Defence Research and Development Canada
Recherche et développement pour la défense Canada

Looking Forward Staying Ahead 2002

...Building on R&D Successes for our Forces




DEFENCE R&D DÉFENSE

Canada

Looking Forward Staying Ahead (LFSA) is a strategic document that challenges all levels of Defence R&D Canada (DRDC) to achieve excellence by setting ambitious goals for the future.

Working within a five-year time frame, LFSA outlines policy directions aimed at bringing together the research centres of DRDC and our partners in the public and private sectors, to provide excellence in R&D for our clients, the Canadian Forces (CF) and the Department of National Defence (DND).

One of the greatest challenges for DRDC is to anticipate the future technological requirements of the CF. LFSA lays the foundation for planning research that will push the boundaries of current knowledge, thereby reducing risk and enhancing future CF operational effectiveness.

Our commitment to be the "best, most responsive and cost-effective source of information, advice and support in defence science and technology," remains as true today as it was with the publication of the first *Looking Forward Staying Ahead* in 1994.

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Table of Contents

A Message from the Chief Executive Officer 2

Introduction 4

Vision, Mission and Values 6

A Five-year Strategic Retrospective 8

Promoting Excellence and Innovation in S&T 8

Meeting Client Requirements 9

Implementing a Technology Investment Strategy 10

Using New Models for Delivery of R&D 11

Streamlining Management 13

Enhanced Collaboration with Partners 13

Building on our Successes 16

The Future Defence Technology Landscape 16

Challenges 18

Meeting the Challenges 19

Conclusion 22

A Message from the Chief Executive Officer

As a defence science and technology organization, the role of Defence R&D Canada (DRDC) is preparing the Canadian Forces (CF) and the Department of National Defence (DND) for future scientific and technological challenges. In defence R&D, we prepare for situations that we hope will never transpire. And so, when the attacks occurred on and after September 11, 2001, we were able to respond with capabilities that had been established in anticipation of such eventualities.

It was DRDC Suffield's expertise and technology in Chemical and Biological Defence, for example, that the U.S. Center for Disease Control called upon for assistance in the investigation at the Brentwood Postal Facility in Washington during the anthrax crisis. Preparedness for asymmetrical threats such as biological attacks allowed us to contribute to the continental security response when the need arose. DRDC was also well positioned to take on new roles in the changing national security environment. We were asked by the government of Canada to lead the Chemical, Biological, Radiological and Nuclear (CBRN) Research and Technology Initiative (CRTI), launched on 10 May 2002. This initiative is a unique model in which government departments and agencies work together in laboratory clusters to ensure the preparedness of Canada against CBRN threats.

Live Agent Chemical/Biological Decontamination in the Field

Our first priority, however, remains the CF. We continued to support the CF in their deployment to operations in Afghanistan and elsewhere. Operational Research staff, who were welcomed into DRDC earlier this year, have a strong track record in supporting military operations and have provided advice that has been incorporated in to Departmental decision-making. Additionally, DRDC Atlantic prepared the deployed fleet by forward ranging ships for extremely low frequency electromagnetic signatures, DRDC Ottawa provided satellite communications support to the ships, DRDC Toronto developed the specifications for the new boots and backpacks for the soldiers in the theatre, and DRDC Valcartier determined the cause of the firing problems on the ERYX missile and allowed its safe return to training and operational use.

Delivering a balanced and fiscally manageable R&D program that will meet the CF needs in current, emerging and future conflicts carries many challenges. In addition to setting out the Agency's strategic plan, this year's version of LFSA takes a retrospective look at the strategic plans over the past five years, aligning previous objectives with the requirements of the future. To ensure that the CF and Canada are prepared for the future, DRDC must look ahead – beyond the conflicts of today. This will take rigorous planning of our science and technology (S&T) program. I am confident that this strategic plan will guide us in achieving those goals.

L.J. Leggat
Chief Executive Officer

Introduction

Defence R&D has evolved significantly since the first publication of Looking Forward Staying Ahead (LFSA) in 1994, but the overall objective "To ensure that the Canadian Forces of the future remain technologically prepared and relevant" remains the same.

In the 1990's, when faced with new challenges from downsizing, the changing nature of global warfare, and competition for highly skilled S&T workers, we explored new models for delivering the R&D program. In 2000, Defence R&D Canada (DRDC) became a Special Operating Agency. The impact of these changes has been broad. The Agency now manages its own staffing and classification to improve the recruitment and retention of S&T workers. Revenue generation has allowed the Agency to have a more flexible management environment and to incorporate risk taking. Through strategic planning, cultural change and organizational development, DRDC continues to evolve as a highly responsive client-focused organization. With the addition of the Operational Research Division in 2002, the Agency is able to respond more comprehensively to Canada's defence and security requirements. We are now pursuing a closer relationship with the Royal Military College to further enhance the S&T capability in the Department.

