VIRSS grenade developed at RDDC Valcartier, where BAL Ltd and SNC TEC took over the development and invested in the projects because there were reasonable assurances of a Canadian market. In 2001, SNC IT was even willing to create a joint pyrotechnics R&D group with RDDC Valcartier (then DREV), and to invest in the refurbishing of the DREV facility.

The approach to revenue generation must also be reviewed. First, DRDC SWE should be entirely born by DND. It must also be realized that all technologies do not have the same potential on the market. For example, some are too risky from a business point of view to attract the private sector; some do not have dual use; others are well developed in the private sector, and are therefore out-of-bound for DRDC. While revenue generation should be considered as an opportunity for the technologies that have a market, the others should not be penalized or feel forced into hopeless

[67] "'Boffins' lead charge in defence research", Peter Calamai, The Toronto Star, January 27, 2002

marketing. On the other hand, to encourage the scientists to exploit this opportunity, there should be substantial benefits or advantages accrued to those research programs that develop a revenue generation market.

Revenue generation is still a relatively new concept within DRDC, and its operating parameters need to be refined and better understood. On occasion, certain contracts were signed which were competing with existing private companies (in the opinion of the author), and others which were perceived by the Canadian Forces clients as compromising DRDC's independence vis-à-vis defence contractors. While those were isolated incidents, certain rules should be implemented to avoid mission drift, to ensure that conflict of interest real or perceived do no compromise DRDC's ability to act as independent advisor to DND, and that serving DND remains DRDC's main raison d'etre. These rules should be well publicized within DRDC, but also within DND and the Canadian defence industry. In addition to the already existing parameters for accepting contractual work, the following are suggested:

1. No commercial work from a defence contractor shall be accepted without the authorization of DND or the CF client(s).
2. DRDC shall not accept sub-contracts from commercial contractors for work that is part of a DND contract to this commercial contractor.
3. For any given technology, the work done for DND must always represent more than 50% of the activities.

CONCLUSION

In a time where technology dominates the battlefield and the economy, Canada has the smallest investment in defence R&D among its closest allies, be it in absolute value, in percentage of its defence budget or in dollar spent per citizens. Canada also has the smallest defence R&D organisation in term of workforce, about the same as the Netherlands. It also spends the largest percentage of its defence R&D budget on outsourcing (USA excluded).

It is the author's belief that Canada has reduced its Defence R&D spending to an unsustainable level that in the long term will make it extremely difficult for the Canadian Forces and the Department of National Defence to fully exploit the military potential of technology. This in turn may limit the ability of the Canadian Forces to fully participate in coalition operations in the future. It also has the potential to limit DRDC's ability to participate fully in international forums and to leverage the defence R&D investments of our allies, and will eventually deny the Canadian Defence industry its fair share of the international market and put in jeopardy their already limited ability to respond to the needs of the domestic market.

If DRDC is to meet all the objectives of its current mission, including the objective of contributing to the national wealth generation, the government will have to substantially raise its defence R&D investment to a level compatible to that of its allies and economic partners, and DND will have to commit to buy Canadian

developed products, at least in selected industrial niche areas. In the short to mid term, as a significant budget increase seems unlikely, the alternate solution is to reduce DRDC's present commitment to spend half of its budget on out-sourcing, to increase in-house spending on personnel and infrastructure, and to rely on collaboration agreements instead of contracting-out to support industry, by sharing expertise and transferring knowledge and intellectual property (the Australian model). This would allow DRDC to rebuild and rejuvenate its workforce, and would prevent further rusting-out of its infrastructure and equipment. However, a major investment in infrastructure (about $200M) would still be required to compensate for years of neglect.

Otherwise, DRDC will have no other choice than to reduce the breadth of it S&T portfolio, to achieve critical mass and excellence in a limited number of technologies.

«If you try to predict what will happen in the future, say in 30 years from now, and it looks like science-fiction, it may be wrong; but if it does not look like science-fiction, it is certainly wrong.»

Peterson, Foresight Institute
(Free retranslation from French translation)

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