DEFENCE R&D DÉFENSE

Defence Research and Development Branch

Annual Report

1998 · 1999

Canada

Foreword

It gives me considerable pleasure to present this Annual Report of the Defence Research and Development Branch, covering the Branch's activities during fiscal year 1998/99. This document is a milestone in the Branch's evolution, in that it is our first annual performance report, presented in a comprehensive yet succinct fashion for the benefit of our clients, staff and stakeholders.

This report is a critical element in our accountability framework. Its purpose is to show our clients how well we have performed relative to the targets set out in our business plan and Service Level Agreements, using a combination of quantitative data and qualitative information. Its preparation has been influenced significantly by the Branch's upcoming conversion to an Agency and our associated commitment to operate in a more business-like manner.

We do not pretend that we have found the ideal in terms of the structure of this report or its level of detail. Nevertheless, I believe that it provides a satisfactory and objective presentation of our achievements during fiscal year 1998/99. Furthermore, I believe that the report demonstrates that we have made good progress on many fronts during the review period. I am pleased to note that:

- We have solid evidence that our R&D programs deliver valuable products and services to our Client Groups in DND and the Canadian Forces.
- We have good reason to be satisfied with our performance on Corporate Objectives. We have met or exceeded all the targets that were set for 1998/99.
- Our success rate on Client Group Major Initiatives is fully satisfactory.
- The Client Satisfaction Survey that we have just completed shows that our Client Groups generally regard us favourably. They consider our work to be of high value, and they are very pleased with the quality of our staff.
- We have a good record of achievement in technology transfer.
- We are making good progress on enhancing our national and international partnerships.

The report also shows that there are areas in which we should make substantial improvements, notably milestone delivery, and we are taking the necessary measures.

The success of an R&D organization depends fundamentally on the competence, dedication and diligence of its people. I commend the Branch's staff for their excellent performance during challenging times. I also extend my sincere appreciation to our clients for their active involvement in our R&D programs. I fully expect that this mutually beneficial relationship will continue, indeed strengthen, after the Branch achieves Agency status.

L.J. Leggat
Chief Research and Development

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Our Vision

As Canada's lead defence science and technology organization, the Defence Research and Development Branch will provide science and technology leadership to the Department, the Canadian Forces and the Canadian defence industrial base into and through the 21st century.

Our Mission

As the national authority for providing S&T leadership in the advancement and maintenance of Canada's defence capabilities, the Defence Research and Development Branch:

- Facilitates and enhances the ability of decision makers to make informed decisions on defence policy, force generation, and procurement by providing expert S&T knowledge;
- Contributes to the success of military operations by pursuing R&D activities that provide improved support, knowledge, protection, and response to potential threats;
- Enhances the preparedness of the Canadian Forces by assessing technology trends, threats and opportunities, and by exploiting emerging technologies;
- Supports government objectives by contributing to the creation and maintenance of a Canadian defence S&T industrial capability that is internationally competitive.

1 Branch overview

The Defence Research and Development Branch (DRDB) consists of a headquarters, located in Ottawa, and five Defence Research Establishments (DREs):

- Defence Research Establishment Atlantic (DREA), in Halifax, performs R&D in undersea warfare, naval platform technology and naval command and control.
- Defence Research Establishment Valcartier (DREV), near Quebec City, is the main centre for R&D related to weapon systems, electro-optics and command and control information systems.
- Defence Research Establishment Ottawa (DREO) is responsible for R&D in electronic warfare, radar, space systems and telecommunications.
- Defence and Civil Institute of Environmental Medicine (DCIEM), in Toronto, conducts R&D in human performance, simulation and training, and life support systems.
- Defence Research Establishment Suffield, in south-eastern Alberta, carries out R&D in chemical and biological defence, military engineering and tactical vehicle systems.

Table 1 provides further detail on the scientific capabilities of the DREs. Table 2 gives a resource summary for the Branch.

This report is concerned with DRDB's performance in fiscal year 1998/99. It begins by highlighting major achievements. Next, progress is noted on nine Corporate Objectives that were formulated in 1998. The Branch's performance in executing the R&D programs for its five Client Groups is assessed, using such information and metrics as progress on major initiatives and success rate in delivery against agreed milestones, as well as key findings from a recently-completed Client Satisfaction Survey. Collaboration with national and international partners is discussed, followed by presentation of indicators of excellence in science. Progress is noted on key initiatives in corporate affairs, including human resource issues, administration and infrastructure. The report concludes with some observations on the Branch's performance in 1998/99.

2 Highlights

We shall begin by describing some of the major achievements arising from the R&D programs for our five Client Groups. Note that we have arbitrarily restricted ourselves herein to an average of ten highlights for each Client Group – we have not attempted to provide a comprehensive list. We conclude this chapter with some corporate highlights.

Maritime Program

The successful completion of the CA/UK Low-Frequency Active (LFA) Sonar trial in 1998 represented a major step forward in Canadian sonar technology. The trial provided an opportunity for naval and maritime air staffs to experience first hand the potential impact that LFA systems will have on future ASW operations. The trial also provided proof of the impressive detection performance achievable through air-based multi-static sonar working in close co-operation with LFA sonar-equipped ships.

DRDB's concept of performing a seabed survey using a towed side-scan sonar, recording the images, and then comparing these with images obtained after mines have been laid, has been incorporated as part of Canada's new mine hunting strategy. This will enable the CF to detect mines in areas with two orders of magnitude greater clutter than with conventional systems. The route surveying and data analysis facilities are now being delivered for the Maritime Coastal Defence Vessels.

The passive localization assistant (PLA) was developed by DRDB to assist operators in performing target motion analysis on submarines. Incorporation of the PLA in CANTASS (Canadian Towed Array Sonar System) has recently been approved.

Under the CANEWS 2 Shipboard ESM development project, work has been completed on the development and trials of a user-friendly Operator Interface for the system. This achievement involved evaluation by a number of EW operators in a laboratory setting, followed by subsequent performance confirmation during a series of shipboard trials of the CANEWS 2 Interim ADM. The final version was widely praised for its clear portrayal of varied and complex operational information.

SHipboard INternal COMmunication (SHINCOM) II Phase 1 was successfully completed. The product of this phase was a modernized, voice only but data compatible, SHINCOM II ADM, which can be taken to production and fitted on any class of warship. Phase 2, which uses the ADM as a test bed to develop a SHINCOM II multi-media communications capability, started in Oct 98. Current

Navy plans call for the production version of the SHINCOM II ADM to be installed in the HALIFAX Class, along with any multi-media capabilities developed in Phase 2 that are mature enough to bring into production in the 2001/02 time frame.

The Improved Ship Structural Maintenance Management (ISSMM) Project is developing a comprehensive suite of ship structural and material information and engineering analysis models, integrated into a user-friendly shell. When complete, this suite will reduce the time required for finite element analysis of damaged ship structures from several months to typically one day.

The Integrated Multi-static Passive/Active Concept Testbed (IMPACT) was developed by DRDB to demonstrate new concepts for airborne sonar in a semi-operational setting. Recently IMPACT has served as a model for the Wide Area Subsurface Surveillance (WASS) system being developed for the Aurora. The existing Aurora processor will soon be replaced by IVASP (Interim VME Acoustic Signal Processor). Not only is the IVASP spec based largely on IMPACT, but its introduction to service is being expedited because of confidence gained during the development of IMPACT and WASS.

A significant collaborative activity has been established with the Netherlands, building on the SIRIUS and APAR joint development projects and our common AWW sensor suite plans. Specifically, the two countries have exchanged knowledge on how to improve the C2 systems of future ships through the implementation of data fusion technology. Other opportunities for collaboration are being explored. The collaboration to date has enabled us to leverage our resources in this area by a factor of two.

As part of its research effort on non-cooperative target recognition (NCTR) under the Maritime Radar Project, DRDB's participation in a NATO Task Group led to the acquisition for Canada of a real-time database of high resolution radar target signatures, with ground-truthing for aspect angle determination, using several different radar systems. The resulting savings in time, effort and trials costs will significantly accelerate our own program of algorithm development for NCTR, which has already shown considerable success in internationally sponsored comparative tests.

DRDB's software model for predicting the infrared signature of ships (SHIPIR) has been adopted by the US Navy, which has also provided funds to validate and improve the model. NATO accreditation is expected in December 1999

The final version of the CANEWS 2 ADM was widely praised for its clear portrayal of varied and complex operational information.

Land Program

A new physical training plan was developed that provides equivalent levels of performance in significantly reduced time, in comparison with current practice. This will permit the army to make substantial reductions in training costs, with no loss in capability.

A compact package of EW analysis software was developed for deployment in Operation Palladium (CF operations in Bosnia). This package was based on a software suite developed by DREO for the Canadian Electronic Warfare Operations Centre.

One garrison and two deployable suites of the Joint Intelligence Information Management System (JIIMS) were released to 1 Canadian Division. Another suite was subsequently provided to DG Intelligence personnel at NDHQ. JIIMS is a document management system designed at DREV to meet the specific requirements of intelligence operations. It should form the basis for future intelligence analysis tools and is a step towards effective knowledge management in the army intelligence community.

3600 copies of Version 2 of the Electronic Battle Box (EBB) were delivered to the army. The EBB is an integrated suite of planning and decision aid tools specially designed at DREV to help staff officers in training and operations. It is a result of a collaborative effort among DRDB, DLR, DAD, 1 Canadian Division and industry. In training exercises, the EBB has been shown to reduce the time required for certain planning activities by a factor of six.

The JIIMS document management system should form the basis for future intelligence analysis tools and is a step towards effective knowledge management in the army intelligence community.

DREV completed its participation in the NATO Data Fusion Demonstrator Project, a large multi-national collaborative project in which two sets of advanced automatic fusion algorithms were successfully tested and evaluated by experienced military officers. The results will be used in the Land Intelligence and Electronic Warfare Automation Project.

Fragmentation vests, breast plates, visors, goggles and the combat vehicle crew helmet were tested in support of the Clothe the Soldier Project, and specifications were produced for four sub-projects.

Results of the work on mine-blast hardening of wheeled vehicles were incorporated into the Heavy Engineering Support Vehicle Project.

Studies in firepower and defensive aids suites were conducted to support the development of the Statement of Requirements for the Armoured Combat Vehicle Project.

Technology to improve the survivability of Armoured Fighting Vehicles was transferred to the Diesel Division of General Motors and has been incorporated into the design of Light Armoured Vehicle (LAV) III.

Three DRES designs of high performance explosively formed projectiles (EFPs) were demonstrated during an international trial in August 1998. EFP's from the US, UK, Australia and Canada were tested and compared. The Canadian projectiles demonstrated the best performance.

The concept of an integrated sensor-to-commander Intelligence Surveillance Target Acquisition and Reconnaissance system, integrating the LAV Reconnaissance Enhanced Surveillance Demonstrator with a sniper detection system and featuring sensor stabilization and advanced image processing, was demonstrated by DREV to the Permanent Joint Board on Defence.

Technology from the Improved Landmine Detection (ILD) Project was transferred to Computing Devices Canada (CDC). Furthermore, the Branch supported CDC in demonstrating the ILD system in the US Vehicle Mounted Mine Detection evaluation. The ILD system came in, or tied for, first in all categories in this competition against US-sponsored contractors.

Air Program

In collaboration with Canadian Forces Electronic Warfare Centre, an IR seeker field test facility was developed and demonstrated in pyrophoric decoy flare trials at the Aerospace Engineering Test Establishment in November 1998. This facility provides the capability to measure the signature of air platforms against IR threats and to measure the effectiveness of countermeasures. It is an essential complement to simulation by permitting the validation and calibration of engagement simulations.

Significant progress has been made toward more effective use of simulation in the Air Force. DRDB scientists have contributed to the development of an Air Force concept paper on simulation. DRDB scientists have continued to exploit collaborative arrangements to improve the CF's simulation capabilities; as an example, a software simulation of an active Pulse Doppler air-to-air missile seeker has been acquired from the UK under NATO auspices.

A successful demonstration of a modest Distributed Interactive Simulation of the EW function in a tactical air mission system was conducted in March 99. In this demonstration, DREV's missile engagement simulator was connected with the Missile Approach Warning System (MAWS) in the Air Crewstation Demonstrator (ACD) located at Canadian Marconi, Kanata using High Level Architecture. This project

The new STING anti-G suit provides the most significant advance in Gz protection for the Air Force since the Mk VI suit design in 1944.

demonstrated the feasibility of connecting the two simulations and feeding remote MAWS declarations to the ACD. This was a very practical demonstration to senior operational staff of the benefit of simulation in requirements definition and validation.