During the eight years that LFSA has been published, this organization has responded to the challenges and objectives set out in the LFSA Strategic Plans. Reflection on the past can be a valuable exercise that leads to strategic positioning for the future. This edition therefore includes a look back at the progress and impact of the following strategic initiatives:

- *Promoting Excellence and Innovation in S&T*– to be the Canadian Centre of Excellence in leading-edge defence technology and world leader in niche defence technology areas.

Research Centres

From its national network of research centres, Defence R&D Canada delivers excellence in leading-edge technology to the CF. The Centres are:

- **Defence R&D Canada — Atlantic, in Halifax (with outstations in Ottawa and Esquimalt);**
- **Defence R&D Canada — Valcartier, outside Quebec City;**
- **Defence R&D Canada — Ottawa;**
- **Defence R&D Canada — Toronto; and**
- **Defence R&D Canada — Suffield, near Medicine Hat;**
- **Operational Research Division, in Ottawa (with military field posts in Kingston, Winnipeg, Halifax, Victoria and Colorado Springs);**
- **Defence R&D Programs, in Ottawa; and**
- **Defence R&D Corporate Services, in Ottawa.**

- *Meeting Client Requirements* – to be engaged and in tune with the CF and DND as a high-impact, valued member of the Defence Team.
- *Implementing a Technology Investment Strategy* – to have the S&T expertise and capacity to enable the CF to deal with the evolving global security environment.
- *Using New Models for Delivery of R&D* – to capture, integrate and demonstrate new technologies.
- *Streamlining Management* – to achieve administrative efficiencies and S&T productivity on par with leading R&D organizations.
- *Enhanced Collaboration with Partners* – to close the innovation gap from emerging technologies to exploitation.

The challenge for the Agency over the next five to ten years is to develop the S&T capacity to enable the CF to deal with the evolving global security environment while ensuring interoperability with our allies. One of the major S&T drivers is the Revolution in Military Affairs (RMA). The national security environment is also changing as the safety and security risks facing modern societies expand with new health hazards, climate change, bio- and cyber- terrorism, and the vulnerability of critical infrastructure.

The technology landscape will continue to evolve at a rapid rate. In the last decade, technology fundamentally transformed our society: the way we live, play, and interact with others. Twenty years ago, few could predict the profound impact of the revolution in information technology, or the emergence of the Internet and cellular phones. Looking ahead another 20 years, we are likely to see even more fundamental changes as information technology matures and current developments in genetics, nanotechnology and robotics are transformed into new applications.

Operational Research Scientists in Kosovo

We are responding to these challenges by implementing a Technology Investment Strategy and expanding our technology watch and assessment capabilities. We are also developing new partnership models to better access and benefit from technology expertise and developments nationally and internationally. The federal Innovation Strategy provides an opportunity to work with federal partners to develop new models such as the Federal Innovation Networks of Excellence (FINE) for delivering S&T in Canada. CRTI, which DRDC is leading, is an example of new approach to collaboration in R&D. Over the next year we will also develop a strategy for international collaboration in R&D to ensure that we obtain maximum benefit from our international activities. The key objectives put forward in the strategic plan focus on meeting the aforementioned challenges and taking advantage of opportunities as they arise. In addition, we will continue to work toward achieving continuing objectives set in previous editions of LFSA.

Vision, Mission and Values

Our Vision

To be known worldwide as the best in defence R&D.

Our Mission

To ensure that the CF remain technologically prepared and relevant by:

- Facilitating and enhancing the ability of decision-makers to make informed decisions on defence policy, force generation and procurement by providing expert S&T knowledge;
- Contributing to the success of military operations by pursuing R&D activities that provide improved support, knowledge, protection and response to potential threats;
- Enhancing the preparedness of the CF by assessing technology trends, threats and opportunities and by exploiting emerging technologies;
- Contributing to the creation and maintenance of a Canadian defence S&T industrial capability that is internationally competitive, by contracting-out to industry, by transferring technology to industry, and by entering into contractual relationships in which cost and risk are shared; and
- Conducting S&T projects for clients external to DND, in order to assist the agency in developing and maintaining its defence-related technological capabilities.

