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Foreword

The Chemical, Biological, Radiological-Nuclear, and Explosives (CBRNE) Research and Technology Initiative (CRTI) was originally launched in May 2002 as a result of the Government of Canada's Public Security and Anti-terrorism budget in December 2001. In 2006, along with the approval of renewed funding for another five years, an Explosives Portfolio was added, expanding the CRTI mandate. Future project funding will now address explosives hazards in addition to CBRN threats.

CRTI is a unique, cross-organizational program mandated to strengthen Canada's preparedness for, prevention of, and response to a CBRNE terrorist attack through investments in science and technology (S&T). Over the first five years, CRTI supported 151 research and Technology Development (RD), technology acceleration (TA), technology demonstration (TD), and technology acquisition projects to enhance the capacity of Canadian preparedness and response. Many of the projects have gained recognition within the S&T and security communities, and have enhanced Canada's ability to respond to CBRNE terrorism.

The 5th Annual CRTI Summer Symposium at the Château Cartier Resort in Gatineau, Québec, provides an opportunity for the CRTI and broader CBRNE communities to learn about the progress of the projects from the first five rounds of funding as well as future plans. The goal of the Symposium is to provide a forum to share and exchange the knowledge created by CRTI partners and to learn about related allied work in CBRNE. This exchange of ideas will further contribute to building Canadian capability and capacity in CBRNE preparedness and response.

The following abstracts outline CRTI and other projects, which will be presented orally or in posters during the Symposium. All of these projects are notable for their breadth and quality and many of them have already made tangible contributions to Canada's national security. I am sure that you will find the presentations stimulating and wish you continuing success in working together to achieve these high-quality results.

Mark Williamson
Director, CRTI

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CRTI 0006RD

Induction of Innate Immunity

Project Lead: Public Health Agency of Canada – National Microbiology Laboratory

Federal Partner: Canadian Food Inspection Agency – National Centre for Foreign Animal Disease

Other Partner: University of Saskatchewan – Vaccine and Infectious Disease Organization, McMaster University

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Objectives

This project is dedicated to exploring novel approaches to achieve immediate protection of humans and animals from the effects of exposure to highly virulent infectious agents. Experts anticipate that many of the infectious agents currently listed as major threats for a bioterrorism attack would be dispersed through both airborne and waterborne pathways. The purpose of this project is to develop products and procedures to provide immediate short-term protection to the airways and the intestines against various organisms, while at the same time delivering vaccines that can provide long-term immunity. The project researchers have studied and identified several compounds and applications to partially protect animals from diseases induced by various pathogens.

Relevance

This project is directed towards initiating instantaneous activation of the immune system of humans and animals to fight infections before vaccination or treatment can be efficacious. The researchers established several animal models for infections with relevant infectious pathogens, and performed protection experiments in low- and high-level containment laboratories.

Recent Progress and Results

The researchers have shown that transmucosal, but not systemic, delivery of CpG oligodeoxynucleotides (ODN) to genital mucosa protected female mice against a lethal mucosal intravaginal (IVAG) challenge with herpes simplex virus type 2 (HSV-2). This protection was due to CpG's

ability to induce local innate anti-viral immune responses in the vaginal mucosa since protection could be induced in mice lacking adaptive immune responses. Local delivery of CpG ODN rapidly induced proliferation and thickening of the vaginal epithelium that occurred within 24 hours and caused significant recruitment of inflammatory cell infiltrates to the submucosa.

Most recently, the researchers developed and tested the efficacy of CpG as protection against poxvirus using a respiratory challenge model. To develop the model, C57Bl/6 mice were intranasally infected with various doses of vaccinia virus WR (VVWR), and their body weight and survival was monitored daily. VVWR proved lethal to the mice. Further, these studies established the Median Lethal Dose $_{50}$ (MLD_{50}) of VVWR as 1 x 104 plaque forming units (pfu).

Subsequently, C57Bl/6 mice were intranasally administered 75 µg of CpG three days prior to intranasal challenge with VVWR at 10 times MLD_{50} or 100 times MLD_{50}. One hundred percent of mice treated intranasally with CpG ODN were protected against both a 10 and 100 times MLD_{50} of VVWR. The control ODN-treated group only showed partial protection when given the lower challenge dose ($10MLD_{50}$), while control mice treated with phosphate-buffered saline (PBS) all succumbed to mucosal poxvirus infection at both doses within six days.

In a further experiment, C57Bl/6 mice were intranasally administered 75 micrograms (µg) of CpG ODN or PBS as a control, and subsequently challenged intranasally with VVWR. Lungs and spleens of these mice were removed, and the tissue virus load determined by plaque assay. Lung virus titres were significantly decreased on days three, five, and seven in the CpG-treated mice compared to PBS-treated controls, and no virus was detectable in the spleens of CpG-treated mice, whereas controls had significant titres of virus in the spleens on days three and five following intranasal infection.

Overall, these results clearly indicate that intranasal administration of CpG three days prior to mucosal intranasal challenge with 10- and 100-times lethal doses of VVWR completely protect against lethal outcome.

Impact

The potential of CpG ODN as therapeutic agents and vaccine adjuvants has been demonstrated in animal models of infectious diseases, allergy, and cancer, and are currently undergoing clinical trials in humans. While CpG ODN are potent activators of the immune system, their biologic activity is often transient, subsequently limiting their therapeutic application. Using CpG ODN to prevent infection or disease, the researchers have demonstrated their potential usefulness against dangerous pathogens.