The development of a new computer performance model for AIM 7 and AIM 9 air-to-air missiles was completed and transferred to the CF-18 contractor, Bombardier. This provides the Air Force, via the Software Engineering Support Centre (SESC), a state-of-the-art software model to support air operational studies. The SESC capability will continue to include the latest upgrade characteristics of air-to-air models as they are developed by DRDB.

Orenda Aerospace, supported by NRC's Institute for Aerospace Research, has completed the Gas Turbine Repair major development project with the implementation of repair procedures for the F404 engine of the CF-18. It produced a Qualification Methodology for Airworthiness Certification, and also a Failure Modes, Effects and Criticality Analysis (FMECA) software package. The Qualification Methodology is applicable to all CF aero-engines and is being integrated into the Airworthiness Renewal program. The FMECA is directly applicable to other powerplants, and can be readily converted for use on other aircraft systems. A cost benefit analysis showed direct savings of $18M as a result of this $4M project, with potential savings of $60M over 15 years.

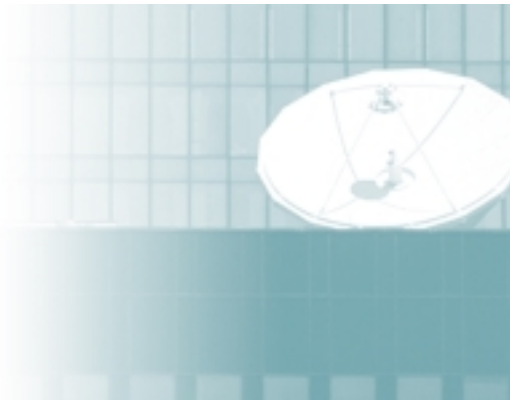
CF-18 squadrons received the new STING anti-G suit, providing the most significant advance in Gz protection for the Air Force since the Mk VI suit design in 1944. The STING anti-G suit combines improved protection with practicality, resulting in high user acceptability. Human centrifuge tests and in-flight evaluations have demonstrated that this suit will significantly reduce the risk of G-induced loss of consciousness. CF-18 pilots in the Balkans are wearing the STING G-suit. The complete STING ensemble includes a modified oxygen regulator for positive pressure breathing. This component, with its upper body pressure vest, is expected to undergo operational evaluation in 1999.

Pilots' tolerance to Gz stress is reduced by preceding hypogravity exposure. A micro-processor-controlled anti-G valve would restore tolerance by pressurizing the G-suit to higher levels when this Gz sequence occurs. Since substantial research in human centrifuges must be carried out to define the performance requirements of such an anti-G valve, an in-flight investigation was conducted to assess the suitability of the centrifuge as a simulator of G transition. In a landmark study, AETE and DRDB collaborated to make physiological measurements on the rear seat passenger in a fully instrumented CF-18 flying 40 missions, demonstrating proof for the existence of the push-pull phenomenon.

Spatial disorientation (SD) and G-induced loss of consciousness continue to be two of the most life-threatening aeromedical problems in flight. Recent studies of mishap flight profiles and laboratory experiments strongly suggest a direct influence of the body's vestibular system on cardiovascular compensation during G transition stress. Findings are integrated into models of the human response to aviation stresses. Recommendations to improve current SD training curricula in the CF have been completed. Significant progress has been made to implement the GYRO Integrated Physiological Trainer for undergraduate pilot disorientation training at the CF School of Aeromedical Training.

Under Handling Qualities Requirements for Military Rotorcraft, a horizontal tracking device has been built and installed in NRC's Flight Research Laboratory to simulate the ship flight deck landing environment. NRC participated in the development of the aeronautical design standard by conducting a trial to determine the impact of an under-slung load on helicopter handling qualities.

Command and Control Information Systems Program



The Military Satellite Communications groups at DREO and CRC have successfully developed ground terminal and payload simulators to examine downlink and uplink synchronization aspects of EHF on-board processing Satcom. A low rate data link anti-jam standard was developed for a frequency hopping waveform compatible for experimentation using a transponding satellite. Trials were carried out over the UK's Skynet 4A EHF transponder, made possible through a memorandum of understanding established under TTCP.

The Joint Warrior Interactive Demonstration (JWID) 97 had highlighted a number of advanced technologies, including previous work on CSNI (Communications Systems Network Interoperability). JWID 98 featured an even more capable networking platform. The networking and advanced application software was tailored to the Navy's requirements and enabled the CF to participate as a part of the Multi-national Naval Task Group. A recognized highlight of JWID 98 is that Canada provided, for the first time, a Global Broadcast Service using Satcom and ISDN (Integrated Systems Digital Network) to four participants (CA, UK, US and New Zealand). Also provided for the first time was Inmarsat high-speed data (64 kbps) to/from a Canadian frigate. Following JWID 98, the Canadian Navy conducted a successful "at-sea" trial of this technology.

A PC software based secure telephone was developed and tested. The unit integrates 2400 bps digital voice and Entrust security protocols, and is designed to operate over dial-up internet protocol based networks. The system is a low cost alternative to secure telephone units in current use.

In conjunction with NDHQ and MARLANT staff, the Branch successfully demonstrated the functionality of the Ocean Monitoring Workstation and the Operational Digital Imagery Navigator. In trials during MARCOT 98 and another later in the year, the systems demonstrated the utility of computer-assisted techniques for target detection and recognition, using surveillance data from a variety of sources.

The potential operational utility of hyperspectral sensors was assessed and reported to numerous CF clients. Using several new techniques, it is possible to detect targets that might otherwise remain concealed. Applications include the detection and classification of land and maritime targets against a variety of clutter backgrounds. This initial work will form the basis for an extended R&D program aimed at providing tools or techniques for operational users.

In collaboration with NRC and the Centre for Research in Earth and Space Technology, a space-qualified package was designed, fabricated, and delivered to the US Air Force Research Laboratory at Kirtland AFB, NM. The set of 12 quantum-well infrared photodetectors (QWIPs) will be deployed on a UK microsatellite in early 2000 in a harsh radiation environment. Half of the devices will be exposed while the others will be shielded in a standard fashion. QWIPs have several potential applications, including the detection of ballistic missiles and aircraft, but their performance in the space environment is not well understood.

Ships and aircraft have been detected out to 450 km with HF Surface Wave Radars.

A 100 MW high power microwave source was developed with the help of the NRC. A preliminary study on the explosive generation of electromagnetic pulse has been completed. A study on the on the use of energy bounds for the prediction of coupling to structures with apertures was also completed. A significant improvement was made in the electromagnetic models of the CPF. Requirements for obtaining reliable Inverse Synthetic Aperture Radar profiles from measured radar cross section data were established.

IRONMAN, a software system for monitoring information network security, was completed and demonstrated at the Defence Evaluation and Research Agency in the UK, the Physics and Electronics Laboratory in the Netherlands and at the Air Force Research Laboratory in the US. There was significant interest in further collaboration among the nations. Initial collaboration will be among the US, CA and Australia under TTCP. A major enhancement to IRONMAN was initiated.

Results from the two HF Surface Wave Radars, built to demonstrate the technology in a coastal surveillance role, show that their performance is close to design. Ships have been detected out to 450 km and have been continuously tracked in real time for periods in excess of nine hours. Aircraft have been detected at 450 km and tracked almost continuously through the coverage area of the radars. The radars' accuracy is well within specifications, and they have operated continuously for periods in excess of 24 hours.

Human Performance Program

Development continued of the field portable Canadian Integrated Biochemical Agent Detection System (CIBADS). Phase 2 (CB Sentry), which was dedicated to real-time detection of CB agents, has been completed, and Phase 3 (CB Ident), which seeks to develop near real-time identification of CB agents, is well underway. A prototype CB Sentry was deployed during Operation Determination onboard HMCS Toronto, and as a result of its success, several allied countries (UK, Germany, France) have expressed interest in purchasing detection units. In 1998, the CB Sentry out-performed American instruments in trials at the Dugway Proving Ground in Utah.

User acceptability trials with army and navy personnel of a hot environment CB suit were concluded. Following acceptability trials by air force personnel, the results will migrate to the Hot Weather Chemical Warfare Garment capital acquisition project.

A novel animal model has been developed to simulate and improve medical management of combined casualties in an operating room setting. The first result is suggested anaesthetic protocols for chemical casualties requiring surgery. Continuing work will determine treatment protocols for individuals requiring further treatment for nerve agent exposure.

In 1998, the CB Sentry out-performed American instruments in trials at the Dugway Proving Ground in Utah.

The effectiveness of liposome-encapsulated form of the antibiotic ciprofloxacin has been demonstrated against two BW threat agents, plague and tularaemia. The long-term impact of this work will be seen in: reduction of the dose required to establish effective protection, decrease in the time to reach effective concentration within the body, and change in the route of drug administration (aerosol puffer vice pill or injection).

A TTCP effort led by DCIEM resulted in the completion of a computerized database for ergogenic aids, i.e. drugs, nutritional supplements and physiological strategies that acutely enhance performance. For example, a combination of caffeine and ephedrine provides acute enhancement of physical performance with no negative effects in a hot environment or on marksmanship. This project was awarded a TTCP Achievement Award because of its operational relevance to combat personnel.

In collaboration with academia, an advanced anti-microbial coating process was developed to reduce the development of bacterial biofilm formation on surgical catheters and to improve the drug-release and non-adhesive properties of novel wound dressings. A patent on the intellectual property associated with this development is pending, and negotiations are in process for technology transfer to industry.

A serological survey of personnel deployed to Haiti was completed. The aim of the study was to define the true risk of tropical disease to soldiers deployed to the region. The results support the practice of vaccination for hepatitis A prior to deployment to the tropics. Since no significant risk for infection with strongyloides, *Helicobacter pylori* or hepatitis E was found, pre-deployment prophylaxis for these organisms is not indicated.

An occupational exposure study of CF indoor firing ranges was conducted to provide a thorough assessment of ventilation, toxic gas exposure level, and maintenance standards. A document "Working Guidelines for Evaluation of CF Indoor Firing Ranges" was published.

The Hi-Fidelity Sea King, a state-of-the-art simulator, uses a high resolution fibre-optic head-mounted display.

The exploratory development of a Hi-Fidelity Sea King simulator was completed under contract with the University of Toronto Institute for Aerospace Studies. This state-of-the-art simulator makes use of a high resolution, fibre-optic head-mounted display. A study of the effectiveness of the simulator was completed, and the results indicate that this approach is valid. The exploratory development of a second, much cheaper, Hi-Fidelity Helicopter Deck Landing Simulator that makes use of commercial off-the-shelf components was also completed at DCIEM. It provides a stereoscopic view of the virtual environment. The validity of this device is now being established.

A major week-long NATO workshop hosted by Canada brought senior military personnel together with human factors (HF) research specialists and operational commanders to examine poorly understood Human Aspects of Command and to discuss critical HF issues such as authority, responsibility, accountability, trust, confidence, decision-making, and leadership. This workshop generated an international research agenda and, as a result of participant reaction, will be held at regular intervals in the future, hosted by other NATO members.

Experimental Diving Unit personnel at DCIEM continued to provide their expertise for forensic accident investigations, including several civil diving fatality investigations for various government departments and significant support to the effort involving the Swiss Air 111 crash. A CF Divers' Stabilization Jacket technical statement of requirements was successfully completed; this is the first major re-configuration of the standard CF diving outfit in 30 years.

Corporate Highlights

50th Anniversary

The R&D Branch reached the half-century mark in 1998/99. In celebration of this milestone, a booklet was published outlining the Branch's many achievements over the years. Also, several commemorative activities were staged to acknowledge the contributions of past and present employees and to increase the Branch's visibility in the research and development community.

The Canadian Centre for Mine-Action Technologies

The R&D Branch provides critical support to the federal government's Mine Action Initiative through the Canadian Centre for Mine-Action Technologies (CCMAT) at DRES. With an initial investment of $17M over five years, CCMAT will help to promote global support for the International Landmine Treaty and develop critical new technologies in humanitarian demining.