DRDC Scientists Receive a Federal Partners in Technology Transfer (FPTT) Award for Development of CASCAD/Blastguard – a Foam-based Bomb Mitigation and Decontamination System

Our Values

- **Commitment:** We demonstrate dedication and pride in working towards Defence R&D Canada's vision.
- **Client Focus:** We bring excellence to clients, both internal and external, by focusing efforts on discovering and meeting their needs.
- **Creativity and Innovation:** We generate innovative solutions, approaches, products or services that improve the status quo.
- **Leadership:** We actively and enthusiastically seek to exert influence and originate action to achieve Defence R&D Canada's goals.
- **Professionalism and Integrity:** We focus our efforts on achieving quality results, and we behave in an honest, ethical manner, dealing with others respectfully and fairly.
- **Teamwork:** We demonstrate effective interpersonal skills, and work cooperatively and productively within and across Defence R&D Canada to achieve common goals.
- **Trust and Respect:** We are open, honest, and responsible in our relationships and we recognize and value the contributions of others.

A Five-year Strategic Retrospective

Looking Forward Staying Ahead was first published in 1994, outlining the strategic plan for the following five years. It is an opportune time to stop and look back at the progress and achievements, focusing on the last five years. The strategic objectives of the last five editions of *Looking Forward Staying Ahead* can be grouped into the following themes:

- *Promoting Excellence and Innovation in S&T*
- *Meeting Client Requirements*
- *Implementing a Technology Investment Strategy*
- *Using New Models for Delivery of R&D*
- *Streamlining Management*
- *Enhancing Collaboration with Partners*

High Frequency Surface Wave Radar Installation in Newfoundland

Promoting Excellence and Innovation in S&T

DRDC scientists are recognized internationally as world leaders in several defence technology areas, including chemical/biological defence, human performance, novel energetic materials, electronic warfare, countermine technologies, surface wave radar and sonar. A recent example of this recognition is the call made to DRDC Suffield by the U.S. Center for Disease Control to test the air in the Brentwood Postal facility for traces of anthrax, and to assess the danger of operating in that environment. The DRDC team was the only foreign team requested to help.

Another example is the High Frequency Surface Wave Radar (HFSWR) system developed by DRDC and Raytheon Canada to detect small maritime vessels and low-flying aircraft in littoral waters beyond the radar horizon. The U.S. Counterdrug Technology Development Program Office and the Homeland Defense Technology Center are currently assessing this system's ability to detect drug smugglers and terrorists.

The many awards bestowed on DRDC staff by national and international organizations are further evidence of our impact and recognition. We have also initiated our own recognition and awards program to recognize outstanding achievements by individuals and teams in scientific, technical, management and corporate services. Very favourable peer reviews of scientific and support services by external reviewers provide further evidence of excellence.

Ultimately, the most important results of defence R&D are new or improved equipment, systems, tactics, processes and procedures as well as technological and S&T policy advice. It is DRDC's mandate to achieve these results.

Meeting Client Requirements

DRDC's mission is *to ensure that the CF remain technologically prepared and relevant.* To achieve this, we have reoriented the research programs to create and sustain a consultative environment for scientific innovation that serves the needs of our clients and prepares them to meet future technology challenges.

The Agency asks for – and acts on – feedback from clients through a variety of mechanisms set up in the last five years, including the DRDC Advisory Board, the R&D Program Board, Client R&D Overview Groups, Thrust Advisory Groups, and formal and informal client satisfaction surveys.

Examples of Innovative Solutions for the CF

- **The Canadian Integrated Biochemical Agent Detection System (CIBADS) is the first commercially available broad-spectrum chemical/biological warfare agent detector capable of autonomous operation. General Dynamics Canada markets this system commercially as "4WARN".**
- **STING (Sustained Tolerance to INcreased G) system provides G protection superior to any current operational system, used successfully by Canadian CF-18 fighter pilots in the UN Kosovo campaign.**
- **Army gear developed under the Clothe the Soldier program was ranked highest in user satisfaction in a CF survey on quality-of-life issues.**
- **High Frequency Surface Wave Radar, installed at Cape Race & Cape Bonavista, Newfoundland detects low-flying, over-the-horizon targets and surface ships.**
- **SARPlan – an aircraft mission planning tool for search and rescue missions.**
- **IMPACT (Integrated Multi-static Active-Passive Sonar Testbed) has provided the CF and Canadian industry with an experimental capability that has significantly impacted the design of the acoustic fit for the Aurora Incremental Modernization Project (AIMP).**
- **The Logistics Analysis (LOGAN) model developed by the Operational Research scientists resulted in a $10M saving for the Hercules fleet.**

- The R&D program is delivered through Thrusts which are essentially packages of R&D projects. Thrust Advisory Groups, with membership from the client groups, oversee the Thrust programs.

- Service Level Agreements with each of the five CF client groups (Maritime, Land, Air, Command and Control Information Systems, and Human Performance) are negotiated each year.

- The R&D Program Review Board, composed of senior representatives of the CF from the Client Groups and the Agency's Scientific Advisors, reviews the defence R&D program to ensure that it reflects overall CF priorities and requirements.

