Defence Research and Development Canada
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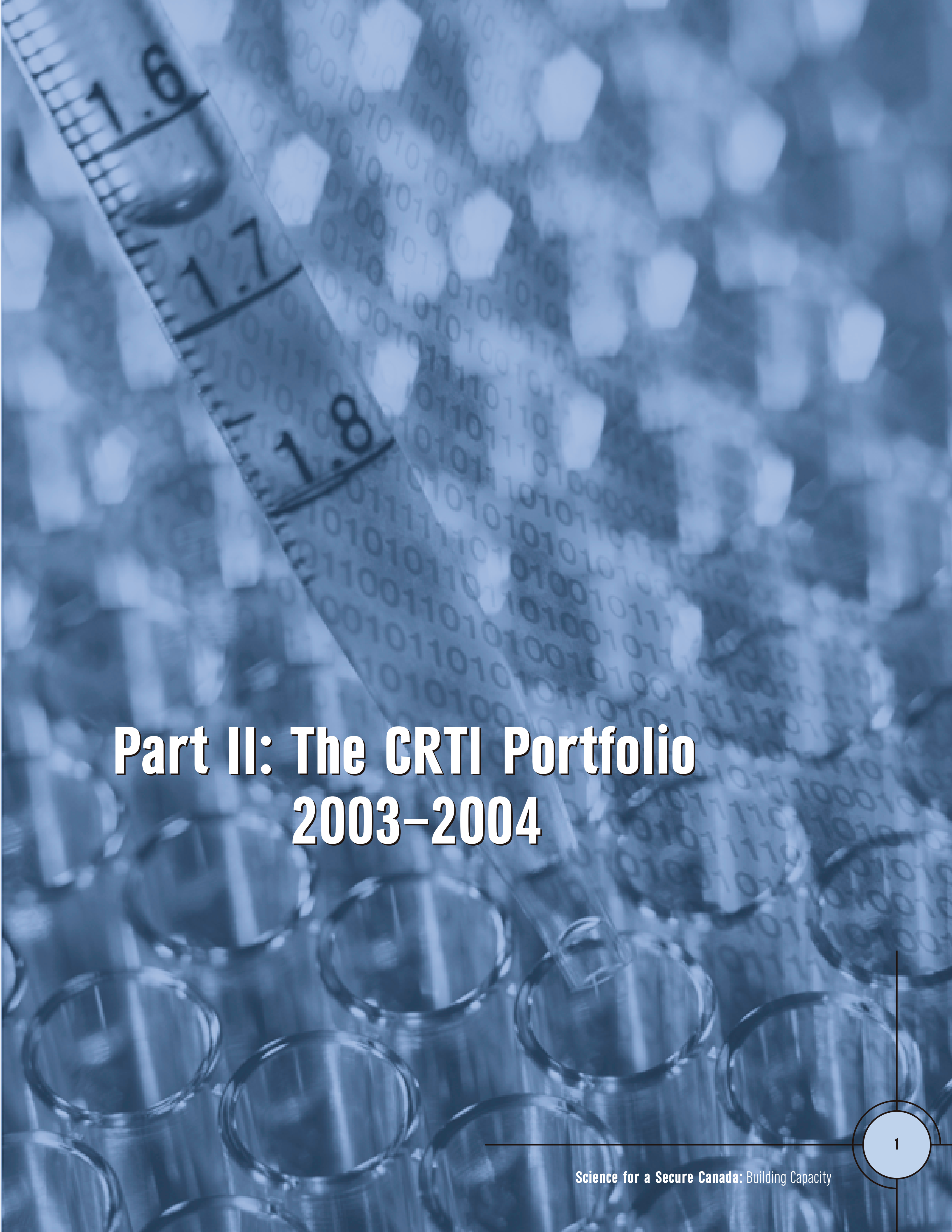
CRTI-IRTC

Science for a Secure Canada: Building Capacity

Part II: The CRTI Portfolio 2003-2004

Canada



Part II: The CRTI Portfolio 2003–2004

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The Chemical, Biological, Radiological and Nuclear (CBRN) Research and Technologies Initiative (CRTI) was announced in the December 2001 National Security Budget as one of the Government of Canada's Public Security and Anti-Terrorism initiatives. CRTI has a five-year mandate to manage a $170 million science and technology fund to invest in Canadian preparedness against CBRN threats. In the first year of operation, 24 Research and Technology Development (R&D) and Technology Acquisition projects were funded.

In the second round of project selection in 2003 a portfolio of Technology Acceleration (TA) and R&D projects was chosen based on the following factors:

- Evaluation criteria (utilization, delivery, management, leveraging collaborations and contributions);
- Mandatory requirements of innovation, relevance and uniqueness;
- The funding envelope;
- CRTI investment priorities; and
- The CRTI Framework.

The 2003–2004 CRTI portfolio is presented in Part II of this Annual Report.

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CRTI 02-0007TA

Medical Countermeasures Against Ricin

Project Lead: Defence Research and Development Canada – Suffield

Industrial Partners: Twinstrand Therapeutics, Cangene Corporation

Ricin has become a serious threat to civilian and military personnel—and public confidence—for two main reasons: it is one of the most toxic substances known, and it is readily accessible in most parts of the world. Lethal in microgram quantities—whether by inhalation or injection—it poses the greatest threat through an attack involving aerosolized forms of the toxin. Moreover, public concern about the ricin threat is fuelled by an absence of effective antidotes. The objective of this CRTI-funded project is to develop a fast-acting and effective antidote to ricin intoxication.

Ricin is a highly toxic protein product of the castor bean, a plant cultivated worldwide for its oil and for ornamental purposes. Millions of tonnes of castor beans are grown annually with major production in Brazil, India and China. The ricin toxin comprises approximately five per cent by weight of the bean, and the protein is readily extracted from beans using low-tech methods.

Despite the benefits of the castor bean, ricin has an ignoble history: it has been used in assassinations in the United Kingdom (UK) and found in the possession of white supremacists in the United States (US) and members of a terrorist cell in the UK. Recently, a flask containing ricin was found in a Paris train station, while elements of the former Ba'athist regime in Iraq are suspected of having developed ricin-based weapons.

The rapid clearance kinetics of the ricin toxin makes a countermeasure strategy based on the passive immunization of afflicted personnel preferable to vaccination. This is because a ricin attack would have to be precisely anticipated days or weeks in advance for a ricin vaccine or ricin booster to be effective.