The Centre brings together members of the CF, DRDB, industry and non-government organizations to work on new solutions for demining. Among the technologies currently being developed are: multi-sensor hand-held mine detector, mechanical assistance to demining, protective clothing and equipment for deminers, antipersonnel landmine blast characterization, prosthetic foot devices and post trauma infection control.

CCMAT will also participate in an International Test/Assessment Program to evaluate new technologies for humanitarian demining. In 1999, a team travelled to Cambodia to evaluate an instrumented prodder developed at DRES, the results of which are currently being used to improve production design.

Alternative Service Delivery (ASD) Review of the Branch

The ASD Review was launched in September 1997. The Screening Phase was completed in February 1998 and the Analysis Phase in June 1998. The culmination of the latter was approval by the Defence Management Committee (DMC) of the recommendation to move into the Development Phase, focussing on the option of a Statutory Agency. As part of its approval, DMC directed that the ASD Review be elevated to a Departmental project to reflect the broad impact that the outcome would have on DND and the Canadian Forces. The Review came under the direction of the Vice Chief of Defence Staff, with the Deputy Minister and Chief of Defence Staff as Executive Authorities.

In the Development Phase, the focus was on developing a framework for the Statutory Agency and providing detailed information on the benefits, risks and costs of conversion to the Agency. The results of this work were documented in a business case for presentation to DMC. The business case showed that with management authorities based on best S&T practices in partnering, funding, human resource management and visibility, together with the flexibility to institute business and management practices tailored to the scientific environment, the Agency will be a much stronger and more capable organization that will deliver significantly greater return on DND's R&D investment.

On this particular subject, it is useful to step outside the bounds of FY 1998/99 and take note of a few key events that occurred subsequently, in order to present a more complete picture.

A business case showed that with management authorities based on best S&T practices, the Agency will be a much stronger and more capable organization.

- The above-noted business case was presented to DMC on 13 May 1999. It received support in principle, but timing in the current government cycle and departmental priorities gave rise to serious doubts as to whether legislation to establish the Agency could be passed in a timely manner. DRDB was directed to undertake a short study to determine what authorities could be delegated to the Agency without invoking legislation.
- During the month following the DMC meeting, extensive consultations were conducted with officials in DND and central agencies. It was determined that in all key areas except Human Resource management, the Department can delegate the authorities that the Agency needs. The findings were documented in a report that was submitted at the end of June.
- On 5 July, the Deputy Minister approved the report's recommendations and directed CRAD to proceed with implementing the Agency, with an inauguration date of 1 April 2000. To achieve the necessary authorities and flexibilities in Human Resources, the Agency will seek Separate Employer status via an Order-in Council, with a target date of 1 April 2001 for commencement of operation as a Separate Employer.

Strategic S&T Issues

The past year has seen a high level of activity and progress on a number of strategic S&T issues, such as the Revolution in Military Affairs, our Technology Investment Strategy, our Human Resources strategy, and business development. These fall under the heading of Corporate Objectives and are reported in the next chapter.

3 Performance on Corporate Objectives

In 1998, senior management set nine Corporate Objectives for the Branch to accomplish by the end of fiscal year 1999/2000. Progress on these is noted below.

1. In partnership with the strategic planning element of the Department, to develop a Canadian position on the Revolution in Military Affairs.

The R&D Branch co-sponsored a symposium "Canadian Defence Beyond 2010" that brought together stakeholders from the Department, allied nations, universities and industry to discuss Canada's response to the RMA. This symposium and the resulting Concept Paper *Canadian Defence Beyond 2010: The Way Ahead* put forth several recommendations that together will help prepare the Canadian defence community for the RMA-age.

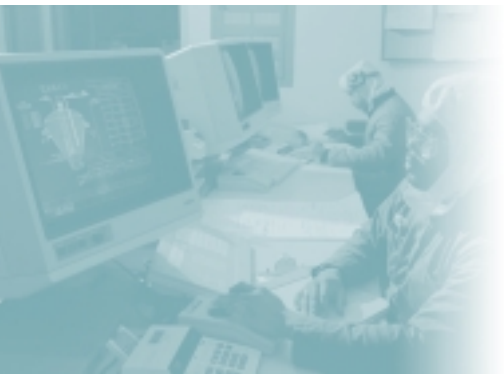
Selected R&D-focused Recommendations for a Way Ahead in RMA

- Establish a joint experimentation facility with greater use of technology demonstration and a robust modelling and simulation capability.
- Initiate closer collaboration with the United States, particularly with their new Battlelab responsible for Joint Experimentation.
- Establish a national infrastructure vulnerability centre with DND, industry and other government departments to co-ordinate Canada's response to asymmetric threats.
- Ensure that the future S&T program is closely integrated with the Department's objectives and goals. Co-ordinate doctrine, organization and technology to achieve the desired level of interoperability.

2. To have at least 10 S&T initiatives/products developed by the Branch adopted for implementation by the CF.

Ten such "products" are noted below.

- The concept of performing a seabed survey using a towed side-scan sonar, recording the images and then comparing these with images obtained after mines have been laid, has been incorporated as part of Canada's new mine hunting strategy.
- The Space System Concepts and Technologies project has supported DND's Joint Space Project by developing new concepts, techniques and technologies for military space-based surveillance and earth observation systems and applications.
- Canadian Forces Nuclear, Biological and Chemical Response Team has been enhanced with the delivery of a new mobile nuclear laboratory which provides the only live agent training available in NATO countries.



- The Joint Intelligence Information Management System (JIIMS) was transferred to 1 Canadian Division. JIIMS is a document management system designed to meet the specific requirements of intelligence operations.
- The passive localization assistant will be incorporated in the Canadian Towed Array Sonar System (CANTASS) to assist operators in performing target motion analysis on submarines.
- The development of a new computer performance model for AIM 7 and AIM 9 air-to-air missiles provides the Air Force with a state-of-the-art software model to support air operational studies.
- A compact version of the software for the Canadian Electronic Warfare Operations Centre was developed for deployment with Operation Palladium.
- Several thousand copies of Version 2 of the Electronic Battle Box, an integrated suite of planning and decision aid tools specially designed to help staff officers in training and operations, were delivered to the army and are now being used in operations.
- HI-6, a nerve agent antidote developed under the Human Performance Program, is available for use by CF units deployed outside Canada.
- Phase 2, CB Sentry, of the development of CIBADS has been completed. CB Sentry performs real-time detection of CB agents.

3. To develop a Technology Investment Strategy that responds to the needs of the Department and the CF in 2020.

Last year we identified a set of 10 defence outcomes towards which the R&D program will be aimed. Based on these outcomes we have identified 21 areas of R&D activities (Table 3) that will be undertaken by the Branch, with support from our allies and our partners in Canadian industry and universities. The following areas will be targeted for investment growth over the next decade:

- Autonomous Intelligent Systems
- Emerging Materials and Bio-molecular Technologies
- Human Factors Engineering
- Information and Knowledge Management, and Decision Support
- Network Information Warfare
- Psychological Performance
- Signature Management
- Simulation and Modelling for Acquisition, Rehearsal and Training
- Space Systems

4. To initiate at least five new Technology Demonstration (TD) projects

The Branch has launched a Technology Demonstration Program to demonstrate and validate technological solutions to CF operational requirements. The Program also gives our partners the opportunity to evaluate and display the utility of technology insertion. Seven TD projects have been initiated.

• *Advanced Distributed Mission Training*

This project will demonstrate the potential of Distributed Mission Training (DMT) in mission rehearsal. Ultimately, this TD will be used for the evaluation of new operational and equipment concepts and will provide guidance for DMT-based acquisition to upgrade the baseline CF-18 Multi-Task Trainers.

• *Ground Moving Target Indication (GMTI) Surveillance*

This TD will modify the design of RADARSAT 2, Canada's remote sensing synthetic aperture radar, to add to an experimental GMTI mode and create the world's first space based radar with GMTI capabilities.

• *Command Decision Aids Technology*

This project will build on past and present R&D on Multi-Source Data Fusion and the Human Computer Interface to present the Maritime Tactical Picture to the operator in a more easily understood and meaningful way.

• *Common Operating Picture (COP)*

This tool set will contain up-to-date information, gathered from surveillance, intelligence and other sources, on the environment, the status of our adversaries and on our own allied forces. The COP will allow commanders to develop strategic, contingency and/or tactical plans and to monitor the execution of those plans.

• *High Capacity Tactical Communications Network*

This project will assess future tactical communications technologies and methods of adapting and exploiting these technologies, in order to assist the Land Forces in meeting its requirements for high capacity data and voice communication networks.

• *Future Armoured Vehicle System*

This initiative will determine whether advanced technologies will permit a light armoured vehicle to successfully fight and survive against main battle tanks on the future battlefield.

DRDB has launched a Technology Demonstration Program to demonstrate and validate technological solutions to CF operational requirements.

• *Tactical Aviation Mission System Simulation (TAMSS)*

This project will create an overall system simulation of the CF146 Griffon that links and focuses subsystem simulations being developed by the DREs, industry and allied nations. In addition, the TAMSS will develop and demonstrate an enhanced contribution of tactical aviation to the situational awareness of the Land Force Commander through a simulation exercise.

5. To establish a business development strategy that maximizes the benefits of defence R&D. Targets for 1999/2000 are to leverage $26M from external partners and to generate $3M from external sources.

The Branch has established Business Development Offices at headquarters and the DREs, and is on track to achieve or exceed these targets. In 1998/99, revenue was $3.66M and leveraging reached about $20M. See Chapter 5 for further details.

DRDB has taken a lead role in the federal government in implementing the government's HR strategies for its science workers.

6. Develop a clear and focussed Human Resources strategy consistent with the TB initiative on HR management in S&T and that addresses the issues raised in employee surveys.

During this review period, DRDB promulgated a human resources strategy that will support the Branch in recruiting, rejuvenating and maintaining a qualified workforce, while maintaining a working environment that fosters innovation, creativity, teamwork and individual initiative. The strategy is described in a document published in 1998, entitled "*Building the Future Together – a Road-map to the 21st Century*". A key element of this HR strategy is that from now on, human resource management activities will focus on all staff – their contribution, competencies, development, career management, training, rewards, recognition, and compensation packages. The first Director of R&D Strategic Human Resources at DRDB HQ was appointed in May 1998.

The strategies resulting from the above-noted Treasury Board initiative are mapped out in a "Blueprint", and CRAD is the ADM Champion for implementation of this Blueprint. Consequently, DRDB has taken on a lead role in the federal government in implementing the government's HR strategies for its science workers. Our participation in interdepartmental S&T Working Groups has been instrumental in bringing forward issues relating to the management of our workforce. For example, we played a key role in identifying issues relating to the adoption of the Universal Classification System and its impact on the management of the Defence Science occupational group. This includes the incumbent-based classification system, pay plan, promotion and level-based staffing.

7. Determine strategies for improving continuous learning opportunities that will provide the emerging competencies required by the Branch's strategic plan.

Unions and management have agreed that skills gap analysis will assist managers in focusing training to enable employees to meet current and future business requirements and to improve their employability. As a first step, DRDB endorsed competency-based management and proceeded with the development of competency profiles for the management cadre. DRDB also participated in the development of the federal S&T management competency profile. The full spectrum of competencies required by the Branch will be developed as part of the 2010 R&D Program road-map, in support of the Technology Investment Strategy.

8. Develop and refine the Branch's accountability and performance measurement framework and implement the program oversight function.

The accountability framework received much attention during the Development Phase of the ASD review, and will be defined in detail during the Implementation Phase. As to program oversight, a team was created in August 1998 to perform this function. Work has been completed on the program oversight framework, and significant progress has been made on formulating the concept and processes of the performance measurement system. This annual report is the first major product of the program oversight initiative.

9. Review our infrastructure requirements taking into account the strategic R&D plan developed by the Technology Assessment Working Group.

Infrastructure requirements and renewal were the subjects of detailed study under the ASD Review.

4 R&D for the Canadian Forces and National Defence

Over the last five years, the Branch and its five Client Groups have developed and implemented a formal framework and associated procedures to govern the formulation and delivery of the defence R&D program. Fundamental to this process are the Service Level Agreements negotiated annually with each CG, which include about half a dozen Major Initiatives per CG, as well as plans for the R&D Thrusts into which the program for each CG is "packaged". Currently, the R&D programs are delivered via a structure of 25 R&D Thrusts (average of five per CG). They are listed in Table 4, along with their fundamental objectives. The Service Level Agreements and supporting documents contain detailed plans for the Thrusts, with resources, schedules, milestones and deliverables described down to project level.