CRTI 0027RD

Biological Dosimetry and Markers of Nuclear and Radiological Exposures

Project Lead: Health Canada
Federal Partners: DRDC Ottawa, Atomic Energy of Canada Limited
Other Partner: McMaster University

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Objectives

Biological dosimetry assesses radiation exposure when physical dosimetry is not available. It can be a means of screening the general population for radiation exposure and identifying first responders who must be restricted from further exposure. It can also be a means of assessing long-term risks following radiation exposure. In the event of a radiation emergency, timely assessment of radiation exposure and response will help guide the actions of emergency officials, first responders, and health care personnel. The first objective of this project was to establish a *National Biological Dosimetry Response Plan* (NBDRP), comprising four core reference laboratories and several clinical satellite laboratories for increasing the throughput of the dicentric chromosome assay. The second objective was to develop rapid methods of radiation exposure assessment to increase throughput in large-scale events.

Relevance

The NBDRP provides a resource for rapid radiation biodosimetry for first responders and exposed individuals following a radiological-nuclear (RN) event. This improves Canada's casualty management capabilities by providing rapid diagnostic techniques for triage purposes as part of a national emergency response plan. The formation of the NBDRP has facilitated the networking of Canadian experts in biological dosimetry and linked government service laboratories with medical emergency response professionals. The NBDRP was also designed to provide emergency response officials with tools to distinguish affected individuals from the worried well, and alleviate public concerns about the health effects of possible radiological exposures.

Recent Progress and Results

Over the course of this project, the researchers developed, deployed, and tested the NBDRP within four partnering (core) laboratories and achieved a significant improvement in capacity and accuracy. Capacity was increased from one laboratory with two trained individuals to four laboratories with 15 trained individuals. Dose estimates improved from 68 percent accuracy in the first exercise to 88 percent in the second exercise. In addition to the four core laboratories, the Canadian Cytogenetic Emergency Network (CCEN) was developed to further increase Canada's capacity to provide rapid biological dosimetry for triage assessment in a mass casualty event. As a result, 18 clinical laboratories across the country participated in a training exercise that enabled them to score samples for the dicentric chromosome assay (DCA), thereby further expanding Canada's radiation biodosimetry response capability.

Within the research component of this project, researchers examined several methods as possible biological dosimeters or indicators of exposure. They developed a novel high-throughput method for assessing radiation-induced micronuclei in interphase leukocytes using the flow cytometer. They also demonstrated, through dose-response experiments with human blood, that this novel assay can detect doses as low as 0.3 gray (Gy).

Spectral karyotyping (SKY) of human chromosomes was assessed as a biological dosimeter. Although SKY was determined to be labour intensive, required specialized equipment, and was much slower compared to the DCA, it provided accurate dose estimates and demonstrated use for long-term monitoring and assessment of irradiated individuals. SKY is best suited for determining specific doses in individuals who have been identified as having received a significant exposure using other conventional techniques, and to evaluate the long-term health risks of the exposure.

The electron paramagnetic resonance research determined that this technology provides exceptional capabilities as an emergency biodosimeter with good sensitivity for low linear-energy transfer (LET) radiation. Human, canine, and rodent teeth were tested with both gamma and neutron irradiation for responsiveness and sensitivity to both neutrons and gamma irradiation.

Research on molecular biology methodologies to investigate and identify novel biomarkers of radiation exposure resulted in the identification of five promising biomarkers. DRDC Ottawa researchers developed a prototype test-kit that will use the validated markers for rapid identification of exposed individuals. Moreover, the researchers identified white blood cell subpopulations as potential in-the-field and sensitive indicators of radiation exposure. Further research will be conducted in this area to establish specific sensitivities of these cells to radiation and stress.

Impact

This project has an impact on the ability of Canada to respond to RN events. By increasing the national capacity for performing accurate biological dosimetry, dose estimates for potentially exposed individuals will be available within a time frame that will be a useful resource for the medical community to assist in the medical management of casualties. With the current methods, this is only possible by increasing the number of individuals able to perform the assay. Developing novel assays will reduce the human resources required and make sensitive high-throughput dosimetry more feasible. The NBDRP is a successful model recognized by our counterparts in the United States (US). The US Departments of Homeland Security and Health and Human Services have approached Canadian researchers to consult on a working group developing a proposal for a US biological dosimetry network based on the NBDRP model.

CRTI 0029RD

Protecting the First Responder Against CB Threats

Project Lead: Royal Military College of Canada

Federal Partners: Royal Canadian Mounted Police, Health Canada, Department of National Defence – Director Nuclear Biological Chemical Defence, Defence Research and Development Canada

Industry Partner: 3M Canada

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Objectives

The purpose of this project was to assess existing personal protective equipment (PPE) for first responders against chemical and biological threat scenarios, identify deficiencies, and recommend new standards to ensure that first responders have the necessary guidance to use and select equipment for terrorist response. Researchers assessed protection performance against a multitude of toxic chemical and biological risks as itemized in the CRTI consolidated risk assessment, provided guidance to equipment users, and developed a process for developing a PPE standard. The members of the project team continue to consult international standards and have rationalized proposed standards where appropriate.

A variety of activities supported this effort, including scenario development and modelling of releases, consultation with the responder community on response activities and protocols, development of evaluation methods and models for protective performance of respirators and clothing, and investigations into dermal toxicity of selected Chemical Warfare Agents and toxic industrial chemicals (TICs).

Relevance

The project has provided support to responder communities and operational authorities through equipment procurement decisions and the development of standards and product evaluation. The project team has provided guidance to first responders on how to deal with a CBRN event and the capability gaps of their protective equipment. The researchers also developed realistic and safe protocols for measuring the protection provided by their protective ensemble.

Recent Progress and Results

In August 2006, the respiratory protection team gave presentations at the International Society of Respiratory Protection (ISRP) Conference, held in Toronto, Ontario. The team showed how current laboratory-protection factor testing can be very misleading, and indicated that

workplace- or simulated workplace-protection factor (WPF) testing is required. The team reported on how these WPF measurements can be determined using the equipment and protocols developed under the project for both non-powered air purifying and powered-air purifying respirators. The team also presented conclusions on the current status of canister testing and how protection assessments can be in error such that the protective capacities being measured are significantly overestimating the amount of protection.