Twinstrand Therapeutics, Cangene Corporation, and Defence Research and Development Canada (DRDC) will use complementary expertise to generate antibody-based countermeasures to ricin. Twinstrand Therapeutics will develop non-toxic ricin antigens with similar or identical immunogenic properties to the authentic toxin. Cangene will use the Twinstrand antigens to generate polyclonal caprine and monoclonal human antibodies. DRDC will evaluate the effectiveness of different antibody preparations in animal challenge experiments.

Key to the success of the project is the structure and activity of ricin antigens. Antibodies prepared using protein fragments or chemically modified or denatured forms of ricin are known to cross-react poorly with the natural toxin. Observations indicate that a full-sized and properly folded protein is necessary for effective immunization and antibody screening. However, Twinstrand has made proteins that are full-sized and properly folded ricin antigens.

Twinstrand has developed unique expertise in the design, expression, and purification of recombinant ricin-like molecules and has patented methods for controlling or attenuating the cytotoxic activity of these proteins. This means dosages for immunizing animals can be improved because the antigens are non-toxic. Recombinant ricin antigens will be made using a *Pichia pastoris* yeast expression according to Good Manufacturing Practices defined by the US Food and Drug Administration.

As a commercially successful leader in the development of antibody-based therapeutics, Cangene Corporation also has relevant expertise in the development of human monoclonal antibodies. The company has proprietary expertise in the preparation of hyperimmune products involving stimulation of the immune system; extraction, purification and decontamination of immunoglobulin from hyperimmune sera; and formulation of immunoglobulins for parenteral use in humans. Cangene will apply its expertise to produce hyperimmune ricin antisera in goats and simultaneously screen antibody phage libraries for ricin-neutralizing monoclonals. This two-pronged approach will facilitate the rapid generation of an antidote based on caprine polyclonal antibodies while enabling the long-term development of an antidote based on human monoclonals.

DRDC Suffield will determine the effectiveness of the polyclonal and monoclonal antibodies using its unique facilities for animal challenge experiments and drawing on its significant background in the handling and testing of ricin. At the conclusion of the project, the consortium will deliver a ricin antidote suitable for scale-up, human testing, commercialization, and protocols for the use of the antidote.

CRTI 02-0021RD

Direct Detection and Identification of Bioweapons' Nucleic Acids Based on Cationic Polymers

Project Lead: National Research Council – Industrial Materials Institute

Federal Partners: National Research Council – Steacie Institute for Molecular Science, Health Canada

Industrial Partners: Université Laval, Centre hospitalier universitaire de Québec, Infectio Diagnostic Inc.

Current detection technologies of biothreat agent nucleic acids rely on prior amplification, a time-consuming critical step sensitive to inhibitors present in the sample. It is also prone to false positive results because of cross contamination of reagents or laboratory infrastructures. A revolution in the field will occur when low-cost portable devices capable of real-time detection and identification of nucleic acids without prior amplification becomes available. This project aims at developing such a sensitive, rapid and compact technology.

This project will provide proof of concept for the development of nucleic acid biosensors that should allow real-time detection and identification of biological pathogens. The proposed technology features simple preparation, trapping, and preconcentration of samples combined with polymeric transducers. The approach will combine minimal sample preparation, highly selective capture and preconcentration of the targets, as well as real-time optical detection using water-soluble, cationic, polymeric transducers.

This novel and simple technology should therefore provide first responders and public health providers with the ability to conduct on-site, rapid detection and identification of potential bioweapons. It should also provide better capabilities for medical triage procedures and high performance tools for detection and classification of events. This will also contribute to the efficient diagnosis of infectious diseases and genetic disorders.

CRTI 02-0024RD

Probabilistic Risk Assessment Tool for Radiological Dispersal Devices

Project Lead: Defence Research and Development Canada – Ottawa

Federal Partners: Canadian Nuclear Safety Commission, Public Safety and Emergency Preparedness Canada, Canada Border Services Agency

Industrial Partners: University of Ontario Institute of Technology, Science Applications International Corporation Canada

Recent events, such as the alleged al-Qaeda plot to employ a radiological dispersal device (RDD), have focused attention on the use of RDDs as terrorist weapons. However, many questions remain about the feasibility and efficacy of RDD construction. This lack of knowledge leads to risk assessments and emergency response plans based on conjecture or even misinformation. There is a need for a comprehensive probabilistic risk assessment (PRA) to address all aspects of RDD construction and use.

This project is aimed at creating a comprehensive risk assessment addressing all aspects of RDD construction and use, including source acquisition, construction risks, delivery mechanisms, consequences of use, and possible countermeasures. Risk assessments based on sound inputs from a number of communities and, whenever practical, experimental trials will facilitate intelligence assessments, border or criminal surveillance, and the search for critical gaps in radioactive materials security. The project will also provide users in defence, nuclear regulation, law enforcement, border enforcement, and intelligence with a software tool that provides access to the risk assessment database.

The principal outcome of this project will be a well-researched and experimentally validated PRA for the construction and use of RDDs. The PRA will be developed through the event- and fault-tree analysis used in the nuclear and software industries, drawing upon data on source security, border security, intelligence trends, health physics, and dissemination modalities. The project will target knowledge gaps in construction feasibility and radiological dispersion through experimental investigation and modelling.

Access to the PRA will be made possible by another key outcome of the project, the software tool. The software will enable users to search for possible risks based on combinations of inputs, such as specific sources or other RDD components, or to identify critical gaps in defence against radiological terrorism. The tool will contain information on selected RDD modalities, including the nature and extent of a potential hazard, and possible countermeasures or steps for remediation. Users will be able to develop realistic risk assessments based on incomplete data that take into account all aspects of RDD construction and use. The user will feed in patterns ranked by probability, consequence, or risk, as desired, and receive potential scenarios matching those patterns. These scenarios will include consequence estimates, additional indications to look for, and even potential countermeasures. By providing this input in such an accessible and flexible form, and providing so much useful information in the package, this project will introduce an unprecedented capability to the software's many user communities.

The project lead, the Radiological Analysis and Defence Group at DRDC Ottawa, is a world leader in radiation dosimetry and spectrometry research. They provide radiation protection support to the Canadian Forces and would be a key player in Canada's response in the event of a radiological incident. The other federal government partners are expected to be potential users of the risk assessment and the risk assessment tool, and bring important perspectives to the project.

Other project partners are the University of Ontario Institute of Technology (UOIT) and Science Applications International Corporation (SAIC) Canada. UOIT, Canada's newest university, will bring a specific focus on radiation science. SAIC Canada will be the lead contractor for the project, providing expert knowledge of PRA, event- and fault-tree analysis, atmospheric dispersion modelling, radiological consequence analysis, physical chemistry, chemical analysis, database analysis, and software development.