- The DRDC Advisory Board, formed in 2000, is composed of senior members of the department and external members from other government departments, industry, and academia. The Advisory Board meets twice a year to discuss strategic R&D issues, managerial and program challenges, linkages, and accomplishments.

The incorporation of the Operational Research Division into Defence R&D Canada will improve the integration of R&D with decision-making through closer ties between the technology R&D community and the operational research scientists within Operational Commands.

Implementing a Technology Investment Strategy

The Technology Investment Strategy (TIS) outlines the R&D we will undertake to develop the S&T capacity needed for future defence and national security, taking into account the strategic direction provided by Defence Strategy 2020 and the new approach of Strategic Capability

TIS R&D Activities

- **Command and Control Information Systems Performance and Experimentation**
- **Information and Knowledge Management**
- **Communications**
- **Human Factors Engineering & Decision Support Systems**
- **Command Effectiveness and Behaviour**
- **Autonomous Intelligent Systems**
- **Sensing (Air and Surface)**
- **Underwater Sensing and Countermeasures**
- **Space Systems**
- **Electro-Optical Warfare**
- **Radio Frequency Electronic Warfare**
- **Network Information Operations**
- **Precision Weapons**
- **Weapons Performance and Countermeasures**
- **Emerging Materials and Bio-Technology**
- **Signature Management**
- **Platform Performance and Life Cycle Management (LCM)**
- **Multi-Environment Life Support Technologies**
- **Operational Medicine**
- **Chemical/Biological/Radiological Hazard Assessment, Identification and Protection**
- **Simulation and Modelling for Acquisition, Requirements, Rehearsal and Training**

Planning. The TIS represents our strategy for in-house R&D. It involves both the reallocation of existing resources and new investments. We draw on Canadian industry, universities, other national partners and our allies to leverage the additional capabilities we need to carry out a defence R&D program based on Service Level Agreements with our Client Groups.

The TIS is based on 21 R&D Activities that span the defence technology spectrum. The TIS will evolve in response to advances in technology, changes in the security environment, and departmental strategic planning. It was recently updated to better reflect technologies that are integral to the Revolution in Military Affairs, including information technology and sensors, and projected advancements in areas such as nanotechnology, biotechnology, material sciences and power sources.

Detailed plans, including requirements for human resources and S&T facilities, have been developed. Significant progress toward implementation has already been made but there are still capacity gaps to be filled. The implementation of the TIS has been partially funded by the Department. We are now in the process of recruiting 85 workers out of the 260 additional S&T workers required.

Using New Models for Delivery of R&D

Two new competitive models for the delivery of R&D have been implemented during the past five years, which address the two ends of the technology development spectrum.

The **Technology Investment Fund** (TIF), initiated in 1998, funds high-risk, high-payoff research with potential military applications. This program currently sponsors 32 R&D projects.

One example of those projects is “Design of Magnetic Shape Memory Alloys”. Magnetic shape memory alloys are a promising new class of actuator materials with high actuation frequency, energy density, and strain. This project will develop a methodology to design magnetic shape memory alloys, and to make, characterize and refine these alloys. Ultimately, the goal is a magnetic shape memory alloy with good toughness.

TIF Projects Approved in 2002

- **Design of Magnetic Shape Memory Alloys**
- **Dielectric Actuators for Active/Passive Vibration Isolation**
- **A Critiquing System for the Improvement of the Military Estimate Process**
- **Ultra-Thin Polymer Coating Technology for Nanoscale Powders**
- **Advanced Radio Frequency Tag for Radar Satellites**
- **Novel Near Infrared Imaging Sensors**
- **Smart Materials System Development and Test for Aircraft Structures**

The **Technology Demonstration Program** (TDP), initiated in 1999, is designed to contribute to defence modernization by demonstrating the use of technology for defence solutions. One of the first projects was MILSATCOM Performance Enhancement, which had as its objective the development of a unique Canadian technology for military communications satellites, increasing their bandwidth. A commercial version of the technology is being built for the Telesat Canada Anik F2 satellite. Another project approved early

Technology Demonstration Projects to Start in 2002

Soldier Integrated Headwear System

Integrated Communications Electronic Warfare Analysis and Radio Frequency Sensor

Force Protection against Enhanced Blast

Unmanned Airborne Surveillance

Common Operating Environment (COE) – Based Multi-Sensor Integration

Advanced SATCOM Terminal

in the TDP program is Towed Integrated Active-Passive Sonar (TIAPS) which will define, build, and demonstrate a sonar concept as a candidate to replace the current CANTASS sonar in the Halifax class frigates. TIAPS combines state-of-the-art passive towed-array sonar with tactical low-frequency active towed-array sonar. TIAPS promises improved detection ranges against the modern, quiet submarine through the use of low-frequency sound. Many of the concepts have been successfully demonstrated in sea trials.