The respiratory protection team collaborated with the Royal Canadian Mounted Police (RCMP) and the researchers involved in the CRTI Technology Acceleration (TA) project, "Radio Frequency- and Electronic Countermeasures-Compatible Chemical and Biological Blast Protective Helmet" (CRTI 04-0082TA) to evaluate the respiratory protection provided by a CBRN blast helmet worn with a powered-air purifying respirator. The team also performed research showing the potentially significant effect that sand or dust particles trapped in the valves of the respirator have on respiratory protection.

The project's standards team further refined and recently published a new version of the guidance document, *Selection and Use of Personal Protective Equipment for the Canadian First Responder to a CBRN-Terrorism Event*. With feedback from the Canadian Emergency Management College, the team also produced a condensed draft booklet for training purposes and, potentially, other applications.

The project's standards team has identified a number of key guidance points regarding the location of support functions with respect to the release area, and performed a comparison of proposed Canadian requirements with existing or developmental United States (US) CBRN standards. The team has established a working relationship with two US standards development organizations (i.e., the National Institute for Occupational Safety and Health [NIOSH] and National Fire Protection Association [NFPA]), and joined two relevant International Organization for Standardization (ISO) standards development Canadian advisory committees pertinent to CBRN protection in order to ensure a Canadian voice in international standards developments.

Impact

This project has produced the following outcomes that directly impact the responder community:

- Test capabilities have been established for body and respiratory protection, permitting evaluation of performance in use;
- Protection capabilities have been determined for existing clothing and respiratory systems, and the importance of system integration and system-level evaluation has been established;
- Guidance for use has been produced, identifying a variety of operational issues;
- Guidance for standards has been produced and has led into standards development; and
- Canister-protection capabilities and limitations have been determined, deficiencies have been identified, and plans to address these deficiencies through a new canister development have been formulated.

As the project comes to an end, input from other first responder groups on the guidance document and the condensed booklet version is being sought, and work continues on evaluating unexpected canister behaviour against a number of chemicals of concern. All other deliverables have been completed for this project. Support for the guidance and standards work will continue under the CRTI project, "Development of a Canadian Standard for Protecting First Responders from CBRN Events" (05-0016RTD) through early 2009.

CRTI 0052TA

Rapid Carbon-14 Analysis by Accelerator Mass Spectrometry

Project Lead: University of Toronto – IsoTrace Laboratory

Federal Partners: Health Canada – Radiation Protection Bureau, Fisheries and Oceans – Atlantic Environmental Radioactivity Unit

Industry Partner: High Voltage Engineering Europa B.V.

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Objectives

The purpose of this project is to provide equipment, and to develop and test procedures for the rapid, sensitive, and high-throughput carbon-14 (C-14) analysis of organic samples. To achieve this, the research team will

- purchase a high-capacity, carbon dioxide (CO_2) gas-fed ion source and integrate it into the IsoTrace accelerator mass spectrometry (AMS) system;
- purchase and modify an elemental analyzer to produce CO_2 from environmental samples;
- construct a gas-transfer line to receive mixed CO_2 and helium (He) from the elemental analyzer and provide it at the appropriate rate and concentration to the ion source;
- integrate software controls of all components to facilitate automated analysis; and
- establish procedures for sample analysis and the identification of the most appropriate materials to be collected by first responders and other survey personnel in a radiological-nuclear (RN) event.

Relevance

The availability of C-14 as a tracer for biomedical research and from its production in Canada Deuterium Uranium (CANDU) reactors could lead to its dispersion during a RN event. In a variety of such events, the level of C-14 in organic samples (especially those related to human health, for example, in the food chain) will need to be accurately and rapidly determined. This project will provide a capability for both assessing the extent of C-14 contamination resulting from an RN event in a particular area and for certifying the efficacy of remediation work.

Recent Progress and Results

A critical element in the overall system is the gas-transfer line between the elemental analyzer and the ion source. The transfer line must accept the output from the elemental analyzer, which can vary from 0 to approximately 40 ml CO_2 at standard temperature and pressure (STP) per minute over a approximately 3-minute period in a constant stream of 200 ml per minute of helium carrier plus CO_2. This mixture must then be released to the ion source at a rate of approximately 100 µl STP per minute. To accomplish this, the CO_2/He mixture is temporarily stored in a trap large enough to hold the bulk of the CO_2 at its peak output. On the way into the trap, additional helium is added to the mixture in a controlled manner so that the CO_2/He ratio is held approximately constant and has the appropriate

level for optimum ion-source performance. The research team has conducted manual tests of the system and found that the system provides a steady beam of negative carbon ions from CO_2 generated by the elemental analyzer.

In the ion source, the negative carbon ions are produced by bombarding the CO_2 trapped on a titanium pellet with caesium ions. The caesium ions are produced by caesium vapour impinging on a heated tungsten ionizer. In the original version of this source, the caesium vapour was fed from a single entrance on the side of the ionizer, which resulted in a caesium ion beam somewhat off-centre. In a recent improvement, the caesium vapour is introduced from six holes distributed symmetrically in an annulus around the ionizer. This resulted in significantly more stable carbon ion currents and isotope ratio measurements.

The team's work on configuring the programmed logic controller (PLC) and the software that provides automation for the transfer line and communication between it and the other processors in the system (elemental analyzer, ion source, and accelerator mass spectrometer) is nearly complete. With this system in place, the researchers can then carry out routine measurements and establish operating protocols. The team plans to test the system at a nuclear reactor exercise planned for the fall of 2007, as well as in a CRTI exercise scheduled for February 2008.

Impact

This system will give Canada the capacity to respond to any event, either accidental or malicious, in which C-14 is distributed in the environment. Specific applications include monitoring the immediate vicinities of nuclear power stations, identifying the extent of contamination of food production areas by explosive dispersal devices or from longer range plumes, and assessing the efficacy of remediation work in either of these locations.