CRTI 02-0035RD

Canadian Network for Public Health Intelligence

Project Lead: Health Canada – National Microbiology Laboratory

Federal Partner: Defence Research and Development Canada

Industrial Partners: TDV Global Incorporated, Canadian Public Health Laboratory Network, TR Labs, University of Guelph, Canadian Council of Medical Officers of Health

The foundation for bioterrorism preparedness and public health safety is an infrastructure or framework that integrates surveillance, epidemiology and laboratory information. An infrastructure would enable health responders to quickly and efficiently identify, communicate and respond to bioterrorist threats. Canada currently lacks a national framework that integrates such expertise and data.

Although Canada has infectious disease expertise and data collection systems, they exist in unconnected pockets across the country. Public health information within provinces and across Canada remains circumscribed by jurisdiction (e.g., local vs. provincial vs. federal); agency or department (e.g., First Nations and Inuit Health Branch vs. Population and Public Health Branch or Health Canada vs. Canadian Food Inspection Agency); and discipline (e.g., laboratory vs. epidemiology or medical community vs. law enforcement and public defence).

This project is aimed at creating a Canadian Network for Public Health Intelligence (CNPHI) that will encourage the timely sharing of information among jurisdictions by integrating relevant public health intelligence into a common national framework. By establishing a framework to collect and process surveillance data, disseminate strategic intelligence, and coordinate responses to biological threats, the CNPHI will improve the capacity of the Canadian health system to reduce human illness associated with infectious disease events.

The objectives of the CNPHI include enhancing Canada's biological event detection, response and preparedness capabilities, and maintaining current jurisdictional boundaries while finding new ways to leverage available Canadian resources and infrastructure. The CNPHI plans to develop an innovative information technology architecture that will enhance the existing public health infrastructure and support data sharing and collaboration among jurisdictions.

The project will include the following activities:

- Creating the Canadian Intelligence and Outbreak Surveillance Centre (CIOSC). CIOSC will be a secure web-based environment that will enable the strategic dissemination of timely laboratory and epidemiology intelligence, including syndromic surveillance, food safety, international disease reports, and other national surveillance information. CIOSC will focus on key laboratory and epidemiological surveillance data as the initial sources of data, such as PulseNet Canada, the National Enteric Surveillance Program and syndromic surveillance pilots.
- Supporting regional and national centres of excellence to build or enhance decision support models and simulations. These models and simulations will focus on either very specific, localized tools, such as decision trees, protocols, automated decision support for alerts, and so on, or on larger decision support and simulation exercises for response capacity and capability evaluation, such as an outbreak exercise to test resource readiness.
- Creating a secure operations centre response framework at local, regional and national levels to coordinate and facilitate response actions using the decision support and simulation tools identified above. This framework will work collaboratively with the Centre for Emergency Preparedness and Response (CEPR) of Health Canada to allow events to be escalated into the CEPR National Operating Centre environment based on their severity. The framework will also support coordination with other key emergency response stakeholders, such as the Department of National Defence and the Royal Canadian Mounted Police (RCMP).
- Providing access to specialized resources, including training resources, for public health stakeholders and first responders, supporting capacity building in the field of bioinformatics and developing, conducting and participating in simulation and scenario exercises to ensure response readiness.

CRTI 02-0041RD

Real-Time Determination of the Area of Influence of CBRN Releases

Project Lead: Atomic Energy of Canada Limited – Chalk River Laboratories

Federal Partners: Environment Canada, Health Canada

If terrorists ever released CBRN material into the atmosphere, an advective airborne plume would form and become more generally dispersed by ambient wind and turbulence fields. A large fraction of the material would end up on the ground, particularly if precipitation occurred during or after the release. CBRN material deposited on urban or agricultural surfaces carry health and economic consequences long after the primary plume has passed. Such a situation requires the best possible knowledge of where and when the material will be deposited, with the shortest possible delay between release and forecast. Decision-makers wanting to minimize health effects and return valuable land to service need this information to assess needs for evacuating populations, determine evacuation routes, implement protective measures, and deploy response teams and plan cleanup activities.

This project is aimed at providing first responders and decision-makers with reliable, real-time forecasts of the timing, location and amount of deposited CBRN material, so that, for both the short and long term, they can respond quickly and effectively to a terrorist event involving an atmospheric release. To achieve this goal, a sophisticated computer model that addresses four key areas is required: forecasting the trajectory and concentration of CBRN material in air; forecasting the location, duration and intensity of precipitation; calculating the amount of airborne material deposited on the ground when it is raining or snowing; and calculating deposition in the absence of precipitation. Such a model will be developed by updating the Canadian Emergency Response Model (CANERM) and Lagrangian Particle Dispersion Model (LPDM) codes currently used in Canada to handle emergency situations. These models will be expanded and improved in the following ways:

- Developing a new numerical approach to deal with small horizontal scales, which will result in improved predictions of air concentrations, and modifying the models to accept radar-derived precipitation fields.
- Improving short-term (0–6 hours) precipitation forecasts with data from Canadian and US weather radar networks, generating longer-term forecasts with the numerical weather prediction system now used by the Meteorological Service of Canada, and blending the radar and numerical forecasts to create the best prediction.
- Replacing the empirical washout model used in CANERM and LPDM with a new model that accounts for the physical and chemical processes affecting wet deposition (precipitation intensity, drop-size distribution, turbulence levels and the characteristics of the CBRN material), and using the information generated to calculate time variances in the concentration of material in rainwater and snow at ground level.
- Updating the current dry deposition model used in CANERM and LPDM by taking account of gas phase removal by atmospheric species, such as hydroxy radical, peroxy radical and

ozone, and by considering the interaction of CBRN materials with background aerosols, and incorporating the predicted evolution of aerosols and gas phase species into the dry and wet deposition models to enhance the accuracy of the removal estimates.

These four components will then be combined into one integrated system and tested before being put into operation. The final model will be able to be used with any airborne contaminant, whether chemical, biological or radioactive, providing a reliable tool for predicting the concentration of CBRN material on the ground as a function of space and at a sequence of forecast times. Following a terrorist attack, it will generate deposition maps, providing first responders and decision-makers with the ability to assess and manage the incident.

This project will create benefits beyond the ability to manage terrorist incidents. Using weather radar data to predict precipitation fields is a groundbreaking technique that promises to improve forecasts dramatically. Routine precipitation forecasts are expected to use the methods developed here and make a positive impact on the Canadian economy and human safety. The new model will also improve the role that CANERM plays in handling the accidental release of radioactive and other hazardous materials, as well as provide the capacity to evaluate the consequences of hypothetical accidental releases during safety assessments.