Estimated resources by Client Group and Thrust are depicted at Table 5. Civilian Full Time Equivalents (FTEs) and total expenditures are shown. The latter figures were obtained by summing expenditures on civilian salaries, operations and maintenance, R&D contracts and capital equipment. The salary figures are only rough estimates since salaries were not charged against Thrusts in the formal accounting system. Therefore, planned FTE's and average salaries were used to estimate salary expenditures.

In Chapter 2, we presented highlights arising over the past year from the R&D programs that we conduct for the five CGs. We shall now supplement this anecdotal information with a review of progress on CG Major Initiatives, statistics on delivery against agreed milestones and results of a Client Satisfaction Survey that we have just completed.

Major Initiatives

Maritime Program

New Way Ahead for Maritime C3I R&D

The Maritime R&D Overview Group approved a proposal to increase significantly the resources devoted to C3I. Most of the new resources (up to 15 new FTEs and substantially increased contracting funds) will be directed toward shipboard C2. Research on data fusion, decision support, human engineering and human factors will feed technology demonstrators in the laboratory and onboard ship.

Shipboard Integration of Sensors and Weapon Systems

To address the requirement for increased integration work, a Way Ahead Working Group has been formed to establish the future direction for the Above Water Warfare Thrust.

Planning for a new Technology Demonstration is underway. It will include computer-based simulation and hardware elements to investigate integration issues involving engagement radar, precision ESM, IRST, radar jammers, and IR countermeasure systems.

JMCIS-Based Sonar Information Management System

A Technology Investment Fund (TIF) project was approved to develop, evaluate and demonstrate decision-aids and data management tools for real-time use by tactical decision makers aboard naval ships, along with the development of integrated sonar system simulations to facilitate testing and evaluation of new techniques.

Warship Underwater Signature Reduction by Active Means

Work began on a TIF project to investigate the application of active noise reduction technologies to Canadian naval ships.

To address the requirement for increased integration work, a Way Ahead Working Group has been formed to establish the future direction for the Above Water Warfare Thrust.

Land Program

Land Intelligence and Electronic Warfare Analysis Technology Demonstration

A decision was taken to convert the Land Electronic Warfare Analysis System Advanced Development Project into the Land Intelligence and Electronic Warfare Technology Demonstration Project. The conversion was based on the Branch's strategic direction to emphasize technology demonstration, rather than equipment development, in order to support the full spectrum of client needs. During FY98/99, new project documentation was drafted, the project management structure was redefined, and approval-in-principle to proceed was granted by the Senior Review Board.

Combat Vehicle Systems Analysis

Studies were conducted on defensive aid suites and firepower concepts to support the Director of Land Requirements in producing the Statement of Requirement for project L2636, Armoured Combat Vehicle. This activity will be subsumed into the Future Armoured Vehicle Systems Technology Demonstration.

Novel Energetic Materials

Branch staff met twice to begin to map out a coherent energetic materials program at DRES and DREV that will ensure that the work at the two laboratories is forward looking and complementary rather than competitive or duplicative.

Air Program

Mission System Technology Demonstration

A Tech Demo project, Tactical Aviation Mission System Simulation, has been initiated. See Corporate Objective 4 in Chapter 3 for a brief description.

Enhanced Synthetic Vision System

This Tech Demo project was approved and contracted. It has financial support from the National Search and Rescue Secretariat, and active collaboration with NRC and industry. It was on time and budget at the end of FY 98/99.

Evaluation of Techniques Against Laser Guided Weapons

Work in this area has been consolidated under a new project.

Joint Approach on Dual-mode Countermeasures

An effort is underway to consolidate the RF and EO programmes by making DREV's EO facilities available to the Air Force A3 EWOS, which uses the EWTD for RF work.

Human Tolerance to Acceleration

Good progress was made last year. See the Air Program section of Chapter 2.

Command and Control Information Systems Program

CA/US Co-operation on Military Space R&D

Negotiations were completed of a Project Arrangement on QWIP devices with the Ballistic Missile Defence Office (BMDO). Two other topics (Radarsat data exploitation and HF Radar for ballistic-missile detection) are covered under co-operation with BMDO's Joint National Test Facility. A trilateral MOU (US/UK/CA) on Space-Based Surveillance R&D was signed in November 1998, as well as a Project Arrangement under this MOU. DRDB supported the Department in negotiations with the US on Space Co-operative Work.

Information Operations (IO)

The basic form of the long term IO program was resolved, thereby allowing the formation of a new IO section at DREO to proceed, with a target date to be functionally operational on 1 April 2000. An IO TIF proposal has been approved for 98/99 - 00/01 entitled Detection of Malicious Code in COTS Software.

Major Project to Create the Tool Sets for the Common Operating Picture (COP)

During this year, limited progress has been made in developing this project in considerable part due to the involvement in the preparations for OPERATION ABACUS and the associated requirement to provide the CF with support on the domestic COP. The project and all following milestones are shifted by a year. The major project will be initiated in Sep 99.

Capturing R&D Requirements from the Joint Client

With the exception of the Joint Surveillance and Intelligence Team, focused guidance on R&D needs has been provided. Work is underway to provide the missing guidance.

Leadership and Co-ordination of DRDB's Entire C2 Program

DSTCCIS has been assigned this responsibility.

Implementation Plan for DRDB's C2 Program

A "Working Group for C2 Co-ordination" was formed. A new position has been created to carry out the co-ordination responsibility.

Review of the CRC Defence Communications Program (DCP)

The review was completed and a report on it published in September 1998. The principal recommendations of the report are that: the DCP be maintained in its present configuration at CRC; the Deputy DG of DREO be given the additional responsibility of Director DCP; and CRC provide an annual year-end report of DCP activities. These recommendations have been implemented.

An epidemiological study of Gulf War veterans has been initiated to establish mortality and cancer incidence.

Human Performance Program

Military Operational Medicine

An epidemiological study of Gulf War veterans to establish mortality and cancer incidence has been initiated. Comparative data will be established by the linkage of CF veterans' statistics to the National Mortality Data Base and the National Cancer Registration System.

NBC Defence

A major project, the Vaccine Development Initiative, seeks to perform all the required elements for development of a *Brucella* vaccine. It is anticipated this project will be completed in FY 2003.

Within the CIBADS major project, currently in Phase 3 of 4 phases, the incorporation of a superior BW agent identification hand-held test kit is being pursued.

Increased awareness of the increasing risk from asymmetric CB terrorist threats has catalyzed an approach from DRDB to Health Canada to participate in collaborative R&D to mutual benefit. It is anticipated that an MOU between the two partners will be signed in 1999.

Human Factors

A Tech Demo project, Distributed Mission Training for Air Force Simulation, Modelling, Acquisition, Rehearsal and Training, was approved. See Corporate Objective 4 in Chapter 3 for a brief description.

Milestone Delivery

Over the past few months, Thrust Co-ordinators and Thrust Leaders have reviewed each Thrust and noted the success rate at meeting milestones during 1998/99, as well as key results. Milestone delivery statistics are tabulated below, aggregated by CG.

	Maritime Program	Land Program	Air Program	CCIS Program	HP Program
Total Milestones Identified	282	228	143	88	108
Milestones Achieved	56%	76%	73%	80%	49%

Note that for the Land Program, the achievement figure given above should be interpreted as percentage completion of the work plans for 1998/99. This situation arises as a result of a major restructuring of the Thrusts in the Land Program last year.

We see from the above data that our performance in meeting milestones varies considerably across the five Client Groups. For three CGs (CCIS, Land and Air), the success rate is fully satisfactory, but for the other two (Maritime and Human Performance), it is lower. In the Maritime Program we note that milestone completion in undersea warfare Thrusts was adversely affected by the significant disruption caused by transferring activities and staff from DREA's Esquimalt site to Halifax, and the associated loss of some key personnel who chose not to make the move. In the Human Performance Program, major restructuring had an impact.

To some extent, the variability in milestone delivery among the CGs also arises from differing perceptions of what constitutes a milestone, the degree of rigour involved in setting milestones in the project plans and the priority placed on achieving them within the agreed time frame. There appears to be a need for guidelines on these issues, as well as a rough relationship between resource expenditure within a Thrust and the total number of milestones in a year.

Since this Annual Report marks the first occasion that the Branch has attempted to present milestone data in the format shown above, we should not be surprised at the variability from CG to CG and Thrust to Thrust. We expect greater consistency next year, since in formulating the Service Level Agreements for FY 1999/2000, Thrust managers were aware that the program oversight system would include milestone tracking.

Client Satisfaction

As part of its new program oversight strategy, DRDB conducted Client Satisfaction Surveys across all five Client Groups.

This year, as part of our new program oversight strategy, we conducted Client Satisfaction Surveys across all five Client Groups. We chose to contract-out this work in order to compile the information in a short time period, to elicit candid feedback from our clients and to guarantee confidentiality of responses.

A key element of this process is the application of a Client Satisfaction Questionnaire, with accompanying interviews, to selected managers in all five Client Groups. As the title of the questionnaire indicates, its purpose is to measure client satisfaction with the Branch's performance. This year, 75 clients were involved, with at least a dozen from each Client Group. These clients ranged in rank from Major to Brigadier General, and civilian equivalents. The questionnaire and interviews were administered under contract by consultants so as to assure an arm's length, unbiased interpretation of data and information. The consultants' report is available under separate cover and will receive wide distribution within the Branch's CF/DND client community.

The results of this examination are generally positive. The Branch appears to be well respected and valued by its departmental clients. In general, we are seen to be doing the right things and doing them well. Our staff is held in high regard. The advice that we provide is generally seen as valuable and useful. At the same time, there were some areas of concern, which, while not universally held, do present us with opportunities for improvement.

DRDB has undertaken to examine the issue of timely services to the CCIS Client Group.

For example, CCIS clients frequently expressed the view *"that it was difficult for the scientific community to keep up with the rapid pace of development and application of existing technologies in the information technologies domain*". DRDB has undertaken to examine the issue of timely services to the CCIS Client Group and, more specifically, to clarify the role of R&D in the context of command and control in DND.

Another recommendation was that DRDB provide Client Groups with a better understanding of the Branch's capabilities and limitations as a scientific research organization. In response, a short document is being prepared that will describe the Branch's different types of R&D activities (e.g. technology investigation, technology application, technology investment fund, technology demonstration) along with the proportions of resources devoted to each. Some clients suggested that DRDB consider additional internal "marketing" of DRDB's capabilities within DND; this will be part of the Agency's communications strategy.

Another noteworthy finding involves the concern of some clients about DRDB's ability to attract and retain high quality personnel. Related to this is the question of the flexibility or "agility" of scientific staff to redirect efforts and deal with changing client requirements.

We must also address the issues of making the R&D Program Review Committee more relevant and effective as a decision-making body and of making the Service Level Agreements with our five Client Groups more "user friendly". The survey also indicates some dissatisfaction regarding the operational medicine program; remedial measures are in hand.