CRTI 0064RD New Technologies for Surveillance of Biowarfare Agents (abstract not provided)

CRTI 0072RD

Nanodosimeters Based on Optically Stimulated Luminescence

Project Lead: DRDC Ottawa
Federal Partner: Health Canada
Industry Partner: Bubble Technology Industries
Other Partner: University of Toronto

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Objectives

In the event of a radiological incident, tracking the spread of radioactive material will be of utmost importance. Long-term monitoring of the contamination distribution will be required to plan response and recovery while minimizing risk to all involved. The aim of this project was to create an electronic dosimeter based on optically stimulated luminescence (OSL) suitable for such long-term monitoring applications. The project followed two separate, but related, tracks: Bubble Technology Industries (BTI) designed the dosimeter and associated electronics; and the University of Toronto Electronic-Photonic Materials Group (EPMG) conducted the research to adapt it to a chip-level design. The project has resulted in two prototype dosimeters: a field-ready prototype minidosimeter, that uses a photomultiplier tube (PMT) with integrated control, read-out, communications, and global positioning system (GPS) electronics, and a lab prototype using an EPMG-designed custom avalanche photodiode in place of the PMT.

Relevance

The dosimeters developed in this project are relevant to any situation that requires unsupervised long-term monitoring of radiation fields with automatic data collection and reporting. This includes long-term monitoring of contaminated areas, such as following a nuclear detonation, a power plant incident, or detonation of a radiological dispersal device (RDD). Other scenarios in which these dosimeters would be useful include monitoring of cargo containers in transit for illicit nuclear or radiological material and personnel dosimetry during near-term response.

Recent Progress and Results

Early versions of the prototype electronic OSL dosimeter used a commercial Geiger-mode avalanche photodiode (APD) to detect the OSL signal. The approach worked well, but could not be continued if an optimized dosimeter were to be produced. Commercial APDs are excellent photodetectors, but limit the performance of the dosimeter in this application. Their maximum sensitivity is in a different wavelength range than required, they typically have a small active area, and they suffer from problems with dark noise. A major research effort in this project involved replacing the commercial APD with a better-suited photodetector. Two options were pursued in parallel: a tiny commercial PMT and a custom avalanche photodiode.

A major outcome of this project was the production of a prototype minidosimeter. The researchers implemented a new design for the electronics board to make the minidosimeter design compatible with not only a mini-PMT, but also a commercial APD minidosimeter is now being developed under a new technology acceleration project, "Optically Stimulated Luminescent Radiation Sensor for Long-Dwell Detection in Transit Applications" (CRTI 05-0006TA) into a long-dwell detection in transit (LDDT) dosimeter for cargo container monitoring. These dosimeters will be tested in Canada/United States (US) cargo screening trials in the summer of 2007.

Partners at the University of Toronto have focused their efforts on producing and optimizing a custom APD. The team developed a production process for the custom APD that allows the peak sensitivity of the detector to be tuned to any wavelength in the required range for optimization of the OSL-based dosimeter. A unique multi-layer APD design coupled with this precise control over the doping levels in the APD structure led to a tunable APD. In addition to this, the custom APD has lower dark noise than available commercial APDs and can operate without as much thermoelectric cooling. The design of this photodetector will eventually allow the dosimeter to be adapted to a chip-level design. Development work beyond the scope of this project will be required to bring a dosimeter using this custom APD to fruition.

Impact

The project was originally slated to end in March 2006, but was extended until December 2006 and then to September 2007 to allow testing of the prototype minidosimeters during Canada/US cargo screening trials. The major deliverables for the project—a suite of minidosimeters—have been essentially complete since March 2006, but delays in scheduling the cargo trials have resulted in a major delay in wrapping up the project.

CRTI 0091RD

The Development of Recombinant Monoclonal Antibodies for Treatment and Detection of Bioterrorism Agents

Project Lead: Public Health Agency of Canada – National Microbiology Laboratory

Federal Partners: DRDC Suffield – Chemical and Biological Defence Section, Canadian Food Inspection Agency

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Objectives

The focus of this project was to improve diagnosis of and provide a means of possible treatment for bioterrorism agents through the design and production of both human and recombinant monoclonal antibodies (mAbs). While several agencies were involved in the overall project, the specific role of DRDC Suffield and the Canadian Food Inspection Agency (CFIA) was to produce recombinant antibodies, both fragment antigen-binding (Fab) and single-chain variable fragments (scFv), targeted against equine encephalitis viruses and *Bacillus anthracis*, the causative agent of anthrax. With the successful production of recombinant human anti-anthrax Fabs, researchers directed their efforts toward completing recombinant single-chain antibodies that recognize Venezuelan equine encephalitis (VEE) virus and Western encephalitis (WEE) virus.

Relevance

The researchers' work on developing and producing recombinant antibodies, including single-chain fragments, is part of a larger antibody-based defence strategy that addresses the need for immediate reaction and near-time consequences management. The goal of this project is to ensure that first responders have reagents and tools that can immediately detect and protect against bioterrorism or biological warfare agents. The function of single-chain antibodies in this initiative is to provide the means for rapid, inexpensive, and reliable detection while providing a production method that does not rely on third-party manufacturers, contractors, or suppliers.

Recent Progress and Results

Using polymerase chain reaction (PCR) to amplify the heavy- and light-variable regions from established monoclonal cell lines and combining those products with a linker sequence, the team successfully produced single-chain antibody fragments. The team produced scFvs targeted against VEE virus and WEE virus and, in both instances, the single chains retained the same antigen binding and specificity of the parent hybridomas. To facilitate use as diagnostic reagents, the researchers constructed single-chain WEE (scWEE) and single-chain VEE

(scVEE) with biotin, streptactin, or alkaline phosphatase (AP) detection tags. Then, the researchers determined the activity of the single chains by their ability to recognize the immunizing antigen used to produce the parent monoclonals with both Western blot analysis and enzyme-linked immunosorbent assay (ELISA).