CRTI 02-0041TA

Deployable CBRN Monitoring Network

Project Lead: Health Canada – Radiation Protection Bureau

Federal Partners: Canadian Nuclear Safety Commission, Environment Canada

Industrial Partners: Bubble Technology Industries, General Dynamics Canada

Addressing the unpredictable nature of terrorist initiated and accidental events, this project is aimed at creating a sophisticated CBRN detection and monitoring network that can be deployed quickly to wherever needed and operated remotely from any location. The network will fill a gap in Canada's emergency response capability, delivering detailed quantitative data for use in evaluating emergency response and long-term follow-up through interfaced sensors. Key to its design is the flexibility inherent in modern technology—flexibility in communications, flexibility in data handling, and flexibility in sensor design.

The Deployable CBRN Monitoring Network will consist of one or more independently operating modules, each configured as required. Each module will comprise a node and an associated suite of detectors or sensors. The node will act as the communications hub between its sensor suite and a remote-control centre. Each sensor, which can be deployed when either stationary or mobile, will have a global positioning system (GPS) and on-board intelligence that provides location, digested data and raw data upon request to the node. Communication between the node and its sensors will normally be wireless; operators will choose the mode based on the spatial extent of the array. Communication between the node and control centre will take place by satellite, cellular or land-line telephone. Internet technology will be used for data transmission and reception, and the software will be designed to facilitate integration with existing or planned response systems, such as the ARGOS system currently being implemented under another CRTI initiative (0080TA).

The partners will develop a commercial chemical sensor that will detect warfare agents and industrial chemicals, a portable biological-agent sensor system (supplied by General Dynamics Canada) that will detect the four standard biotoxin simulates, and nuclear detectors (supplied by Bubble Technology Industries). The nuclear detectors include a gamma monitor that uses advanced circuitry to enable spectral analysis in high radiation environments, dose and dose-rate calculations, isotope identification, and scenario analysis for complex fission-product releases; and a compact portable air monitor that automatically or remotely actuates filter advances and spectral analysis of airborne alpha, beta and gamma radiation.

Health Canada is also collaborating with partners Bubble Technology Industries, the Canadian Nuclear Safety Commission, Environment Canada and General Dynamics Canada to develop a node and software for the sensors and a node and remote data reception and control. The software architecture will be designed with maximum flexibility to enable future development of the system. Other possible developments for the future include adding other detectors, such as meteorological, sound, motion and imaging sensors, and adding actuators to initiate actions in response to sensor stimuli or commands from the centre.

CRTI 02-0043TA

Accelerated Consequences Management Capabilities

Project Lead: Defence Research and Development Canada – Suffield

Federal Partners: Environment Canada, Royal Canadian Mounted Police

Industrial Partner: Vanguard Response Systems Inc.

Canadian national and regional CBRN response teams currently use the world-leading Blast Guard System* to contain, mitigate or decontaminate areas of chemical, biological and radiological warfare (CBRW) agents. The Blast Guard System consists of various decontaminating foams and equipment that can be used in different scenario, (e.g., if a package suspected of containing CBRW agents has been found, if an enclosed area is contaminated by a known chemical or biological warfare agent, or if there is a CBRW terrorist attack at a specific target or event).

In the case of a suspicious package, first responders, such as firefighters or police officers, use the Blast Guard System decontaminating foams to erect a portable enclosure over the package and fill it with foam before explosive experts can safely detonate the bomb and destroy or neutralize toxic materials. The enclosure will suppress the explosion, contain any fragmentation and confine any aerosol agents present. The foam can also be applied directly to a contaminated enclosed area, such as a room surface or vehicle, as well as large areas, such as buildings, equipment, vehicles and terrain.

* Subsequently renamed the Universal Containment System (UCS)

More research on the Blast Guard System is needed to assess its long-term effect, examine remediation measures and address important performance issues, including its environmental effects and operating temperature range, against a wider spectrum of agents on a variety of surfaces. This project aims to accelerate the development of the Blast Guard System and apply the researched information to the design of a product that can be used in further CBRN scenarios.

The research will be completed in five tasks, each addressing a specific area of need:

- Task One: Determine the effectiveness of the Blast Guard and related formulations when foam is applied to a series of surfaces contaminated with traditional chemical warfare agents. This will involve analyzing vapour concentrations of selected chemical warfare agents that desorb into a flowing air sweep above a contaminated surface that has been subsequently covered with the decontaminant foam formulations. The analysis will use a North Atlantic Treaty Organization (NATO) approved standard vapour desorption cell or residual agent in a liquid extraction test, followed by gas chromatographic analysis. The surfaces tested will be representative of materials used in an office environment. This laboratory work will be undertaken at DRDC Suffield.
- Task Two: Using various analysis procedures, determine the liquid-phase rates and stoichiometries of reaction. If applicable, also determine the identity and composition of reaction products and any toxic intermediates of Blast Guard and related formulations in reaction with a series of traditional and potential chemical warfare agents. Finally, analyze the effectiveness of the Blast Guard System in detoxifying selected biological warfare agents and simulants for colony-forming units or residual agents at predetermined contact times. This work will also be performed at DRDC Suffield.
- Task Three: Determine the need for any post-treatment or effluent containment by conducting testing to quantify environmental impact. Testing will include both aquatic toxicity and soil toxicity tests and will be undertaken by commercial laboratories. The results will be initiated by industrial partner Vanguard and reviewed in consultation with Environment Canada.
- Task Four: Enhance the performance of the foam components so that they operate over a wider climatic range more suitable to the Canadian winter environment. This work will be conducted in liaison with Vanguard, McMaster University and Farrington Lockwood Company Ltd. Modifications to the formulation will be evaluated by field trials conducted by the RCMP and assisted by DRDC Suffield.
- Task Five: Investigate extending the evaluation of the system for remediation measures. Vanguard will evaluate the data resulting from the work described above to make the best use of the Blast Guard System equipment. This may result in the capacity for mass or wide area decontamination and remediation. A database using the available information on the performance of Blast Guard against CBRW agents on a variety of surfaces will be developed and made available to end-users.

Blast Guard is unique in that it captures forensic evidence, making it possible for police to reconstruct and analyze the CBRN device. The research work undertaken in this project, specifically Tasks One and Two, will be vital in analyzing the ensuing foam residue because investigators will be able to identify any CBRN agents used. The work of the tasks will also bring benefits to first responders. The information gained will help train them in the use of the Blast Guard System equipment and enable them to use the product more effectively for immediate response and near real-time consequences. The capacity to manage longer-term consequences will also be enhanced.