Projects to start in 2002 include "Force Protection against Enhanced Blast." This project focuses on new methodologies to protect against the threat of enhanced blast. It includes characterization of the blast environment from enhanced blast weapons and the development of countermeasures and protective measures that minimize blast effects.

A **Technology Outlook Thrust** has also been initiated to identify emerging technologies, assess their potential relevance to Canadian defence and provide advice on the impact of S&T developments on national and departmental policies and strategies.

As part of this Thrust, DRDC co-sponsors symposia/workshops to place new and emerging issues in S&T on the defence strategic agenda. Especially noteworthy are the "Revolution in Military Affairs" symposium in 1998 and the follow-on "Modelling and Simulation and Concept Development and Joint Experimentation" symposium held in April 2000. The results of these symposia led to the formation of three new organizations in the Department:

- Director General Joint Force Development;
- Future Force Synthetic Environment Section at DRDC Ottawa; and
- The Canadian Forces Experimentation Centre, co-located with DRDC Ottawa, to address future defence capabilities in terms of doctrine, technology and organization.

A joint symposium on Knowledge Management was held with other DND groups in September 2002 to develop a departmental strategy for Knowledge Management.

The Technology Outlook Thrust

- **Symposia/workshops on emerging issues**
- **Expert assessment of emerging technologies**
- **Technology Watch and Foresight to provide early warning of technology developments, evaluation of those developments and their potential impact**
- **Research and implementation of Knowledge Management practices**
- **Communication on emerging technology issues and recent advances in technology**

Streamlining Management

On 1 April 2000, Defence R&D Canada was formed as a Special Operating Agency (SOA), with additional delegated authorities in financial and human resources management.

One of the first objectives established upon obtaining Agency status was to optimize cost effectiveness, efficiency and quality in delivery of the R&D program by increasing the in-house effort devoted to R&D by 20% from the 1999 baseline by 2004. A Project Activity Reporting System (PARS) has been developed to capture the efforts of staff to various tasks, and to compare with the 1999 baseline. Efficiencies are being obtained mainly through streamlining of internal processes and offloading tasks to support staff.

Other management initiatives included:

- Career management for all staff;
- Succession planning and leadership development; and
- Participation of all staff in the development of a new vision and set of values reflective of the Agency's mission.

We continue to pursue management and cultural changes reflecting our new values to enhance our innovative environment and achieve world-class excellence in defence science and technology.

Enhanced Collaboration with Partners

DRDC has a long history of partnering, especially with our international allies through The Technical Cooperative Program (TTCP), the North Atlantic Treaty Organization (NATO), and bilateral and trilateral agreements.

The unique relationship that Canada shares with the U.S. has benefited the Canadian defence R&D program, and has led to the successful development, commercialization and exploitation of many technologies and systems. It has also led to favourable conditions for Canadian industry to access U.S. defence programs. The U.S. Department of Defense (DoD) is the largest single sponsor of technology development in the world. To develop defence capabilities compatible with future U.S. forces, it is critical for Canada to access advanced technologies from the U.S. Cooperation in S&T at an early stage of concept and equipment development is a precursor to effective interoperability.

On the national S&T scene, DRDC has played a leading role in the development of the Federal Innovation Networks of Excellence (FINE), in which federal labs, universities and the private

Testing the Seaweb underwater acoustic network for the joint CA/US Rapidly Deployable System (RDS-4) Project

Examples of Current Projects with the U.S.

- **Advanced Distributed Mission Trainer – to develop and demonstrate a new generation of cost-effective, distributed air combat simulation.**
- **Production of vaccines and prophylaxes – to protect military personnel against biological weapons agents, such as smallpox.**
- **Coalition Aerial Surveillance and Reconnaissance (a multi-national project) – which integrates different forms of surveillance information and processes to provide an improved coalition operational picture to the war fighter and ensure interoperability among allied nations.**
- **Soldier Information Requirements – to define and validate the performance requirements for the future soldier system.**
- **Common Operating Picture – to provide a number of features related to knowledge environment, visualization, decision support, geospatial and imagery information services, and interoperability among coalition forces.**
- **Hard Chrome Alternative Technologies – to adopt high velocity, high temperature jet spray coating technology for certain aircraft components.**
- **High Energy Missile for Light Combat Vehicles – to demonstrate the concept of a small hypervelocity missile that would provide the firepower of a main battle tank in a light combat vehicle.**

sector would be networked under federal leadership to augment and integrate Canada's S&T capacity. The objective is to provide solutions to national policy issues and to seize economic opportunities. DRDC leads a pilot project for FINE called the Chemical, Biological, Radiological and Nuclear Research and Technology Initiative (CRTI) on behalf of the federal S&T community. CRTI is a fund of $170M over five years established in the December 2001 federal Budget. The initiative will strengthen the nation's preparedness for a CBRN terrorist attack by investing in research and technology, that supports the development of new capabilities in CBRN preparation and response.