The researchers found that Western blot analysis of recombinant VEE-E2 structural protein was strongly and specifically detected by all of the scVEE-tagged variants with little difference noted between the ability of each variant to resolve the antigen. The detection of VEE-E2 with ELISA demonstrated that scVEE could clearly and specifically detect the antigen in a dose-dependent manner, scVEE-AP performed the best in this immunoassay. Using a constant one microgram per millilitre (ug/ml) of VEE-E2 structural protein, scVEE-AP could detect antigen 10-fold compared to background at a concentration 2 ug/ml. The researchers could not achieve this outcome with either the scVEE-streptactin or scVEE-biotin.

Similar to the VEE scFVs, recombinant WEE-E1 structural protein was specifically detected on Western blot by all of the scWEE variants with little difference noted between their ability to resolve the antigen. Using WEE-E1 at a constant concentration of 1ug/ml, scWEE-biotin, scWEE-streptactin, and scWEE-AP were all able to detect antigen specifically and in a dose-dependent manner. Again the AP-tagged scWEE outperformed the others with the ability to detect antigen eight-fold over background at 1ug/ml and a maximal 10-fold difference at 5 ug/ml. By comparison, the scWEE-biotin and scWEE-streptactin could only detect a two-fold difference at 1ug/ml and a maximal five-fold difference at 10 ug/ml.

The researchers determined that in addition to increased sensitivity, both scVEE-AP and scWEE-AP could produce results more rapidly than either biotin or streptactin single chains due to the one-step detection and development procedures allowed by AP.

Impact

Producing recombinant antibodies or antibody fragments with a variety of biological detection tags provides several advantages. The use of biological tags allows the resultant product to be customized, based upon the desired use, during the initial manufacturing process. There are no additional processes required. It eliminates the need for chemical conjugation of detection tags, an inefficient process that can result in significant loss of product, or loss of functionality or specificity of the antibody. Finally, it provides a stable, reproducible, and scalable method of reagent production. Currently, the team has produced and delivered functional scVEE and scWEE with a variety of detection tags and in stable expression platforms. These reagents may be utilized immediately for diagnostic purposes or safely stored until required at a later date.

CRTI 0131TA

HI-6 Nerve Agent Antidote System

Project Lead:	DRDC Ottawa
Federal Partners:	Public Health Agency of Canada, Public Safety Canada
Industry Partner:	UGM Engineering Limited
Other Partners:	United Kingdom Ministry of Defence, Netherlands Ministry of Defence

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Objectives

The purpose of this project is to develop a new HI-6 nerve agent antidote (NAA) system that will address several deficiencies in the current HI-6 auto-injector. The new NAA system will establish an industrial source of supply of HI-6, develop an auto-injector capable of delivering three drug substances, and will undertake formulation of the three-in-one drug product. Project partners will then conduct efficacy and toxicity pre-clinical studies, culminating in a Phase 1 clinical trial. The project will also establish a Good Laboratory Practice (GLP) environment in a suitable animal test facility at DRDC Suffield and will conduct preliminary studies on an intravenous formulation of HI6.

Relevance

HI-6 is the NAA of choice for several nations due to its superior effectiveness against a broad range of nerve agent threats. However, there are no current reliable sources of HI-6 and the existing NAA system requires the use of two separate auto-injectors.

Through this project, HI-6 dichloride (2CI) in the existing auto-injectors will be replaced by the more soluble HI-6 dimethansesulfonate (DMS), and diazepam, currently administered in a separate auto-injector, will be replaced by avizafone. HI-6 DMS, avizafone, and atropine will then be combined into a new single auto-injector with superior delivery characteristics.

Recent Progress and Results

Functioning under a trilateral Memorandum of Understanding (MOU) with the Ministries of Defence for the United Kingdom (UK) and the Netherlands, the HI-6 project initially completed a baseline project plan. The plan provided definitive guidance for the development of novel manufacturing processes for HI-6 DMS, the development of a novel auto-injector, and the conduct of pre-clinical studies necessary to support a regulatory submission.

Initial efforts to identify a new process for the production of HI-6 DMS without the use of bis (chloromethyl) ether (BCME) were deemed economically unviable. The project team identified an offshore facility suitable for the production of HI-6 2CI and its subsequent conversion to HI-6 DMS and demonstration batches of high-grade drug substance were produced. Efforts by the UK partner to produce HI-6 DMS by a non-BCME process recently met with preliminary success.

Difficulty in obtaining information on an existing source of avizafone led to the development of a new process for avizafone production. Subsequent to the production of a small test lot, the UK partner also revealed a source of supply for this component.

Under UK leadership, the team has identified a prospective manufacturer of a new auto-injector. To date, several prototypes of this auto-injector have been produced. While the UK plans to continue with the development of this three-in-one auto-injector, a separate program for the development of an auto-injector that would meet Canadian requirements has also been obtained, thereby ensuring that an alternative delivery device could be developed, if required.

In preparation for a separate investigation to develop an intravenous formulation of HI-6 for use in a clinical setting, a test facility at DRDC Suffield has implemented GLP procedures. Protocols suitable to demonstrate efficacy in appropriate animal model are under development in anticipation of conducting these studies in fall 2007.

CRTI funds enabled Canada to initiate a trilateral effort to develop a new NAA system and to establish a source of supply for its components. As these funds have now been spent, the UK Ministry of Defence has assumed leadership and will continue with the development of a novel NAA through to Phase 1 clinical testing of the individual components of the overall system.