CRTI 02-0045RD

Forensic Optically Stimulated Luminescence

Project Lead: Defence Research and Development Canada – Ottawa

Federal Partners: Public Safety and Emergency Preparedness Canada, Royal Canadian Mounted Police

Industrial Partner: Bubble Technology Industries

RDDs pose a severe threat to Canada's health and economic infrastructure. Colloquially known as "dirty bombs," RDDs incorporate radioactive materials acquired by stealth and then concealed from authorities until ready to explode.

Several alarming statistics point to the possibility of illicit radioactive material falling into the hands of terrorist organizations. Firstly, there is the volume of "missing" radioactive sources. The US Nuclear Regulatory Commission attests to over 1,500 sources unaccounted for since 1996. In less regulated countries the scale of such sources must be greater—in the aftermath of the Iraq war, for example, the country's largest radioactive storage facility was looted. Secondly, examples abound of belligerent use of radioactive material. In 1995, Chechen nationals left cesium-137 sources under a bench in a Moscow park; in 2000, Uzbekistan officials confiscated ten strontium-90 sources possibly destined for Afghanistan; and also in 2000 Islamic Jihad attempted to procure uranium or plutonium from Russia.

This project will help to track radioactive sources and, following an event, positively attribute the RDD to its source and identify the persons involved in the terrorist act. The method is based on Optically Stimulated Luminescence (OSL), a well-documented radiation phenomenon. The application of OSL to forensic needs represents a unique advancement in counterterrorism.

OSL takes advantage of the properties of natural materials recently exposed to radiation. The radiation interacts with electrons in the natural material, exciting them from their low energy ground states. In many cases, these electrons are "trapped" in energy levels above the ground state, where they reside according to a characteristic half-life. Optical excitation—usually a laser light source—then stimulates the release of the electrons. When these electrons fall, they emit visible photons. Researchers measure the intensity of this emission to estimate the incident radiation dose.

OSL has been used in geological dating work and in retrospective dosimetry at Hiroshima and Nagasaki, where materials such as roof tiles were examined for information about radiation dose distribution. OSL also has forensic applications. For example, a terrorist holding radioactive material will go to great lengths to conceal it, possibly even moving the material from site to site. Conventional radiation detection techniques require that the detector and the field from the source be in proximity to each other at the same time. Once the radiation source has been moved, no conventional detector can specify its previous location. Forensic OSL, however, is aimed at clearly indicating the radiation source's former location through the optical stimulation of nearby materials and the subsequent measurement of the induced light output.

The forensic OSL study began in July 2003 and will conclude in March 2006. It is focused on materials commonly used in buildings, roads, and other infrastructure. Preliminary experiments at DRDC Ottawa have been successful in using the OSL technique on materials such as sand, which contains feldspar and quartz and is the main constituent of concrete, and gypsum, the main constituent of wallboard. The technique will be extended to materials commonly used in vehicles or on personnel.

The work to design, develop, test and verify an OSL system that will function in the field will include the following activities:

- Conducting a thorough literature review of the status of OSL, including its use in retrospective dosimetry and geological dating. Specifically, probing the existence of luminescent traps with properties amenable to forensics (e.g., energy and half-life).
- Determining which materials show the most promise as OSL receptors.
- Conducting laboratory experiments with the chosen materials, employing a variety of radiation types, and developing a matrix of material and OSL performance.
- Ensuring the relevance of the developed matrix to forensic needs.
- Designing and reviewing a preliminary OSL system.
- Constructing a prototype system.
- Testing the prototype system against various challenge scenarios to be developed by the team.
- Delivering the prototype system to the Canadian Security Intelligence Service and the RCMP.
- Enabling forensic personnel to test and comment on the system.
- Modifying, if necessary, and delivering the final system.

CRTI 02-0053TA

Simulation-Based Decision Aid for the Optimization of Detection, Protection and Decontamination Systems with Team Structures and Procedures

Project Lead: Defence Research and Development Canada – Programs

Federal Partner: Department of National Defence – Directorate of Nuclear Biological and Chemical Defence

Industrial Partner: Greenley and Associates Inc.

Response to a CBRN threat in Canada is based on a Directorate of Nuclear Biological and Chemical Defence multi-level construct that involves various roles for the first responder community and the Department of National Defence. The CBRN Protection Construct varies the planning and types of units involved in response across four levels: strategic, operational, tactical and technical.

For the construct to function as intended, the national, provincial and municipal agencies involved need to understand their role in relation to each other. Each of these agencies must also decide what equipment to purchase (detection, protection, and decontamination), where the equipment would best be deployed, and what response procedures to use. Because the agencies are interdependent across systems and the four levels of preparedness, they cannot make these decisions in isolation.

The CBRN Simulation-Based Decision Aid assists agencies in making such decisions. Because a decision aid makes multi-dimensional visual simulations possible, it provides agencies with an understanding of the CBRN Protection Construct across the different levels of preparedness or response. Agencies can specify the number and type of detectors, protection systems, and decontamination systems within an area of operations, along with the number and types of emergency response units and their procedures. They can simulate alternative configurations of detection, protection, decontamination, and procedures at the tactical level under differing environmental and CBRN threat conditions. They can also conduct "what if" analyses at the tactical and technical level. Such analyses enable agencies to evaluate the cost and benefit of the different configurations, as well as change and re-evaluate their performance characteristics.

This project is aimed at establishing a chemical and biological (CB) Decision Aid Module within the InterSCOPE™ product that is currently used by the first responder community in Canada and the US, and based around Canada's CBRN Protection Construct. Developed by ITSpatial Inc., the InterSCOPE™ Visualization System is an enterprise level information system that integrates data between multiple sources of information and displays this information in a unified three-dimensional visualization. Examples of data sources that have been integrated into the InterSCOPE™ environment include legacy databases, web pages, incident-reporting systems, GPS data feeds and discrete event simulations. InterSCOPE™ also has the capacity to include time-based data, enabling the simulation of traffic (trains, cars, planes, and so on) and human movement. With the product's visualization ability, agencies can make changes to the physical environment to evaluate the impact on vehicle or personnel flow. Although used mostly in dense urban environments and by the emergency response community, InterSCOPE™ can also be used in military command and control applications.