CRTI Investment Priority Areas

- **Lab Cluster Management and Operations**
- **Collective Command, Control, Communications, Coordination and Information (C4I) Capabilities for CBRN Planning and Response**
- **Equipping and Training First Responders**
- **Prevention, Surveillance and Alert Capabilities**
- **Immediate Reaction and Near-term Consequence Management Capabilities**
- **Longer-term Consequence Management Issues**
- **Criminal Investigation Capabilities**
- **S&T Dimensions of Risk Assessment**
- **Public Confidence and Psycho-Social Factors**

Building on our Successes

The Future Defence Technology Landscape

The future technology landscape will continue to evolve at an accelerated pace. Increasingly, we will see the influence of commercial technologies on military systems. DRDC's Technology Outlook Thrust was conceived to identify emerging technologies, assess their potential relevance to Canadian defence and provide advice on the impact of S&T development on national and departmental policies and strategies. Assessments of emerging technologies are conducted and technology watch methodologies are being refined and applied in the defence context to provide early warning of developments in S&T.

The hardware that enables information technology will continue to evolve, yielding more processing power, memory and speed. Computers will be everywhere, with chips embedded in equipment and clothing. Microprocessor chips, 10,000 times more powerful than those we use today, are possible with revolutionary new technologies. Optical computing is just around the corner, and quantum computing is on the horizon. The challenge will be to develop software that can manage the growing amount of information. To quickly take advantage of new developments, modular object-oriented software systems are required that can easily be upgraded.

As our knowledge of specific genes and their interactions increases, the techniques of recombinant DNA, cell fusion and gene splitting will enable the transfer of complex multi-gene characteristics into cells and organisms. Substances with new properties will be produced, such as those for discrete recognition of a particular organism, compounds that modify biological responses, artificial body fluids and new foods. Advances in the medical sciences, such as artificial blood, rapidly growing skin and tele-medicine, will reduce requirements for on-site medical support in all military operations.

Assessment of Emerging Technologies

- **Advanced Power Sources – completed**
- **Nanotechnologies – completed**
- **Future Military Logistics – in progress**
- **Exploitation of the Human Genome – in progress**
- **Non-Conventional/Non-Lethal Weapons – in progress**
- **Net Centric Warfare – planned**
- **Intelligent Autonomous Systems – planned**
- **Sensors/Activator to Monitor and Improve Health and Cognitive Abilities – planned**

Genetic engineering offers the prospect of providing treatments and cures for most diseases, and genetically modified crops will offer the potential to improve the nutrition of the world's mal-nourished people.

Our increasing understanding of the brain will provide clues to the origins of conflicts and the psychology of warfare. Electronic devices that couple directly to the brain are already available. Safe drugs will be available to temporarily enhance cognitive and physical performance. The improved fidelity of simulators will allow a shift to training in virtual environments. Improved training methods will reduce training periods from months to weeks.

Through the skillful incorporation of smart sensors, adaptive control (computer) systems, and actuators (active systems), smart structures will be developed that can adapt themselves to changes in operating conditions or environmental parameters, thus exhibiting greatly enhanced performance. Networks of sensors, systems and weapons will provide robust enhancements to battlefield information flow and weapons effectiveness.

Molecular manufacturing – the ability to design and manufacture devices that are only tens or hundreds of atoms in dimension – promises rich rewards in electronics, sensors, and materials. The usefulness of molecular manufacturing depends on the ability to produce large enough structures and sufficient quality and quantity to be effective. While this may not become a reality within the next ten years, a wide range of micro-electronic mechanical systems (MEMS) will be available, incorporating various sensors, actuators, transmitters and power sources on a single chip. Development of future MEMS and nanotechnology devices may ultimately rest on the ability to manufacture and package adequate power

Simulation to Test Vulnerability of LAV-3 Vehicle

sources. In fact, power sources, from tiny batteries to megawatt diesel generators, are key to all military operations. New equipment and systems enabled by advanced technologies will require reliable power sources. Numerous power generation technologies are currently being evaluated, including fuel cells, hydrogen as fuel for engines and turbines, molecular motors, boot-heel strike electrostrictive power, micro-turbogenerators that can be embedded into handheld devices, and chip-mounted electric devices for portable power generation and storage.