Impact

The existence of a source of supply for a NAA will significantly enhance Canada's ability to prepare for chemical agent threats. If ongoing financial support can be obtained, Canada can continue to play a role in conducting the necessary studies required for a subsequent regulatory submission. It is anticipated that HI-6 DMS of a quality necessary for clinical studies will be available by fall 2008. Development of a three-in-one auto-injector is expected to be completed in early 2009. The required pre-clinical studies should be completed in early 2009 followed immediately by a Phase 1 clinical study. Outside the trilateral MOU, Canada will have identified a source of supply for HI-6 and will have prepared preliminary plans for the production of a suitable auto-injector, should that be necessary. Finally, by fall 2008, the GLP efficacy studies will be completed for the intravenous administration of HI-6.

CRTI 0154RD

Rapid DNA-based Diagnostic Tests to Identify Two Bacterial Biothreat Agents

Project Lead: DRDC Suffield

Federal Partner: Public Health Agency of Canada – National Microbiology Laboratory

Industry Partner: GeneOhm Sciences Canada Inc.

Other Partner: Université Laval – Infectious Diseases Research Center

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Objectives

The objective of this project was to design, develop, and test rapid (less than one hour), real-time deoxyribonucleic acid (DNA)-based diagnostic assays in a dried-reagent format for the specific, sensitive, and ubiquitous detection and identification of *Yersinia pestis* and *Francisella tularensis* in clinical and environmental matrices. These assays will augment and improve medical response strategies for detection of these biothreat agents among operational communities. The assays, designed by the Infectious Diseases Research Center (IDRC), amplify unique DNA sequences in conserved chromosomal genes and pathogen-associated virulence genes, as well as internal positive control sequences to monitor polymerase chain reaction (PCR) inhibition. IDRC researchers also developed sample processing techniques to process live agent-spiked matrices (i.e., blood, nasal swabs, and powders). Project partners at GeneOhm Sciences Canada Inc. prepared dried reagent formulations, while researchers at DRDC Suffield and the Public Health Agency of Canada's National Microbiology Laboratory (PHAC-NML) analysed the live agents.

Relevance

The assays, protocols, and products developed in this project provide the capability to detect and identify *Y. pestis* and *F. tularensis* in complex matrices in hours rather than days or weeks. This will improve immediate reaction and near-term consequence management of a bioterrorist attack and will help crisis management authorities to make informed decisions during a crisis, to reassure public confidence,

and reduce fear and panic. Dried reagents should offer significant advantages as they simplify assay set-up (i.e., fewer steps), reduce the sample-to-result time frame, reduce the risk of assay contamination, improve reproducibility, and eliminate cold-storage requirements.

Recent Progress and Results

After procuring bacterial strains and genomic DNA from various collections, the research team generated and analyzed over 900 genetic sequences representing 11 different gene targets for primer or probe design. Primers for the *Y. pestis* assay amplify three target genes (two plasmidic and one chromosomal), while primers for the *F. tularensis* assay amplify two chromosomal gene targets associated with either housekeeping functions or virulence. The team first developed multiplex assays using conventional PCR, where each amplicon was distinguished by its size using gel electrophoresis.

The gel-based assays were subsequently adapted to fluorescence-based amplicon detection using SYBR Green I dye, where each amplicon was distinguished by analyzing the melting curves generated by the Smart Cycler instrument. Multiplex assays were then optimized for real-time detection on the Smart Cycler using TaqMan Minor Groove Binder (MGB) probes, reducing amplification and detection to less than one hour. The assays were found to exhibit detection sensitivities that ranged from 2 to 10 genome copies per PCR reaction using purified DNA. Internal control sequences were included in the multiplex assays and co-amplified using agent-specific primers.

The IDRC research team also developed rapid sample preparation methods for extracting PCR-grade nucleic acids from intact bacteria spiked into blood, nasal swabs, and powders. When the researchers conducted live agent testing of clinical samples using liquid TaqMan MGB reagents, they found that nasal swabs had a negligible impact on sensitivity while blood had a more significant impact. For the powders, salt and creamer had a negligible to minor impact on sensitivity while silica had a greater impact. As the team expected, the internal control sequences were detected in the absence of template and sometimes at low template concentrations, but not in the presence of higher template concentrations. When positive signals were occasionally observed in the negative controls, suggesting contamination during assay set-up, the team implemented protocols for regular decontamination of pipets and equipment with DNA-denaturing reagents prior to and after analysis.

Researchers at IDRC and GeneOhm Sciences assessed the quality of the dried TaqMan MGB assays and found them to be comparable to liquid TaqMan MGB assays using purified DNA. The researchers then developed dried TaqMan MGB reagents to industrial standard specifications and shipped them to the federal labs for testing. Live agent testing of dried TaqMan MGB assays generated similar results to liquid TaqMan MGB assays, except that the contamination issues experienced during the liquid reagent-testing phase did not occur.

Impact

The project, which was completed in December 2006, produced the following outcomes:

- two federal sites now have the capability to detect and identify *Y. pestis* and *F. tularensis* in various clinical and environmental matrices using different PCR-detection chemistries;
- dried reagent TaqMan multiplex assays with internal controls have been validated to industrial standards;
- species-specific and strain-specific sequence data for future molecular research of these organisms have been developed;
- establishment of a working relationship among the partners, which may be exploited in times where additional assistance may be required (e.g., if a bioterrorism event was to occur in Canada); and
- the ability to develop additional assays for other biothreat agents in the future.

The assays from this project also have the potential to be rolled out to other frontline users and may be of particular interest to provincial public health laboratories. Rollout to the provincial laboratories through the Canadian Public Health Laboratory Network (CPHLN) would be beneficial to Canada.