Annex A provides further details on the survey, including the questions that were asked and, for those questions with numerical scores, the mean response. Also in Annex A are the results of an analysis of the data to extract indicators of the impact of the Branch's program in the following areas:

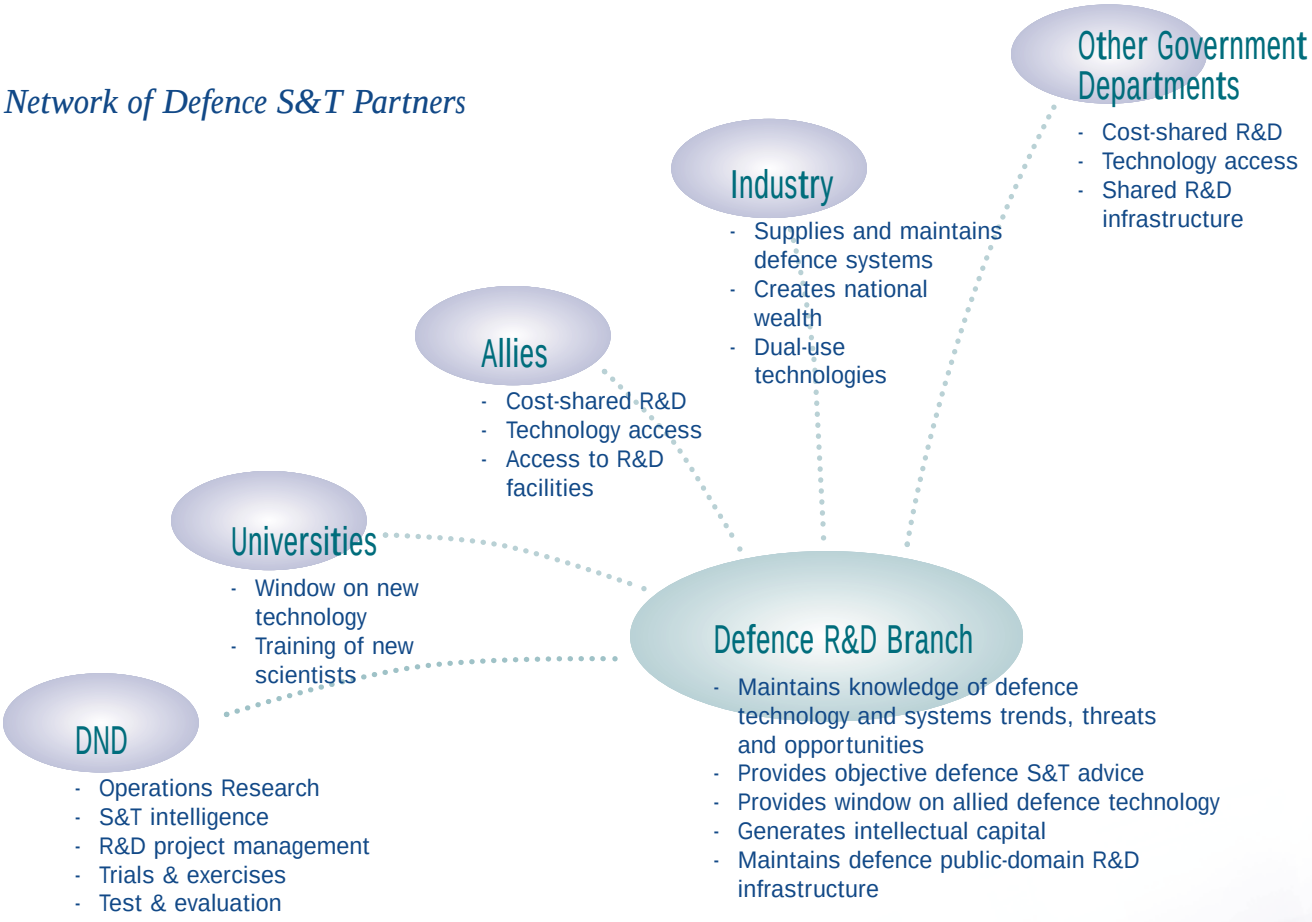
DND/CF Decision Making
CF Operational Capability
Life Cycle Costs
Benefits to Industry
Program Formulation

5

Working with partners

We rely on our partners, both national and international, to provide us with access to a broad technology base and to participate in delivering the defence R&D program. At the same time, we contribute to national wealth generation by transferring technology and knowledge out of our laboratories for use in Canadian industry. The diagram below provides a useful depiction of our relationship with, and our dependence on, S&T partners. Enhancing the effectiveness of these partnerships is a key element of our R&D strategy, and to this end we are taking new initiatives to promote collaboration and expand existing arrangements.

Network of Defence S&T Partners



National Partners

Increasingly, we seek to engage national partners in cost-shared collaborative projects. In 1998/99, we estimate that the Branch leveraged a total of $20M through such arrangements. We believe that the potential for growth is excellent and have set a national leveraging target of $30M in five years' time.

The Defence Industrial Research (DIR) Program, a cost shared arrangement with industry (typically 50/50), continues to provide an important and successful mechanism for leveraging. Through the DIR Program, we solicit innovative R&D proposals from industry that have potential defence application. In 1998/99, there were 41 active DIR projects, on which expenditure totalled $4.06M during the fiscal year. The projects are listed in Table 6. Highlights and success stories of some of the DIR projects are shown at Table 7.

The Defence Industrial Research Program continues to provide a successful mechanism for leveraging.

Table 8 lists some recent examples of technology transfer from the Branch to Canadian industry.

A recent example of networking at the national level is the Centre of Excellence in Geomatics for Informed Decisions (GEOID), of which DREV is a founding member. DREV has also participated in the creation of the Information Interoperability Institute to oversee the evaluation, maintenance and exploitation of the Open Geospatial Datastore Interface (OGDI), which a number of vendors of geographical information systems have already integrated into their products.

Revenue Generation

The Branch made substantial progress on its initiative to generate revenue through exploiting its S&T base to serve the needs of clients outside DND, including Canadian industry and other government departments. Such work and the associated income will help DRDB to develop and maintain its technological capabilities. In 1998/99, revenue was $3.66M, well in excess of the target of $2.5M. Table 9 provides some examples of revenue-generating projects.

University Partnerships

In partnership with the Natural Sciences and Engineering Research Council (NSERC), the R&D Branch will pilot a Technology Watch Program at Canadian universities. This program funds long-term research at universities by defence scientists and academic staff in emerging technologies with dual-use applications.

The R&D Branch also works with NSERC in a jointly funded and managed Research Partnership Program. The goal of this program is to obtain support from university-based research for defence requirements. The R&D projects are co-funded by the Branch, NSERC and industry.

The R&D Branch continues to co-sponsor Chairs at Dalhousie University and the University of Victoria to monitor developments in the field of ocean acoustics. Over the next year we will sponsor two chairs in other technology areas as part of the Technology Watch Program.

International Collaboration

By participating across a spectrum of international collaborative bodies, including The Technical Co-operation Program, the NATO Research and Technology Organization and numerous bi- and multi-lateral arrangements, we gain access to leading-edge defence technologies and information. Last year, through our collaborative activities in the international arena we leveraged roughly $27.5M worth of R&D. We plan to expand co-operation with the United States while continuing to be active in other international R&D projects. Our goal to increase internationally leveraged R&D to $40M annually in five years time.

By participating across a spectrum of international collaborative bodies, we gain access to leading-edge defence technologies and information.

The Canada-US Co-operation Initiative is both a response to the requirement for interoperability and a reflection of the importance of leveraging our limited resources with our closest ally. The aim is to access and share advanced technologies to enlarge competencies, fill technology gaps and reduce the cost of technology development and insertion.

6 Excellence in science

AN S&T ORGANIZATION MUST MAINTAIN A HIGH STANDARD OF SCIENTIFIC QUALITY IN ORDER TO DELIVER R&D PRODUCTS AND ADVICE THAT ARE VALUABLE AND CREDIBLE. TO ASSESS DRDB'S STANDING IN THE SCIENTIFIC COMMUNITY, WE TRACK A NUMBER OF INDICATORS OF EXCELLENCE IN SCIENCE AND CONDUCT PEER REVIEWS OF DEFENCE TECHNOLOGY AREAS.

Scientific Indicators

- Our staff published 192 papers in the open literature.
- Our staff made 272 scientific presentations at national and international conferences.
- Our DREs published 305 technical documents. In addition, 177 technical reports resulted from research contracts funded by the DREs.
- Our staff secured 8 patents and filed 21 Reports of Invention.
- Technology transfer to Canadian industry took place across a broad spectrum of our R&D activities. Table 8 lists many examples.
- 23 of our staff received national and international awards. See Table 10.
- DRDB participated in 61 national S&T activities (councils, networks, projects and other collaborative arrangements).
- DRDB was active in 294 international defence S&T activities (formal programs, projects, working groups and information exchange arrangements).

Peer Reviews

In October 1998, we conducted a peer review of the Life Support Systems and Human Protection/Survival activities at DCIEM. A very highly regarded Peer Review Team spent two days gathering information about these activities (this included briefings and facility tours) and a third day analysing the information and discussing the findings. The resulting report, written by the Team chair, noted the high quality of the work and the scientific and technical staff. Liaison with industry and academia was seen as good to excellent, as were the facilities and technical support. Finally, communication between the sectors within the program was considered to be very good.

At the same time, questions arose regarding several issues:

- follow-up to assess whether a final product was actually implemented by the CF;
- blurred distinction between service functions and traditional R&D, and appropriateness of using R&D funds for test and evaluation;
- relevance and likelihood of effective application of certain topics in Operational Medicine research.

Arrangements are progressing for peer reviews of Radar technology at DREO and Command and Control at DREV. We are also discussing with both establishments the idea of adding to the Peer Review process a technique that has been utilized effectively by the Defence Evaluation and Research Agency in the UK, called Technology Assessment. This involves:

(1) scientific and technical staff in the Technology Area (i.e. the Technical Team) answering a set of questions pertaining to Team effectiveness;

(2) the Peer Review team answering the same questionnaire; and

(3) a joint session of the Peer Review and Technical Teams to compare and discuss results.

7

Corporate affairs

Human Resources

PROGRESS ON SEVERAL KEY HR INITIATIVES HAS ALREADY BEEN NOTED IN CHAPTER 3, UNDER CORPORATE OBJECTIVES 6 AND 7.

A key component of the Development Phase of the ASD Review is the proposed HR framework. This framework focuses on incorporating core values and principles into HR management practices and policies, while defining the tools and support needed to facilitate the future business directions in DRDB. It was developed within the context of the DMC decision to work toward a Statutory Agency, taking into consideration government-wide, DND and CF renewal initiatives as well as Branch-specific vision, mission, principles and values.

During the review period, a DRDB demographic analysis was conducted in order to forecast pending recruitment challenges. As a consequence of this analysis, a recommendation was made to adopt a tailored workforce revitalization plan, including a technological apprenticeship program.

Administration and Infrastructure

Noteworthy administrative activities and accomplishments include:

- Re-organization of Branch Headquarters in August 1998. Re-organizations at DCIEM and DRES. Creation of the Information Operations Section at DREO, to work on techniques for attack detection and analysis, information protection and assurance, and information exploitation.
- Establishment of Business Development Offices at Headquarters and the DREs.
- Response to the demands imposed by the Universal Classification System project. This included: creating Branch model writing teams, training managers and employees; developing generic work descriptions for typical jobs in DRDB's main functional areas; drafting work descriptions for positions not covered by these examples; and extensive consultation and broad collaboration with various stakeholders for the finalization of model work descriptions to facilitate the mapping of current jobs to UCS. As a result, the Branch is among the leaders in UCS Conversion.
- Extensive testing of computer systems to determine if they are year 2000 (Y2K) compliant. DREV has made a key contribution to Operation ABACUS, the CF response to the effects of the Y2K bug on essential services throughout Canada, by developing the National Infrastructure Database, which will be used by the CF to anticipate, monitor and portray the status of critical Canadian infrastructure.

- Staffing at DREA to fill vacancies arising from the transfer of positions from Esquimalt to Halifax and from the initiative to increase effort on Naval Command and Control.

Infrastructure highlights include:

- Building modifications at DREA to accommodate underwater testing facilities for the Electromagnetics Section.
- Ongoing mid-life refit of DREA's research ship, *CFAV Quest*, now scheduled to be completed in autumn 1999.
- Start-up of the Munitions Experimental Test Centre (METC), a collaborative venture involving DREV and the Directorate of Ammunition Program Management. METC brings together the ammunition firing ranges which formerly belonged to the Proofing and Evaluation Test Establishment with weapons technology facilities at DREV.
- Inauguration of the Electro-optical Engineering and Evaluation Centre (EEEC) at DREV. EEEC provides consulting, design and testing services in the fields of detection, imaging, countermeasures and protection across the ultraviolet, visible and infrared spectrum.
- Upgrade of the Human Centrifuge and Climatic Facilities at DCIEM.
- Inauguration of the Canadian Centre for Mine Action Technologies at DRES (see Corporate Highlights).
- Completion of a CA/UK 15 year development plan for CFB Suffield, which includes creation of a "zone" on the base for future DRES development and setting of priorities for construction of new facilities and buildings.

The Munitions Experimental Test Centre brings together ammunition firing ranges and weapons technology facilities.