A CB Decision Aid Module within InterSCOPE™ will have a personnel unit definition and simulation system, an Environmental Condition simulation system, and a Threat Definition and Dispersion modelling system. These systems will enable the simulation-based analysis to be configured for a range of different events in support of the trade-off analysis. Agencies will be able to view the domestic Strategic and Operational Levels, enter an operational scenario to create a simulation at the tactical level, and conduct simulation-based analyses. They will be able to alter the characteristics of detectors, protection systems, decontamination systems, and procedures at the technical level, allowing tactical level simulations to be re-run to evaluate the impact of different system components.

CRTI 02-0057TA

Canadian Radiation Alert and Expert System for Critical Infrastructure Monitoring

Project Lead: Health Canada – Radiation Protection Bureau

Federal Partner: Canada Border Services Agency

Industrial Partner: Science Applications International Corporation Canada

The development of a comprehensive, expert radiation alert and monitoring system capable of low false alarm rates and highly sensitive detection of radioactive material releases and trafficking should position Canada as a world leader in the management of radionuclide incidents. This project is aimed at developing real-time alarming; isotope and incident identification; automated, high-sensitivity numerical full spectrum analysis; high-speed data transmission to multiple remote sites; and secure web access to network information for first responders and central decision-makers. The long-term study of radioactive emissions from nuclear facilities that will result from the application of this new technology will lead to improvements in the ability to confirm and enhance local scale meteorological models (1 to 50 kilometres). These improvements will, in turn, have broad implications on CBRN airborne agents.

This unique technology will provide Laboratory Cluster support, classifying events and distributing information to enable multiple users to share critical emergency information efficiently. Early detection and rapid assessments of radionuclide contamination will be made easier with its measurement capabilities. Municipal, provincial and federal agencies will be able to coordinate emergency responses by using data linked to agricultural, environmental, and infrastructure decision support systems based on geographic information system maps. First responders and central decision-makers will receive timely reports and analysis from the information technology component, which integrates the alarms into the operational response to a nuclear incident. For alerts and assistance, front-line security personnel can either integrate the application into radionuclide event decision support systems or operate it as a stand-alone detection system. Enhanced detection, identification and quantification of isotopes associated with radionuclide events will lead to an improved ability to detect and assess the significance of specific radioactive materials and to automatically classify possible sources of these materials in near real time.

The project includes the following activities:

- Developing near real-time data analysis systems for detector and detector arrays to enhance identification of a terrorist attack or alarm, report isotopic composition and levels, evaluate significance and integrate this information with decision support systems.
- Developing and applying Noise-Adjusted-Singular-Value-Deconvolution (NASVD) data algorithms to fixed facility and regional monitoring networks.
- Developing, validating and using new full spectrum analysis and modelling methods in combination with time-series analysis of spectra.
- Linking the improved capacity to detect, measure and identify radioactive materials to an expert database to simultaneously provide alert, consequence assessment, and source and event categorization, and applying these algorithms to robust sodium iodide spectrometer field technology.
- Establishing a secure virtual private network to enable access to the data.
- Using the whole spectrum of each event for analysis, adding the ability to detect any spectral errors, as well as adding the ability to flag or notify items that do not fit any previously known event to improve the reliability of identification for later examination by expert personnel.

CRTI 02-0066RD

Development of Simulation Programs to Prepare for and Manage Bioterrorism of Animal Diseases

Project Lead: Canadian Food Inspection Agency

Federal Partner: Environment Canada

Industrial Partners: US Department of Agriculture, Ontario Ministry of Agriculture, University of Guelph, Colorado State University

This four-year project is aimed at developing technologies that will greatly enhance Canada's preparedness and response to the possible introduction of bioterrorist agents, (such as foot-and-mouth disease), to Canada's livestock population. The project will give the Canadian Food Inspection Agency the tools it needs to prepare for, respond to, identify and manage outbreaks caused by the release of bioterrorist agents. It contains three complementary subprojects:

- Developing a computer simulation program for animal disease bioterrorist agents to be used in preparing for and during the response to a bioterrorist event.
- Producing an atmospheric dispersion model for human and animal disease bioterrorist agents transmitted by air to identify the potential source of release and the pattern of spread.
- Creating and implementing the national Foreign Animal Disease Emergency Response System (FADERS) to store, track and manage information collected during a terrorist-mediated event.

Computer simulation programs are at the cutting edge of technology for modelling and identifying critical factors of disease outbreaks and testing control measures. Development of the computer simulations will be carried out by a modelling team of scientists from regulatory agencies and departments and academia in Canada, the US and Mexico working in collaboration. The team of scientists will compare and evaluate models in other countries to determine which features to include in a North American model. One of the computer programs to be developed is based on a spatial stochastic state-transition model; the other program—a multi-scale atmospheric transport and dispersion model for animal and human disease agents—is based on existing capability for chemical and nuclear agents. The stochastic model will be tested and validated with actual outbreaks. Sensitivity analyses will enable input parameters affecting the outputs of the model (e.g., duration and size of the epidemic) to be identified. These analyses will also help to identify areas at risk of larger outbreaks in the country, areas that could be targeted by terrorists.

The two computer programs will be essential in evaluating the extent of the spread, source, and direction of bioterrorism agents. If a bioterrorism agent is introduced into Canada's livestock population, the computer programs will predict the extent and most probable direction of spread of the biological agent. Before a disease outbreak, the computer programs can also be used to evaluate outbreak mitigation strategies in different animal populations, animal densities and geographic and climatic regions of Canada to improve the country's preparedness against bioterrorist agents. Decision-makers will be prepared for a possible bioterrorist event with the "bank" of outbreak scenarios the computer programs will then create, and that will contain information on the best control strategies to apply according to the agent, the location in the country, the season, and so on. This will be an indispensable tool at a time when decisions must be made rapidly if control and eradication measures are to succeed.

FADERS will be designed to complement the computer simulation programs. Made up of five database applications, it will be designed to store large amounts of information on populations and laboratory results, and keep track of interventions (depopulation, vaccination, and so on) in a timely manner. Analysts, modellers and decision-makers will receive the information they need to determine the source of the agent and the most effective way to control and stop the spread of that agent. Current systems are not able to handle the information generated in a bioterrorism event, making FADERS much needed for animal health.

The five database applications are at different stages of development. The most important application to be developed in this project will be the Canadian Animal Disease Emergency Management System (CADEMS). This will be used to track and manage terrorist-mediated outbreaks. It will include features found in other systems in the world, such as EPIMAN in New Zealand and EMRS in the US, and will store the information required by the stochastic simulation model and the wind dispersion program during a bioterrorism event.