CRTI 02-0024RD

Probabilistic Risk Assessment Tool for Radiological Dispersal Devices

Project Lead:	DRDC Ottawa
Federal Partners:	Canadian Border Services Agency, Canadian Nuclear Safety Commission, Canadian Security Intelligence Service, Public Safety Canada
Industry Partner:	Science Applications International Corporation Canada
Other Partner:	University of Ontario Institute of Technology

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Objectives

Recent events have focused attention on radiological dispersal devices (RDDs) as a potential terrorist weapon. However, there remains considerable disagreement with respect to the feasibility of constructing an RDD and the consequences of deploying it. Furthermore, the single category, "RDD," consists of a plethora of potential terrorist devices involving different radioisotopes, activity levels, and dispersion modalities. All of these factors have significant impacts on both the feasibility and consequences of an RDD attack. This uncertainty seriously hampers the work of those charged with preparing for, preventing, or responding to radiological terrorism. This project aims to systematize the analysis of RDDs, permitting a comprehensive study of the feasibility, consequences, and risk of RDD attacks. The project will facilitate this analysis through the use of a software tool that allows intelligent searching and manipulation of an RDD risk assessment database.

Relevance

The project clearly addresses the CRTI investment priority to focus on the science and technology (S&T) dimensions of risk assessment. There is a scientific gap in the understanding of RDDs and of the risk posed by these devices. The software tool produced by this project will close this gap by bringing together available information in a format that allows the user to assess the risk of RDDs and, in particular, the relative risks posed by different kinds of RDDs. Emergency planners could use these data to assess which scenarios they should plan for. The data could also help security personnel determine what might be the weaknesses in Canada's defence against radiological terror and thus direct their efforts at preventing RDD attacks.

Recent Progress and Results

Last year the project team completed development on the three major sections of the Probabilistic Risk Assessment (PRA) Tool project. First, the project team completed a model describing the construction of a generic RDD. Second, the project team completed inputs to the RDD risk assessment database, which feeds the feasibility assessment half of the risk calculation. Finally, the project team developed a generalized method to calculate RDD consequences for the more than 1.3 million possible RDD configurations considered by this risk assessment tool, thus allowing the

automated consequence assessment. The project team incorporated the three sections of the PRA Tool project into a software tool that performs automated risk assessments. The beta version of the software tool was delivered to the project team early last year. Working with the beta version of the tool allowed the project team to refine the PRA model and incorporate a long list of enhancements into the final version of the software.

The final version of the PRA Tool software was delivered to the project team in early summer 2006. This highly adaptable and configurable software tool allows rapid assessments of feasibility, consequence, and risk for a wide array of possible RDD attack modalities. Furthermore, the configurable nature of the tool allows the user to perform sensitivity analyses on these risk assessments by modifying feasibility estimates at all stages of the RDD construction and deployment process, scenario-specific variables that affect how the consequences of a given class of RDD events are assessed, or system variables that determine globally how consequences are assessed for all RDDs. In the past year the tool has been undergoing user testing by project partners. With the delivery and testing of the final version of this software tool, this project is essentially complete. All that remains is the finalization of a long-term strategy for the use of the PRA Tool. Discussions are taking place between DRDC Ottawa, the CRTI Radiological and Nuclear (RN) Laboratory Cluster, and the Operational Research (OR) Team at the Centre for Security Science (CSS) to determine the best implementation and ownership for the PRA Tool.

Impact

The final version of the PRA Tool software provides capabilities that have not existed before and these capabilities represent a considerable step forward in RDD risk analysis. The project team expects that the tool will be adopted by security-mandated agencies to enhance their understanding of the RDD threat and to focus their attentions on the scenarios of greatest concern. It is expected that this software tool will greatly improve the risk assessment process that the CRTI RN cluster takes when setting priorities. Furthermore, under guidance from an organization such as the OR Team at the CSS, this software tool could be generalized to other hazards. This would help streamline the CRTI Consolidated Risk Assessment and possibly even enhance it by adding the capability to test investments and mitigation strategies against their reduction of the overall risk posed by CBRNE terrorist events. This could be used not only to set investment priorities, but also to evaluate proposals and assess their impact on Canada's overall readiness to prevent, respond to, and recover from CBRNE events.

CRTI 02-0035RD

Canadian Network for Public Health Intelligence

Project Lead:	Public Health Agency of Canada
Federal Partner:	Canadian Food Inspection Agency
Industry Partner:	TDV Global
Other Partners:	Canadian Public Health Laboratory Network, University of Guelph, TRlabs, Canadian Council of Medical Officers of Health

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Objectives

The Canadian Network for Public Health Intelligence (CNPHI) will improve the capacity of the Canadian public health system to reduce human illness associated with infectious diseases by supporting intelligence exchange, surveillance activities, and outbreak investigations. This capacity is being achieved by establishing a secure, web-based framework to collect and process surveillance data, disseminate strategic intelligence, and coordinate response to biological threats.

The goals of CNPHI are to

- enhance Canada's ability to detect, respond to, and prepare for biological events by facilitating national, integrated, real-time laboratory and epidemiological data sharing, and by supporting response capability and capacity;
- maintain and respect jurisdictional responsibilities while leveraging Canadian resources and infrastructure in innovative new ways for the benefit of the broader stakeholder community; and
- develop an innovative information technology and management architecture that will enhance the existing public health infrastructure to support multi-jurisdictional data sharing and collaboration.

Relevance

The integration of surveillance, epidemiology, and laboratory information, maintained within an infrastructure that has the capacity to identify, communicate, and respond, is the foundation for bioterrorism preparedness and effective public health management. Many unique pockets of expertise relating to infectious diseases and data collection systems exist in Canada, but a national framework to allow the timely integration of these has been lacking. CNPHI will facilitate the integration of relevant public health intelligence into a common national framework to support coordination among jurisdictions. CNPHI brings together laboratory, epidemiology, and other operations communities, providing stakeholders with an integrated surveillance and response framework.