8 Conclusion

THIS DOCUMENT IS ITSELF A MILESTONE IN THE DEFENCE R&D BRANCH'S EVOLUTION, IN THAT IT REPRESENTS OUR FIRST ATTEMPT TO DOCUMENT ANNUAL PERFORMANCE IN A COMPREHENSIVE YET SUCCINCT FASHION, USING A COMBINATION OF QUANTITATIVE DATA AND ANECDOTAL INFORMATION. THE TARGET READERSHIP FOR THIS REPORT INCLUDES OUR CLIENTS, STAFF AND STAKEHOLDERS, AND WE AWAIT FEEDBACK FROM THEM ON SUCH KEY ISSUES AS THE STRUCTURE OF THE DOCUMENT AND WHETHER IT IS SUFFICIENTLY COMPREHENSIVE OR INSUFFICIENTLY SUCCINCT.

As the foregoing chapters demonstrate, we have made good progress on many fronts during the review period. By way of conclusion, we offer the following observations.

- The highlights given in Chapter 2 provide solid evidence that our R&D programs deliver valuable products and services to our Client Groups in DND and the Canadian Forces.
- We have good reason to be satisfied with our performance on Corporate Objectives. We have met or exceeded all the targets that were set for 1998/99.
- Our success rate on Client Group Major Initiatives is fully satisfactory.
- Our performance in Milestone Delivery is spotty. For the CCIS Client Group, performance is very good, with an overall success rate of 80%. For several of the other Client Groups, however, the success rate is substantially lower. This shows that for the latter programs, we must (a) set realistic milestones and (b) place higher priority on milestone completion. Practices in the CCIS program can serve as a model.
- The Client Satisfaction Survey that we have just completed shows that our Client Groups generally regard us favourably. They consider our work to be of high value, and they are very pleased with the quality of our staff. At the same time, the survey identified a number of areas where we can make improvements.
- We have a good record of achievement in technology transfer, as attested by the many examples in Table 8.
- We are making good progress on enhancing our national and international partnerships. We expect further growth in these areas and accordingly have set aggressive leveraging targets.

The Client Satisfaction Survey shows that our Client Groups consider our work to be of high value, and they are very pleased with the quality of our staff.

Tables

Table 1 – Scientific Capabilities of Defence Research Establishments

DREA	• Sonar sensors and undersea environmental acoustics • Naval and airborne sonar technologies • Electromagnetics • Marine materials • Ship operability, safety and signatures • Mine and torpedo countermeasures • Naval command and control
DREV	• Advanced electro-optical systems • Military laser technology and systems • Remote sensing technology and systems • Acoustic surveillance systems • Electromagnetic sensor performance prediction • Information systems technology • Weapon effects • Weapon delivery systems • Energetic materials
DREO	• Aerospace radar and navigation • Surface radar • Electronic warfare – electronic support measures • Electronic warfare – electronic countermeasures • Military communications • Space systems technology • Information operations • Radiation biology and radiation detection
DCIEM	• Human engineering • Simulation and training technologies • Information processing • Human protection and performance • Aerospace life support • Air vehicles • Experimental diving
DRES	• Detection and identification of chemical and biological (CB) agents • Physical protection against CB agents • Medical countermeasures against CB agents • Countermine technology • Threat assessment and explosive effects • Tactical vehicle mobility and robotics

Table 2 – Defence R&D Branch 1998/99 Resource Summary

EXPENDITURES BY FUND TYPE AND SITE ($000'S)

	Salary	Local O&M	R&D Contracts	Equipment	Total
DREA	10,736	2,598	4,682	2,091	20,107
DREV	16,364	7,405	13,235	2,723	39,727
DREO	7,977	2,380	15,194	1,971	27,522
DCIEM	6,543	2,102	11,039	2,760	22,444
DRES	7,874	2,374	6,826	1,701	18,775
CRAD/HQ	4,845	2,702	35,133	8,371	51,051
Total	**54,339**	**19,561**	**86,109**	**19,617**	**179,626**

SOURCES OF REVENUE BY SITE ($000'S)

	Private Sector Sources (Local Revenues)	Specified Purpose Accounts	OGD's	Intellectual Property	Total
DREA	125	–	–	–	125
DREV	496	–	–	–	496
DREO	96	–	–	700	796
DCIEM	619	–	100	–	719
DRES	–	351	1,833	–	2,184
CRAD/HQ	24	–	–	350	374
Total	**1,360**	**351**	**1,933**	**1,050**	**4,694**

CIVILIAN FTE'S BY GROUP

	FTE's	# Hired	# Departed
Defence Scientists	343	26	11
Other Professionals	49	1	1
Technologists	273	11	13
Executives	2	1	–
Administrative Staff	206	22	15
Operational Staff	89	16	8
Total	**962**	**77**	**48**

Total Number of Military FTE's 38

Table 3 – Defence R&D Activities

1. Autonomous Intelligent Systems
2. Chemical/Biological/Radiological Threat Assessment and Detection
3. Command and Control Information Systems (CCIS)
4. Communications
5. Electro-Optical Warfare
6. Emerging Materials and Bio-Molecular Technologies
7. Human Factors Engineering and Decision Support
8. Information and Knowledge Management
9. Multi-Environment Life Support Technology
10. Network Information Warfare
11. Operational Medicine
12. Platform Performance and Life Cycle Management
13. Precision Weapons
14. Psychological Performance
15. RF Electronic Warfare
16. Sensing (Air and Surface)
17. Sensing (Underwater)
18. Signature Management
19. Simulation and Modelling for Acquisition, Rehearsal and Training (SMART)
20. Space Systems
21. Weapons Effects

Table 4 – R&D Thrusts

Thrust		Objectives / Scope
		Maritime
1.a	Maritime Integrated Above Water Warfare	To develop new techniques in sensor signal and data processing, investigate systems integration concepts and improve individual technologies of sensors, weapons and countermeasures associated with above water warfare.
1.b	Maritime Command, Control, Communications and Intelligence	To enhance the effectiveness of commanders ashore and at sea by improving command's ability to manage data and information from all sources. More specifically, to develop cost-effective solutions in key areas such as local and wide data fusion, situation assessment, resource allocation, interoperability, computer networks, shipboard multimedia communication and to integrate Above Water Warfare and Under Water Warfare tactical world pictures into an accurate and understandable Maritime Tactical Picture.

1.c	Maritime Underwater Warfare	To investigate and develop techniques, concepts, system components and systems for detecting submarine, surface, torpedo, and mine targets. The primary emphasis of the thrust is on Naval and Airborne sonar systems. Electromagnetic detection of submarines from ASW aircraft is also included.
1.d	Maritime Mine Countermeasures Systems	To counter a mine threat to CF vessels by: advancing the state of the art in route surveying, mine hunting, mine identification, mine avoidance and ship silencing
1.g	Naval Platform Technology	To maximize Canadian Maritime Forces operational effectiveness and safety by reducing underwater acoustic signatures, improving structural integrity, and establishing safe ship and submarine operational envelopes. To minimize construction, operating and maintenance costs by applying new platform and materials technology to Canada's naval fleet.
		Land
2.c	Soldier Systems	To meet the army's S&T needs in soldier systems, including: lethality, survivability, mobility, sustainment, command, control, communications, and human performance.
2.f	Tactical Vehicle Systems	To meet the army's S&T needs for tactical vehicle systems, including: mine blast protection, active/reactive armour, defensive aid suites, unmanned vehicles, vehicle technologies, and advanced land fire control systems.
2.k	Information Operations	To meet the army's S&T needs in support of information operations, including: surveillance, target acquisition, night observation, EW, command and control information systems, tactical communications and countermeasures, and counter-surveillance.
2.m	Military Engineering	To meet the army's S&T needs in combat engineering, including: counter-mobility (demolition systems), mobility (countermine), and formation-level protection.
2.n	Munitions & Firepower	To meet the army's S&T needs for weapon systems, including: direct and indirect fire weapons, directed energy weapons, munitions life cycle management, energetic materials, combustion processes, and terminal effects.

		Air
3.a	Air Force Operational Information Management	To explore, develop and demonstrate advanced technologies that can be applied to command, control and intelligence systems to enhance air force effectiveness during normal, deployed, and contingency operations.
3.c	Air Electronic Warfare	To enhance the effectiveness of the self-protection of CF aircraft through the application of electromagnetic technologies, in understanding the threat and in developing countermeasures.
3.d	Airborne Surveillance	To develop and exploit surveillance and observation techniques to enhance the surveillance and target acquisition capability of airborne platforms.
3.e	Air Weapons Systems	To assist with the improvement to existing weapons systems or the acquisition of new systems by evaluating the threat and system effectiveness, integrating weapon sub-systems and integrating weapons and platforms,
3.f	Aircraft Crewsystems Technologies	To enhance the operational effectiveness and safety of CF aircrew during exposure to the stresses of the aerospace environment.
3.g	Air Vehicles	To reduce the costs of aircraft operations through the innovative application of S&T, while maintaining or improving airworthiness standards. To incorporate advanced technologies into airframes and engines to reduce the life cycle cost associated with those systems.

		Command and Control Information Systems
5.a	National Level Command and Surveillance	To provide solutions to meet the current and future CF requirements for national level command and control functions. This includes the capability to develop and present the national common operating picture (COP) and to improve the associated strategic wide-area surveillance systems.
5.b	Information Warfare	To ensure the CF and DND have assess to technologies and technical advice which will allow them to establish and maintain information superiority by affecting adversary information while protecting their own; and to enhance electromagnetic surveillance and survivability by exploiting new developments in signal processing, electromagnetic technology and propagation.

5.c	Military Information Technology Infrastructure	To meet the CF requirements for world wide, secure, reliable passage of information to support stated and anticipated command, control, and intelligence (C2I) functions.
5.e	Space Systems and Technologies for Defence Applications	To support the DND space-policy objectives through the development of capabilities in space systems and technologies; space environment and electronics; space-based surveillance; and surveillance of space.
		Human Performance
6.b	Simulator Training Technologies	To maximize combat readiness and job performance, while minimising costs, environmental damage, and risk to personnel safety.
6.c	Military Operational Medicine	To enhance the CF's capability to assess and prevent health hazards; to prepare for and sustain the delivery of health care and diagnose, treat and manage illness and trauma arising from conventional military operations.
6.i	Diving & Underwater Intervention	To support the development and acquisition of effective diving equipment for the CF; reduce injury and death of divers; and optimize the use of divers.
6.k	Human Factors in Military Systems	To support DND in the acquisition and operation of effective manned systems through R&D activities that: provide a better understanding of human decision-making; develop models of human capabilities and limitations; support the acquisition or modification of effective human-machine systems and equipment; and develop effective human engineering tools and techniques to support DND projects.
6.q	Defence Against Chemical, Biological and Radiation Hazards	To conduct R&D leading to improved hazard assessment tools for field commanders, better detection systems, effective medical pre-treatments and therapies, improved decontamination equipment, and less burden-some personal protective equipment.