Robotic Systems will be fully exploited on the future battlefield (e.g., micro robots for surveillance and target identification, and robotic weapon systems). Primary roles will include early sensing and shaping of the battlespace prior to and during force deployment. Robots or remotely controlled platforms, such as unmanned combat air vehicles and tanks, will be common on the battlefield in the near future. Developments in autonomous systems will also allow reduced crew for most platforms.

Space will be an increasingly important component of the global security environment. For future coalition warfare, space superiority will be fundamental to coalition defence posture and operations. Advances in microstructural materials, nanotechnologies, highly efficient power sources and cheaper launch vehicles will continue to drive down the cost of space systems and make it increasingly economical to deploy wide area surveillance and early warning systems in space. Trends evident in the development of space systems include the increasing availability of high-resolution commercial imagery satellites, smaller satellites with greater on-board processing power, assembly-line production of constellations of satellites, and concerted efforts to develop less expensive launch vehicles.

New technology applications will also be needed to monitor and deal with emerging global security issues such as population growth, ecological degradation, infectious disease, and the safety and security of food and water resources. Global warming will also challenge the international community as indications of a warming climate occur, such as meltbacks of polar ice, sea level rise, and increasing frequency of major storms.

Challenges

The Technology Investment Strategy will continue to evolve with the changing technology landscape. Full implementation of the TIS remains a challenge. The Agency is on track to meet its targets in revenue generation, and national and international leveraging as well as the projected increase in in-house effort devoted to R&D. National security issues are being addressed through CRTI. Good progress has been made in implementing the CF

Continuing Key Objectives

- **To fully implement the Technology Investment Strategy by 2004.**
- **To develop and implement a detailed facilities plan for infrastructure renewal.**
- **To annually leverage $30M from national partners and $30M from allies, and to generate $10M in revenue from external sources by 2004.**
- **To increase the in-house effort devoted to R&D by 20% from the 1999 baselines by 2004.**
- **To develop a strategy to secure funding to add a Canada-U.S. collaboration element to the Technology Demonstration Program by March 2003.**
- **To partner with industry on five international projects.**
- **To initiate R&D in at least three new areas that address national security issues by 2003.**
- **To achieve, in cooperation with the Deputy Chief of the Defence Staff and the Vice Chief of the Defence Staff, the full operating capability of the Canadian Forces Experimentation Centre by September 2003.**
- **To have at least three concepts based on emerging technologies accepted for experimentation by September 2003.**
- **To recruit 85 new S&T workers by 2003.**

Experimentation Centre. The Unmanned Airborne Surveillance Technology Demonstration Project has been adopted for experimentation.

The Revolution in Military Affairs is being enabled by the integration of rapidly advancing technologies, such as long-range precision capability, sensor technologies, low observable technologies, and information and systems integration technologies. These technologies are changing the nature of conflict. We are seeing the emergence of new ways of military thinking and new approaches in the uses of technology, through the Revolution in Military Affairs (transformation/modernization of the warfighter, interoperability, agility). New threats have arisen in the form of global terrorism, which present challenges both internationally and domestically.

The ability of the CF to defend against increasingly sophisticated weapons, including those associated with asymmetric attacks and weapons of mass destruction (WMD), is a key issue. The increasing availability and sophistication of offensive weapons is attributable to advances in arms-related technologies, and increased accessibility of adversaries to advanced hardware. Proliferation of advanced technology will likely become more prevalent through sales, exploitation of dual-use related systems and indigenous (probably niche) developmental programs. Greater vigilance will be required to deal with threats to information systems.

Leveraging scarce technology, research, and development funds is essential to address the key challenges faced by the CF. Recent terrorist attacks have strengthened the need for collaboration with the U.S. and other allies on a broad range of defence and national security issues. Collaboration with the U.S. will also enhance the Canadian technology industrial base and help it become more competitive internationally. It offers Canada access to advanced technologies and provides Canadian industry better access to opportunities in the U.S. The U.S. defence technology developments are increasingly dual-use with commercial applications. It is therefore important to maintain strong links with the technology generators in the U.S. to advance the Canadian agenda of economic development and technological innovation.

Interoperability, particularly with the U.S., remains a priority for the CF. The recent incident in Afghanistan during Operation Apollo, in which four members of the CF were killed by friendly fire from a U.S. aircraft illustrates the importance of interoperability in combined air and land operations. The Combat Identification (CID) capability can only be achieved by combining non-materiel solutions (tactics, techniques and procedures, restrictive rules of engagement and training) with the development of appropriate technologies to improve situational awareness and target identification sensors.

Meeting the Challenges

The Canadian defence R&D program focuses on strategic technologies that will benefit CF operations, systems, equipment and tactics, and protection of military personnel. The Technology Investment Strategy identifies the R&D capabilities that will be required by 2005 to support the realization of the CF 2020 vision. During the next year, concept papers will be developed to examine the evolution of linkages between the TIS and the future technology landscape to the longer-term future environment and requirements of the Canadian Army, Navy, Air Force and Joint

Forces. We will also explore new methodologies to set priorities and to ensure a balance of investment between client groups, immediate, near and long-term requirements, and external and internal R&D funding.