CRTI 02-0067RD

Restoration of Facilities and Areas After a CBRN Attack

Project Lead: Environment Canada

Federal Partners: Health Canada, Defence Research and Development Canada

Industrial Partners: Science Applications International Corporation, US Environmental Protection Agency, VLN Ottawa, Vanguard Response Systems Inc., Hytec Calgary

This project is aimed at developing a suite of methods to decontaminate and restore buildings and areas after a CBRN attack. The project involves gathering and compiling information on restoration and then testing and validating all known restoration, procedures for buildings, exteriors of buildings, the interior contents of buildings (including interior air and contaminated surfaces), and areas adjacent to buildings, such as parking lots, lawn, and vehicles. Restoration includes pickup, neutralizing, decontaminating, removing and destroying, and depositing the contaminant, and cleaning and neutralizing material and contaminated detritus. The project is also intending to develop new ideas and test existing ideas for their application to restoration.

In the first phase of the project, at least 16 methods of restoration will be tested, including picking up, neutralizing or encapsulating, concentrating or separating, and disposing of the contaminant, as well as methods used across the CBRN spectrum. Some of these methods may involve more than one process, such as neutralization or destruction as well as pickup. Restoration concepts will be adopted from several sources, including the US. Method testing will proceed with a survey and then a test of the best candidates on a laboratory scale. All selected chemical target items will be tested, including at least one model biological candidate and one nuclear isotope.

In the second phase, laboratory scale experiments will test the efficacy of the proposed concepts. The radiological portion will proceed with the premise that radiation decontamination is a two-step process consisting of removal and concentration and removal of the radioisotopes from the removal fluid.

The third phase will test the remaining candidate procedures on a small scale. NATO and DRDC Suffield have developed standard tests with a small surface token. The Environment Canada facility in Ottawa will test the chemicals; the Health Canada facility in Winnipeg will test the biologicals and DRDC Ottawa will test the radiologicals.

The fourth phase will involve preparing procedures for decontamination and restoration. A trade-off decision basis will be developed to provide information on abandonment and quarantine versus cleanup.

Finally, in the fifth phase of the project, a detailed report will be prepared covering all phases of the work. The report will form the basis of a detailed manual for restoration of facilities.

CRTI 02-0069RD

Molecular Epidemiology of Biothreat Agents

Project Lead: Health Canada – National Microbiology Laboratory

Federal Partner: Defence Research and Development Canada

Industrial Partner: Infectious Diseases Research Centre

When individuals became infected by exposure to anthrax spores in the US in October 2001, the topic of molecular forensics came to the forefront. With outbreaks in Florida and New York, authorities investigating the anthrax cases wanted to know whether they were caused by the same strain. The whole issue increased awareness of the importance of being able to rapidly detect a potential threat agent and to develop technologies in the molecular forensic field to trace the possible foci or source of the attack or outbreak.

Canada also needs the capacity to identify a bioweapon, diffuse it, trace it, and determine its potential origins. This project is aimed at improving Canada's microbial forensic investigations by increasing the capacity of federal laboratories to subtype biothreat agents using existing molecular methods, and by developing new molecular methods for subtyping. Canada's National Microbiology Laboratory in Winnipeg and laboratories at DRDC Suffield will be given the tools necessary to rapidly deliver the high and low genotypic discrimination techniques.

A comprehensive approach to molecular forensics should encompass two complementary typing methods—one with a high degree of discriminatory power and one with lower discriminatory power. The highly discriminatory subtyping method would be tailored to differentiating loci that change at a high frequency. It could determine whether one strain is related to another over a relatively short period of time, for example, during a bioterrorist attack that lasts for weeks to several months. As the strain changes over time, however, this method would become too discriminatory. The second approach, which involves loci evolving at a slower but steadier rate to allow the organisms to cluster together into larger clonal groups, would provide valuable insights into the potential origin of the strain used for the attack.

Work on the project will involve the following main tasks:

- Adopting highly discriminatory protocols already documented in the literature for subtyping the three pathogens of major concern to molecular forensics—*Bacillus anthracis, Yersinia pestis,* and *Francisella tularensis*.
- Developing new molecular techniques for typing these organisms to improve the time it takes to determine molecular type, and improving the throughput to enable even more samples to be processed in a given time period.
- Ensuring these techniques are standardized between the two laboratories to enable rapid electronic data exchange.

- Subtyping and adding organisms to the database, and providing other Level III laboratories within the Public Health Laboratory Network access to these protocols to increase capacity and surge response during a major terrorist event.

CRTI 02-0080RD

Psychosocial Risk Assessment and Management (RAM) Tools to Enhance Response to CBRN Attacks and Threats in Canada

Project Lead: University of Ottawa – Institute of Population Health

Federal Partners: Health Canada, Canadian Food Inspection Agency

Canada is faced with the need to improve its readiness to cope with the consequences of CBRN threats or attacks. Research indicates that the behavioural and psychological impacts of CBRN terrorism are widespread, long-lasting and costly. Every response to a CBRN terrorist event is unique, since it depends on the agent and its expression. As a result, non-traditional first responders, such as local public health authorities, front-line health care providers, food inspectors, and lay responders, may be involved. It is crucial that all such responders receive adequate training as a way to manage the long-term psychological effects of CBRN terrorism.

This project will develop an integrated framework for managing the psychosocial aspects of CBRN risks and will provide guidelines for CBRN agent risk assessment, perception and evaluation, as well as risk communication. The project will use field-based training tools to enhance the capability of first responders to mitigate the psychosocial and human health impacts of CBRN threats and attacks.

Led by the Institute of Population Health of the University of Ottawa, along with the Institute for Risk Research of the University of Waterloo, the project will attempt to broaden understanding and mitigate the psychosocial impacts arising from social disruption, stress, distress, and anticipated behavioural changes by developing an integrated psychosocial risk management framework for CBRN agents. Training tools in CBRN risk assessment and management and best practice guidelines will be developed for first responders. Psychological support strategies and risk communication will be enhanced, thus helping to manage general population responses associated with either a CBRN attack or threat, and to address the psychosocial needs of the Canadian population.

The research program will involve surveys, field work and test experiments to assess CBRN risk perceptions among the Canadian public. It also requires developing and evaluating guidelines for best practice to assist health professionals and multidisciplinary teams in risk communication to effectively manage the psychosocial consequences for the general public, and developing and evaluating training programs for key responders.