Table 5 – 1998/99 Expenditures by Client Group and Thrust ($000's)

Client Group/Thrust		Civilian FTE's	Total Expenditures
Maritime Client Group			
1.a	Maritime Integrated Above Water Warfare	28	6,617
1.b	Maritime Command, Control, Communications and Intelligence	9	4,793
1.c	Maritime Underwater Warfare	63	11,429
1.d	Maritime Mine Countermeasures Systems	14	2,750
1.g	Naval Platform Technology	55	8,844
Total Maritime		**169**	**34,433**
Land Client Group			
2.c	Soldier Systems	21	3,783
2.f	Tactical Vehicle Systems	33	6,967
2.k	Information Operations	40	8,842
2.m	Military Engineering	18	3,941
2.n	Munitions & Firepower	19	4,710
Total Land		**131**	**28,242**
Air Client Group			
3.a	Air Force Operational Information Management	13	1,963
3.c	Air Electronic Warfare	26	6,558
3.d	Airborne Surveillance	31	5,958
3.e	Air Weapons Systems	24	2,572
3.f	Aircraft Crewsystems Technologies	12	5,074
3.g	Air Vehicles	4	4,843
Total Air		**111**	**26,968**

Command Control Information Systems Client Group			
5.a	National Level Command and Surveillance	37	4,943
5.b	Information Warfare	15	4,897
5.c	Military Information Technology Infrastructure	10	8,082
5.e	Space Systems and Technologies for Defence Applications	16	4,798
Total Command Control and Information Systems		**79**	**22,720**

Human Performance Client Group			
6.b	Simulator Training Technologies	7	2,590
6.c	Military Operational Medicine	11	3,221
6.i	Diving & Underwater Intervention	7	1,003
6.k	Human Factors in Military Systems	19	2,791
6.q	Defence Against Chemical, Biological and Radiation Hazards	64	12,656
Total Human Performance		**107**	**22,261**

Corporate Management and Support Services			
7.a	Management and Administration	237	21,114
7.b	Central Technical Support	71	6,128
7.c	Site Support	51	7,365
Total Corporate Management and Support Services		**359**	**34,607**
Departmental and Interdepartmental Initiatives		**6**	**10,400**
Branch Total		**962**	**179,631**

Table 6 – Defence Industrial Research Projects in 1998/99

DIR Project Title	Firm	FY98/99
Uncooled Algorithm Research and Remote Operation Capability Program	AlliedSignal Aerospatiale Canada Inc.	$124,590
Tools for the Generation of Advanced ScanSAR Data Products with RADARSAT	Atlantis Scientific Inc.	$57,719
Signal Image and Data Processing Algorithms	A.U.G. Signal Ltd.	$60,306
Immune Modulator Strategy Phase II	Biophage Inc.	$122,874
Advanced computational fluid dynamics for analysis/ design of aircraft aerodynamics configurations	Bombardier/Canadair Inc.	$148,177
Research into Piezoelectric and Electrostrictive Materials for use in Smart Structures	B.M. Hi-Tech Inc.	$214,657
ESM Against Modern Military Communications	Calian Technology Services Ltd.	$72,364
High power high temperature superconductor for communications satellites	COM DEV Ltd.	$256,121
LAV Recce Surveillance Enhancement Demonstrator	Computing Devices Canada	$249,064
An Enzyme-based Bioreactor for Carbon Dioxide Management in Submarines	Groupe Conseil Gesco Inc.	$131,197
Orthopedic and Cardiac Clinical Trials with Hemolink in Surgery	Hemosol Inc.	$252,993
Biosensors for Detection/Identification of Chemical and Biological Warfare Agents	IatroQuest Corporation	$35,017
Hyperspectral Land Mine Detection	Itres Research Limited	$89,246
Advanced Agile Frequency Sources for Defence Applications	I.T.S. Electronics Inc.	$128,432
Inorganic intumescent coating technology for improved firesafety on naval vessels/submarines	J.O. Bernt & Associates Limited	$60,430
Image Analysis and Object Recognition Decision Aids for Airborne Surveillance	Lockheed Martin Canada Inc.	$141,967
Magneto-Inductive Duplex Communication System	Magneto-Inductive Systems Ltd.	$68,868
Sector Scan Sonar Data Fusion Demonstrator	MDA	$30,464
Mine Boot Protection System (MBPS)	Med-Eng Systems Inc.	$168,821
Water Activated Foam for Cold Water Immersion Garments	Mustang Survival Corporation	$38,816
Radiation Hardened Startracker Research Project	OPAL-RT Technologies Inc.	$12,629

DIR Project Title	Firm	FY98/99
Optimization of the Mechanical Characteristics of Nanocrystalline, Superplastic formed Zirconia Toughened Alumina	Pacific Safety Products Inc.	$85,005
Digital Elevation Model Extraction from RADARSAT SAR Stereo Imagery	PCI Enterprises Inc.	$44,309
Plasma Atomisation/Powder Metallurgy, and Net Shape Forming of Lightweight Armour	PyroGenesis Inc.	$64,879
Seabed Classification for Multibeam Sonars	Quester Tangent Corporation	$75,177
Evaluation of IM Technology for the Large Calibre Ammunition	SNC Industrial Technologies Inc.	$83,358
Research into Synthesis of Ultra-Fine Metallic Powders	Tekna Plasma Systems Inc.	$209,444
Advanced Ultrasonic Methods for High Speed, High-Sensitivity Airframe Corrosion Detection	Tektrend International Inc.	$12,892
Explosive Standoff Minefield Breacher	Thomson-CSF	$15,478
Tactical Engagement Simulation System (TESS) R&D	TTI Tactical Technologies Inc.	$60,320
Advanced Degaussing Unit	W.R. Davis Engineering Ltd.	$33,907
Studies of Toxicity and Efficacy in Humans of O-Raffinose cross-linked Hemoglobin	Hemosol Inc.	$55,435
NOVA2: Virtual Interactive Role Playing for Military Training	IntelAgent R&D Inc.	$3,500
High Resolution Grey Shade and Colour EL Displays	Computing Devices Canada	$16,128
Distributed real-time&low latency multi/parallel processing simulation&operation environment/testbed	Maple Computer Systems	$16,151
Next Generation Megapixel CCD Image Sensors for Reconnaissance Applicatioins	Dalsa Inc.	$84,000
Experimental Investigation into the Feasibility of Using Ceramic Vanes in Gas Turbines	Ceramics Kingston Ceramiques Inc.	$3,673
Development of an Instructional Design Performance Support System	Eduplus Groupe Conseil	$302,131
Portable Aircraft/Missile Tracker	IMAGO Machine Vision Research Inc.	$136,940
CM Internet Search Engine	International Neural Machines Inc. (Megalith)	$107,854
Concept Discovery Engine - Project Extension	International Neural Machines	$181,152
	Total FY 98/99 Spending	**$4,056,484**

Table 7 – DIR Success Stories

Hemosol Inc.

An ingenious approach to convert a supply of aged blood into a type-independent and virus-free artificial blood substitute for use as an oxygen transport and transfusion agent in the battlefield or civil emergency applications. This technology is currently in Phase III, orthopaedic and cardiac, clinical trials at the Ottawa Heart Institute.

IMAGO Machine Vision Inc.

R&D of video target tracking and intruder detection systems resulted in a portable, PC-based video auto-tracker at a fraction of the cost of conventional large cine-theodolite systems. Sales have been made to the Canadian army and air force, the US army, marines and navy, companies in the US and Europe, the Japan Defence Agency, and the South Korean military.

Bombardier

Computational fluid dynamics (CFD) work has provided Bombardier with the aerodynamic design tools to serve the needs of the Canadian Forces in such applications as stores separation and high angle of attack flight with the CF-18. This CFD work has been validated by correlation with the extensive wind-tunnel trials for the range of commercial aircraft from the C-601 Challenger to the immensely successful, world-class Regional Jet and the Global Express.

COM DEV Ltd.

Development of advanced high temperature superconductive (HTS) devices for applications in the space environment. A superconductive device resulting from the DIRP-supported research was successfully launched on the ARGOS satellite on 23 February 1999.

Computing Devices Canada (CDC)

Electroluminescent (EL) grey shade display research at CDC has resulted in application as the Commander's Thermal Viewer Display in the US M1A2 Abrams Battlefield Tank. This replaces the earlier bulky CRT display as part of the System Enhancement Package (SEP) for the US Army involving 1079 units. In addition, 300 EL display units have been sold to the Australian Navy for the "NULKA" displays.

Advances in communications and sensor technology have resulted in the implementation of embedded software systems and an independent FLIR sensor giving the M1A2 Abrams Tank a hunter/killer capability (the commander finds targets independently of the gunner).

Mustang Survival Corp.

Mustang was successful in beating three US companies, including the company responsible for the EVA suits for the Apollo Moon Program, in winning the contract for the Anti-g/Immersion Suit for the Boeing F-22 Fighter Aircraft.

PyroGenesis Inc.

Vacuum plasma atomisation and near net shape forming of materials (mainly Titanium alloys). The company has won a $11M contract in a US Navy competition for a shipboard plasma furnace for waste treatment. The company has grown from a one-person start-up to current revenues of $12M and now employs 60 people.

Dalsa Inc.

World-class Megapixel CCD Image Sensors for reconnaissance applications. These devices apply fast forward motion compensation right at the pixel level rather than post processing compensation. These CCD sensors are used in most US airborne reconnaissance and surveillance cameras operationally

AlliedSignal Aerospatiale Canada (ASaCa) Inc.

"POWERVISION", a new product line of thermal imager, is based on uncooled micro-bolometer focal plane array technology, which offers high reliability with low total-life costs. Applications include the Canadian LAV and the Bradley families of vehicles, and can be used in other types of vehicles by simply changing the vehicle interface unit.

Table 8 – Examples of Technology Transfer

- Goldorac 2, an adjustable torso developed at DREV to simulate the natural curvature of the human body for ballistic testing of body armour, is now produced and marketed by Bosik Consultants Limited.
- Following a technology transfer from DREV, Lyre Défense et Aérospatiale has just been awarded new contracts connected with verification devices of sensors used for the protection of military aircraft against missiles.
- Expertise gained through working for DREV on laser illuminators and active IR imagers has positioned the National Optics Institute to win contracts worth several million dollars in 1998 and 1999.
- EG&G Optoelectronics Canada received the 1998 Photonics Circle of Excellence Award for the High Angular Resolution Laser Irradiation Detector developed jointly with DREV.
- RDX/HMX Biotreatment Technology - transferred under licence from DREV to Biogenie Inc.
- Pocket Illuminator for the AN/AAR-47 – transferred under licence from DREV to Technologies Lyre Inc.
- Survivability/Lethality Analysis and Modelling Software – transferred from DREV to SNC Industrial Technologies.
- Visual Infrared Smoke Screen – transferred from DREV to SNC Industrial Technologies.
- Pyrophoric Flare Technology – transferred from DREV to Bristol Aerospace.
- STING G-Protection Ensemble – transferred under licence from DCIEM to Gentex Corporation.
- Air Cooling Vest – transferred under Letter of Intent to licence to Mustang Industries.

- Intelligent Clothing & Equipment Sizing System (ICESS) – transferred under Letter of Intent to licence from DCIEM to Image and Vision Systems.
- Aircrew Cockpit Crewstation Demonstrator – transferred under a partnering arrangement from DCIEM to Canadian Marconi.
- Helicopter Deck Landing Simulator – transferred under Letter of Intent to licence from DCIEM to Adacel Corporation.
- Load Carriage Simulator – transferred under licence and loan agreement from DCIEM to Queen's University.
- Universal Escape Exit for Helicopters (UEE) – transferred under license from DCIEM to Survival Systems Inc.
- Portable Handheld Aqueous Suppressant Analysing Refractometer (PHASAR) – transferred under license from DREA to Novus Inc.
- Combined Omnidirectional/Resolved Dipole Sensor (CORDS) – transferred under license from DREA to Northrop Grumman.
- Finite element structural analysis methods, implemented as the VAST computer code and licensed to Martec by DREA, were accepted by a number of international ship classification societies.
- Technology for miniaturized barrel-stave acoustic projectors – transferred under license from DREA to Sensor Technology for use in oil exploration systems.
- Multi-sensor vehicle-mounted mine detection technology – transferred from DRES to Computing Devices Canada.
- Improvements to instrumented mine probe – transferred from DRES to HF Research Inc and Dew Engineering.
- Enzyme-linked Viral Assay (method for detecting pathogens using viruses) – transferred from DRES to Biophage Inc.
- Method for detecting presence of bio-aerosols – transferred from DRES to TSI Inc.
- Spotlight synthetic aperture radar (SAR) technology – transferred from DREO to Array Systems Computing.
- High frequency surface wave radar technology – transferred from DREO to Raytheon Canada.
- Intrapulse technology – transferred from DREO to Omega Telemus.
- Canadian Advanced Radar Deception System (CARDS) technology – transferred from DREO to Macdonald Dettwiler.
- Beam*Link technology – transferred from DREO to COM DEV.
- Detection software – transferred from DREO to PCI.
- Ocean Monitoring Workstation – transferred from DREO to Satlantic Inc.
- Ringmaster technology – transferred from DREO to Calian Communications.