The rapid development of new technologies, both domestically and internationally among Canada's allies, continues to demand that we increase our ability to monitor S&T developments at home and abroad. An enhanced "technology watch" capability is required to identify S&T trends of significance to defence and national security, influence our R&D program priorities, leverage our R&D program, and avoid technological surprises for the CF. Dual-use (military/civilian) technologies have become a growing part of "technology watch"in which advances in one domain may be adopted or adapted to fit the needs in the other. Such awareness and utilization reduces unnecessary duplication, optimizes the productivity of defence-related S&T spending, and finally enhances the value of continued and expanded international collaboration.

DRDC is a key player in federal S&T initiatives to develop new models for delivering government science to support the federal Innovation Strategy. DRDC's leadership of CRTI serves as a good example. We will continue to be part of the federal science initiatives, with the objective of garnering a minimum of 10% of any new federal science initiatives.

The Defence Industrial Program (DIR) has proven to be an effective program for assisting Canadian industry in developing knowledge and equipment for future use by the CF. There is an opportunity to link our DIR Program with the U.S. Dual Use Science and Technology (DUST) program.

The Operational Research Division became part of DRDC on 1 April 2002. One of the priorities will be to harmonize planning processes, including the Technology Investment Strategy, so the synergy between R&D and Operational Research is fully realized. One step in this direction is through joint projects.

New Key Objectives

- **Produce concept papers on strategic S&T issues for the Army, Navy, Air Force and Joint operations in the future by 2004.**
- **Develop an enhanced Technology Watch program, and identify and analyze five strategic technologies that could have significant impact on defence and national security by 2004.**
- **Work with other federal science-based departments and agencies to develop new models and to obtain increased funding for federal S&T. Garner at least 10% of the increased funding.**
- **Expand the Defence Industrial Research program and link into the U.S. Dual Use S&T program with three joint projects by 2004.**
- **Initiate five joint activities among research centres and the Operational Research Division over the next two years.**
- **Establish a Defence Research Institute in partnership with the Royal Military College with full operational capability by 2005.**
- **Develop a strategy to maximize the benefits from international collaboration.**

The Royal Military College (RMC) at Kingston educates and trains future leaders for the CF. RMC provides advanced degree programs and professional development for postgraduate students in key areas of engineering, humanities, and science in support of the CF. In addition, RMC undertakes research in several technology areas that are of vital importance to national defence. RMC and DRDC are exploring the concept of a jointly managed Defence Research Institute that would mutually benefit both organizations. Such an Institute will provide DRDC with an expanded S&T capability and RMC with an enhanced capability to support the Post-Graduation Training Program. The net effect will be more capability for DND and the CF for the same investment, as well as trained officers with post-graduate training in advanced technologies.

NATO Field Experiment to Develop Countermeasure Techniques Against High Resolution Radars

International collaboration exists through scientists' networks with their colleagues, participation in international panels and conferences, and, more recently, through specific joint projects with our allies. Benefits of international collaboration include access to allied technologies, knowledge of world technology advances, leverage of knowledge, technology and expertise, development of networks of trusted contacts for time of crisis/conflict, and improved interoperability. A strategy on international collaboration will ensure that the agency does not miss any opportunities and maximize the benefits achieved from collaboration.

Conclusion

Since the first version of Looking Forward, Staying Ahead was published in 1994, we have continuously addressed the challenges of managing the defence R&D program for the technological preparedness of the CF within a rapidly changing environment. Embarking on new strategic directions that focused on military clients, new delivery models, national and international partnerships, technology investment, fiscal and human resources management, and innovation has positioned Defence R&D Canada to conceive and exploit future opportunities. Past successes and lessons learned can be leveraged towards our vision of being known as the best in defence R&D.

Defence R&D Canada will build on past strategies by continuing to focus the R&D program on future client needs and finding efficiencies in management structures and techniques. The investment in our intellectual capital will continue to grow as we build our capabilities and contribute to Canada's Innovation Strategy. We will pursue partnerships with our closest allies and work with the Canadian defence and scientific communities to build our national capacity.

Anticipating future threats and opportunities in the defence environment will be an ongoing concern of Defence R&D Canada. Along with the CF and other DND stakeholders, we recognize that the need to anticipate disruptive and emerging technologies is stronger than ever. Focused and collaborative efforts in technology watch will be required to anticipate the military needs of the future. This strategic plan will assist us in achieving these objectives by continuing to look ahead for our CF clients.