CRTI 02-0091TA

Clostridium Botulinum Type A Genomic DNA Microarray

Project Lead: Health Canada – Bureau of Microbial Hazards

Federal Partner: National Research Council

Industrial Partner: Institute of Food Research, Norwich UK

Botulinum neurotoxin is the most poisonous substance known to humankind. A single gram of crystalline botulinum toxin, evenly dispersed and inhaled, would kill more than one million people. Unfortunately, governments and terrorists have long tried to use botulinum neurotoxin as a biological weapon. For example, a Japanese biological warfare group used it for the first time during that country's occupation of Manchuria, which began in the 1930s. More recently, the Japanese cult Aum Shinrikyo unsuccessfully dispersed botulinum neurotoxin as an aerosol at multiple sites in downtown Tokyo and at American military installations between 1990 and 1995. After the 1991 Persian Gulf War, Iraq admitted to having produced 19,000 litres of concentrated botulinum toxin. These 19,000 litres remain unaccounted for and represent approximately three times the amount needed to kill the entire human population.

Botulinum neurotoxin is produced by the bacteria *Clostridium (C.) botulinum*, which is commonly found in soil and water. Given the extreme potency of botulinum neurotoxin, and the ubiquity of *C. botulinum*, it is critical that methods to genome type *C. botulinum* become available. Creating a *C. botulinum* type A genomic microarray will enable *C. botulinum* isolates to be characterized on the genomic level. Such an array will serve as a tool for studying gene transcription in *C. botulinum* in response to environmental stimuli.

This project is aimed at developing a *C. botulinum* type A genomic Deoxyribonucleic acid (DNA) microarray to be used in two ways: as a multi-functional gene expression platform and as a sensitive detection assay for *C. botulinum* and botulinum neurotoxin producing bacteria. A *C. botulinum* type A genomic microarray will contain the complete *C. botulinum* type A sequence, and include the structural genes for all seven serotypes (A through G) of botulinum neurotoxin. The platform will enable the simultaneous detection of any organism, including *C. botulinum*, botulinum-producing strains of *C. barati* and *C. butyricum*, and any organism genetically modified to produce botulinum neurotoxin. This will enable the rapid detection of botulinum neurotoxin structural genes within micro-organisms and address Canada's prevention, surveillance and alert needs. It will also provide a subtyping method based on comparative genomics to address forensic needs, and a tool for conducting gene expression studies.

The first stage of the project involves the construction of a whole genome, amplicon-based DNA microarray of *C. botulinum* type A at the Institute of Food Research in the UK, with the investment of federal government partners in Canada and the Institut Pasteur in France. Once developed, the microarray will initially be used at the Botulism Reference Service for Canada laboratory, and in laboratories in the UK and France. Other laboratories across the world will be able to purchase the microarray for the cost of its production.

CRTI 02-0093RD

Advanced Emergency Response System for CBRN Hazard Prediction and Assessment for the Urban Environment

Project Lead: Environment Canada – Canadian Meteorological Centre

Federal Partners: Defence Research and Development Canada, Health Canada, Atomic Energy of Canada Limited

Industrial Partners: Kosteniuk Consulting Limited, University of Alberta, University of Waterloo

A CBRN agent released in an urban environment presents problems associated with atmospheric transport, dispersion, and deposition that can extend across space and time scales. For example, a chemical agent may have a hazard range of a few to tens of kilometres, while a biological agent may pose hazards over a range of several hundreds of kilometres, and radiological and nuclear agents may result in a hazard range of several to tens of thousands of kilometres. Canada's effort to advance its counterterrorism planning and operational capabilities requires high-fidelity, time-dependent models able to predict a CBRN agent's movement and fate in an urban environment.

This project is aimed at developing and validating an integrated, state-of-the-art, high-fidelity multi-scale modelling system that will accurately and efficiently predict the flow and dispersion of CBRN materials in an urban area. Such a system will provide the real-time modelling and simulation tool needed to predict injuries, casualties, and contamination, and the predetermined decision making framework needed to minimize the consequences. The modelling system will predict the evolution of a CBRN agent cloud faster than real time, providing front-line decision-makers with an understanding of the situation and enabling them to choose the best response options.

Modelling this phenomenon accurately will involve multiple levels of physical and mathematical descriptions and will be based on state-of-the-art physics. It requires developing models that can predict flow in urban areas at the micro-scale, adding sub-grid scale urban parameters to a meso-gamma scale numerical weather prediction model, and then coupling the urban micro-scale model with the "urbanized" meso-gamma scale model. A Lagrangian Stochastic model for predicting urban dispersion will also be developed and interfaced with the multi-scale flow model. The entire modelling system will then be verified and validated.

When the research work is successfully completed, the Environmental Emergency Response Division at the Canadian Meteorological Centre will have a fully operational high-fidelity multi-scale CBRN modelling system that can serve as a nationwide general problem-solving environment for first responders involved with CBRN incidents.

CRTI 02-0093TA

Advanced Polymer Research for Application to Personal Protective Equipment

Project Lead: Acton International Inc.

Federal Partners: Defence Research and Development Canada

The personal protective equipment (PPE) and clothing, such as protective masks, overshoes and gloves, worn by first responders to protect against CBRN materials can be damaged through extended contact with certain oils, fuels and lubricants (POL). In particular, first responders, without the same level of CBRN training as their military counterparts, may be slowly damaging their specialty CBRN PPE by allowing it to come into contact with such contaminants. Other shortcomings, such as the need for PPE that is flame resistant and the failure of military CBRN PPE to meet the required civilian standards, has created a need to improve PPE and make these items more multi-purpose.

This project will address these shortcomings by accelerating research into the CBRN resistant polymers used for military CBRN PPE, and developing an advanced rubber formulation that will provide nuclear, biological and chemical (NBC) protection as well as resistance to fire, POL, acid, and other industrial contaminants. These materials can then be quickly adapted for use by first responders. By increasing the "broad spectrum" resistant polymer materials, it will be possible to improve service life, reduce premature damage, assure users that their equipment keep them safe, integrate CBRN protection into their actual equipment, and meet both civilian norms as well as military specifications.

The project will proceed through a five-phase gated project management approach and include a technical performance file for each of the products developed. Phase One will benchmark the different NBC products available on the market for gloves, overboots, and respirators. Phase Two will determine the product performance parameters. Phase Three will develop multiple polymers and blends to determine the compounds with the most promise. Phase Four of the project will produce an optimized and characterized mix for the selected compounds. Finally, in Phase Five of the project, industrial partner Acton International of Acton Vale, Quebec, will use the optimized compounds to create samples of injected molded gloves and overboots, and assembled first responder boots.

With a release date of November 2005, the resulting polymer formulation will support the need to properly equip and train first responders, as well as the capacity for managing immediate reaction and near-time consequences.