Table 9 – Examples of Revenue Generation Projects

DREO

- Antenna Measurement Study
- Development of Antenna Design Software
- Tracker
- High Altitude Studies
- Deconvolution Study
- Support to Nuclear Emergency Response
- Electrostatic Discharge
- ECM Investigations
- EMP Vulnerability Tests
- CARDS Receiver Development
- ELINT Data Collection
- Signal Processing Chain Analysis

DCIEM

- Development and Implementation of a Prebreathe Protocol to Protect against Decompression
  Sickness and Improve Efficiency of International Space Station Assembly and Maintenance During Extravehicular Activities
- Evaluate New Solid State Adsorbent Technology for Use in Rebreather Systems
- Define and Develop Embedded Microprocessor-based System for Medical Tomography Imaging Applications
- Effectiveness of Modular Egress Training Simulator and Shallow Water Egress Trainer for Helicopter Ditching
- Development and Evaluation of Air Bag Restraint System for Helicopters
- Impact Facility Dynamic Sled Tests for Advanced Crash Test Dummy
- Impact Facility Dynamic Sled Tests of Commercial Infant and Child Carrier Seats
- Impact Facility Dynamic Sled Tests in Support of Restraint System Standards and Compliance Testing
- Training in Doppler Monitoring and Bubble-based Decompression Models
- Testing of Narcotics Detection System under Various Pressures

DREV

- Pyrophoric Flare Tests Using the Open Jet Facility (two contracts)
- Experimental Feasibility Study on Bolometric Focal Plane Arrays For CO2 Laser Beam Profiling
- Ballistic Testing and Evaluation of Helmets Using an Instrumented Headform
- LIDAR Measurements to Map Aircraft Spray Plumes for Mosquito Control
- LIDAR Measurements of Cloud and Precipitation Conditions Leading to In-flight Icing of Aircraft
- Characterization of Sediments in Lac St-Pierre
- Training Videos for the ERYX Anti-Armour Weapon

DREA

- Propeller Trials on HMCS Nipigon
- Historical Perspective of Ambient Noise on Sable Bank
- Environmental Acoustic Data for Sable Bank
- Development of Finite Element Stress Analysis Code MGDSA
- Tactical Decision Aid for Passive Towed Array Sonar
- Towed Body Modelling
- Prediction of Sonar Detection Performance
- AN/SQS 510 Sonar Minefield Data
- Paint Stripper Analysis
- Drop Tests
- Filter Debris Analysis

DRES

- Analysis of Range Trial Data
- Consulting Services for Mine Prodder Engineering Design
- Access to Range for Product Evaluation
- Trial/Evaluation Support of Multi-Sensor Mine Detection System
- Oligonucleotide Therapy Research and Development
- Joint Assessment of Nerve Agent Therapy for Insecticide Intoxication
- Trial Support – Biological Detector Assesment
- Quality Assessment of NBC Masks
- Evaluation of Mine Protection Equipment
- Development of Aerosol Dissemination Models
- Scientific Consultation – Chemical Neutralisation Processes
- Field Evaluation of Explosive Device
- Mechanism of Action of Sulphur Mustard Toxicity
- Filed Evaluation of Blast Resistant Window Coverings
- Evaluation of Chemical Agent Protection of Fabrics

Table 10 – Scientific Awards

Federal Partners in Technology Transfer Award (June 1998)

Brian Sabiston and Manny Radomski of DCIEM for the Hemolink™ Blood Substitute.

Federal Partners in Technology Transfer Award (June 1998)

Robert Chesney of DRES for contributions to the robotics community through the Vehicle Control System project.

Technology in Government Week – Gold Medal

Cary Risley and Don Mosher of DREA for work on the Self-Locating Datum Marker Buoy. This also received a Deputy Minister's Commendation.

The Albert Behnke Jr. Award of the Undersea Hyperbaric Medical Society

Ron Nishi of DCIEM for lifetime achievement in decompression modelling and developing advanced diving decompression tables which have significantly enhanced the safety of diving.

National Research Council Merit Award

Sonia Thiboutot of DREV for work on environmental aspects of energetic materials.

The Technical Cooperation Program Achievement Awards

- *Ira Jacobs of DCIEM for collaboration in ergogenic aids research.*
- *Bill Roger and Christopher Progue of DREA for planning and executing a major international sea trial supporting research on data integration for maritime systems.*
- *Derek Lenard of DREA for collaboration on stress corrosion cracking of weldable aluminium armour alloy 2519.*
- *George Haslam, Maria Rey and Anthony Damini of DREO for collaboration on applying Synthetic Aperture Radar to automatic target recognition of ground vehicles.*
- *Denis Bergeron of DRES and Jocelyn Tremblay of DREV for collaboration on terminal effects of weapons.*
- *Cam Boulet of DRES for collaboration on detection of biological agencts.*
- *Scott Duncan of DRES for collaboration on integrated NBC protective clothing.*
- *Jim Ho of DRES for collaboration on detection of biological agents.*

Best Paper Awards

- *Paul Labbe of DREV, 1998 Command and Control Research and Technology Symposium.*
- *Sonia Thiboutot of DREV, 29th International Institute for Chemical Technology Conference, Karlsruhe, Germany, June 1998.*
- *Tom Cousins of DREO, RADECS 98 (with co-authors from the Defence Evaluation and Research Agency in the UK).*
- *Satish Kashyap of DREO, Applied Computational Electromagnetic Society Journal.*

Annex A

Client Satisfaction Survey – Key Details

Questionnaire – General

The first two questions dealt with the level of experience of the interviewee with the Branch. The next four asked the client to characterize the value of DRDB's output, the relevance of the R&D Program and the quality of DRDB's staff and facilities; for these questions the type of response was qualitative (e.g. Poor, Good, Very Good, Excellent). The next set of questions called for numerical scores in the range of 1 to 5, with the following guidance re the meaning of the scores:

1 – Not at All **3 – Moderately** **5 – To a Great Extent**

Our interpretation of the scores is that five signifies a very positive response, one a very negative response, and three a basically neutral answer. Obviously, for a given question an average score below 3 is unsatisfactory to us. Averages in the range of 3 to 3.5 give us cause for concern. Above 3.5, we get into the comfort zone.

Questionnaire – Results

In the exposition below, we begin with questions 3 to 6 (qualitative responses), showing the percentage distribution of responses among the options provided. We then move on to the questions with numerical scores, showing in each case the mean response.

3. *Please characterize the value of the output or benefits you received from DRDB's programs and projects.*
   Low 7% **Good Value 23%** **High Value 51%** **Very High 19%**

4. *From your perspective, is the R&D program of DRDB addressing the right research and technology development goals to meet DND and CF needs?*
   Yes 65% **No 15%** **Suggest Changes 20%**

5. *How would you characterize the quality of the DRDB R&D staff with whom you have worked and dealt?*
   Poor 1% **Good 14%** **Very Good 34%** **Excellent 51%**

6. *How would you characterize the quality of the DRDB facilities and equipment available to support the program areas with which you are familiar?*
   Poor 8% **Good 42%** **Very Good 45%** **Excellent 5%**

	Average Score
7. DRDB has been:	
a. Successful in anticipating needs in my area of concern.	**3.64**
b. Responsive in meeting my requirements.	**3.76**
8. The advice I have received from DRDB on specific problems has been:	
a. Valuable	**4.29**
b. Useful	**4.15**
c. Timely	**3.69**

9. DRDB contributions have been effective in the development of:
   a. Doctrine/Policy **3.26**
   b. Plans **3.22**
   c. Studies **3.87**
   d. Documents **3.50**

10. DRDB's recent contributions to DND and the CF have benefited my organization through:
   a. Enhanced Capabilities. **3.97**
   b. Improved procedures **3.39**
   c. Improved systems **3.72**
   d. Reduced Life Cycle Costs **3.13**

11. General Observations on the DRDB Program:
   a. The R&D program is in line with the Defence Development Planning. **3.57**
   b. DRDB has been successful in maximizing the benefits to Canadian industry of DND's R&D investment. **3.50**
   c. I am satisfied with the opportunity to contribute to the formulation of the R&D program.. . . . . **3.71**
   d. The R&D program provides a vital contribution to overall defence capabilities. **4.13**
   e. The R&D program gives appropriate emphasis to DND/CF requirements.. . . . . **3.54**
   f. Do you feel that DRDB provides good value for the resources expended? **3.88**

Impact Analysis

We have used the data in the consultants' report to focus attention on the following impacts of the DRDB program:

DND/CF Decision Making
CF Operational Capability
Life Cycle Costs
Benefits to Industry
Program Formulation

DND/CF Decision Making

Questions 8 (a-c) ask clients about the quality of DRDB's advice. The scores are tabulated below. The responses generated an average score of 4.0, which we see as very satisfactory. We are also pleased with the strong modal score of five (extremely satisfied) to these questions and by the fact that 70% of respondents were either very satisfied or extremely satisfied with the Branch's advice. It's worth noting that our score for timeliness of advice, although satisfactory, is not as high as our scores for value and usefulness.

Question 8(a-c)

	1	2	3	4	5	**Ave**
a	0.5	0.5	9.0	22.5	29.5	**4.3**
b	0.5	1.5	10.5	25.0	24.5	**4.2**
c	0.5	9.5	18.0	15.0	19.0	**3.7**
Total	**1.5**	**11.5**	**37.5**	**62.5**	**73.0**	**4.0**

Responses regarding the contributions to doctrine/policy, documents, studies, and plans were borderline, with an average response of 3.5. Moreover, 29% of respondents answered "not applicable" or "don't know to these questions. Accordingly, as the consultants' report states:

"A number of interviewees simply did not see a role for DRDB in…these [areas], although many were able to make the connection. Nevertheless, for those who answered the Item, the distribution of scores does not suggest any serious problems in these areas…. The effectiveness of DRDB in the development of "Studies" and "Documents" was more readily interpreted by most respondents. Again, the distribution is not remarkable, and in all cases the Centre of Gravity of responses is favourable to DRDB."

Questions 9 (a-d)

1	2	3	4	5	**Ave**
1.5	34.0	55.0	83.5	26.0	**3.5**

CF Operational Capability

Two questions (10a and 11d) in the questionnaire assess client perceptions of the benefits of the Branch's work in improving operational effectiveness. Question 10a provides a mean response of 4.0 and 11d an average of 4.1, both of which are very satisfactory.

In addition, questions 10b and c deal with DRDB contributions to improved procedures and systems. The averages are 3.4 for 10b and 3.7 for 10c.The first of these is mediocre and the second is marginally satisfactory. However, question 10b also produced a large proportion of "Not Applicable" or " Don't Know" responses.

	1	2	3	4	5	**Ave**
10a	0.0	4.0	10.5	26.5	17.0	**4.0**
10b	2.0	4.0	19.0	19.5	3.5	**3.4**
10c	0.0	4.5	15.0	30.5	8.0	**3.7**
11d	0.5	3.5	11.0	21.0	28.0	**4.1**

Life Cycle Costs

Question 10d attempts to gauge client satisfaction with DRDB's contribution to reducing Life Cycle Costs, but the results are not at all definitive. Indeed, 63% of respondents answered "Not Applicable" or " Don't Know" with 90% CCIS Client Group interviewees responding in this manner. The consultants' report concludes: *"At this point, one is tempted to conclude that the question is invalid, and needs to be recast, as the results are essentially nugatory."*

	1	2	3	4	5	**Ave**
10d	3.0	4.0	7.0	7.0	3.0	**3.1**

Benefits to Industry

Our question regarding the Branch's benefits to industry (11b) generated a mean response of 3.5, which is borderline. Once again, we experience a high level of "Don't Know" or "Not Applicable" responses. This leads us to conclude that we must employ other means to determine the Branch's industrial impact

	1	2	3	4	5	**Ave**
11b	3.0	4.0	12.5	24.5	5.0	**3.5**

Program Formulation

Six questions in the survey relate to program formulation (7a,b; 11a, c, d, e). The cumulative mean response to these questions was 3.7. This result is satisfactory, if not exceptional. Noteworthy for high scores was the question of whether DRDB provides a vital contribution to overall defence capabilities. This received a mean response of 4.1. While this, in a sense, is a "motherhood" sort of question, anything other than a high response would be cause for concern.

	1	2	3	4	5	**Ave**
7a	0	3.5	23	26.5	8	**3.6**
7b	0.0	3.5	21.5	26.0	13.0	**3.7**
11a	0.0	8.0	15.5	29.5	6.0	**3.6**
11c	2.5	10.0	10.0	22.5	19.0	**3.7**
11d	0.5	3.5	11.0	21.0	28.0	**4.1**
11e	1.0	6.5	19.5	28.0	7.0	**3.5**
Total	**10.0**	**36.0**	**81.0**	**150.0**	**70.0**	**3.7**