Recent Progress and Results

The CNPHI team developed a number of new surveillance modules over the past 18 months. A new West Nile virus (WNV) surveillance application connects human and animal health stakeholders from across Canada, allowing them to aggregate data and share information about avian WNV activity. A new outbreak summaries application for infectious diseases is nearing its launch date. The outbreak summaries application will assist regions, provinces, territories, and the Public Health Agency of Canada (PHAC) to manage infectious disease outbreaks, and provide a platform to collect, share, and store information about outbreaks. In partnership with researchers on the CRTI project "Real-Time Biosurveillance and Response Readiness Using an Interconnected, Electronic Information Infrastructure" (CRTI 03-0019TD) the team has integrated the Canadian Early Warning System (CEWS), a syndromic surveillance platform, into CNPHI's application suite.

Management and coordination of multi-jurisdictional infectious disease outbreaks and disease events of international relevancy is a core responsibility of PHAC. To help meet this need, PHAC has implemented an Incident Command System (ICS) framework at its Emergency Operations Centre (EOC) in Winnipeg. The CNPHI team developed and implemented the Dynamic Event Management System to help operationalize ICS.

In an attempt to improve the timeliness of data exchange among public health stakeholders, the team designed and produced a pilot version a new data extraction tool. Smart Engines enables regional, provincial and territorial, and federal stakeholders to extract and share data from existing databases while maintaining confidentiality and jurisdictional responsibilities.

Also during this year, CNPHI made the transition from a CRTI project to a core PHAC information management/ information technology (IM/IT) platform. Efforts are currently underway to implement an appropriate governance model and to define long-term objectives.

Impact

Because of the success of CNPHI, public health stakeholders are better equipped to detect and respond to infectious disease threats. CNPHI's data exchange tools and many surveillance modules provide stakeholders with more timely and accurate surveillance information. CNPHI's alert capabilities, intelligence exchange resources, and event management tools enable stakeholders to rapidly exchange secure information, and provide them with web-based resources to help manage and coordinate investigations and responses. CNPHI's knowledge management resources enable stakeholders to quickly access relevant documents and information.

CRTI 02-0041RD

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

Project Lead: Health Canada

Federal Partners: Health Canada, Environment Canada, Atomic Energy of Canada Limited

Other Partners: McGill University, York University

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Objectives

The goal of this project is to provide first responders and decision makers with reliable, real-time assessment and forecasts of the timing, location, and amount of deposited CBRN material in the event of a terrorist attack. To achieve this goal, an integrated modelling system is required to address four key areas: forecasting the trajectory and concentration of CBRN material in the air; forecasting the location, duration, and intensity of precipitation; estimating the amount of airborne material deposited on the ground when it is raining or snowing; and calculating deposition in the absence of precipitation. These improved capabilities have been developed and implemented within the existing atmospheric transportation and dispersion models running operationally at the Environment Canada's Canadian Meteorological Centre (CMC) and are available for access by Health Canada's Accident Reporting and Guidance Operational System (ARGOS).

Relevance

CBRN material released to the atmosphere by terrorist activities will form an airborne plume that will undergo advection and dispersion by ambient wind and turbulence fields. An appropriate response to this situation will require the best possible knowledge of how the material will be influenced by precipitation, and where and when the material will be deposited, with the shortest delay between releases and forecast.

The predictions will quickly identify the total area of the deposited material, as well as hot spots of high concentration requiring immediate attention. The predictions will be essential for the rapid assessment and mitigation of effects. Forecast maps of the area of deposition will help first responders set priorities, reach the most critical locations as quickly as possible, and minimize personal risk. The predictions will help reduce psychological impacts by minimizing the interval between deposition and the time residents are allowed to return to their homes and resume normal use of their properties.

Recent Progress and Results

The project participants have studied the relative forecast accuracies of Numerical Weather Prediction (NWP) models and the nowcast methods of the McGill Algorithm for Precipitation forecasting by Lagrangian Extrapolation (MAPLE) through previous project tasks. They have followed these studies with studies on how best to merge the two precipitation forecasts to surpass the accuracy of either individual method. Merged NWP/nowcast precipitation forecasting has been transferred to the CMC and implemented in the integrated system. A new scheme of below-cloud scavenging for rain and snow, and two new in-cloud scavenging schemes have now been developed and implemented into the Modèle lagrangien courte distance (MLCD) and Modèle lagrangien de particules (MLDP) dispersion models. The project participants used Atomic Energy of Canada Limited (AECL) data on the washout of tritiated water (HTO) vapour from airborne plumes to evaluate the new below-cloud scavenging scheme. Measurements of the wet deposition of Beryllium-7 by Health Canada have been used to validate the newly developed in-cloud scavenging schemes.

The project participants have continued research into potential advances in wet deposition and precipitation forecasting during the past fiscal year. They have developed a framework to handle wet deposition of aerosols with multiple modes and components. To improve precipitation forecasting, the participants have examined the most predictable effects of the diurnal cycle on rainfall. They have also developed and implemented a new size-resolved model and a four-mode parameterization of dry deposition of atmospheric aerosols to address the issue of the significant underestimation of the dry deposition velocity for submicron aerosols by existing dry deposition models. The dry deposition velocities predicted by the new model and the new parameterization were found to be in agreement with the measurements reported in the literature. This work has resulted in the submission of a paper for publication. In the past fiscal year, three additional papers from this project were accepted for publication in journals.

Impact

The system developed in this project is unique as there are few systems that take into account real-time precipitation information and apply it to improve the assessment of the amount of material scavenged by precipitation. The system uses the best available forecasts of precipitation by merging short-range numerical weather prediction (NWP) model precipitation output with radar-derived nowcasting to predict the wet deposition of material. The project team updated the MLCD and MLDP dispersion models with these improved advanced wet and dry deposition schemes.

The developed system is linked to the ARGOS platform and runs operationally at the CMC's Environmental Emergency Response Division. As a primary end-user, Health Canada accesses predictions through the ARGOS system to provide an improved estimation of the amount of hazardous material released in the air and deposited on the ground.

CRTI 02-0045RD

Forensic Optically Stimulated Luminescence

Project Lead: DRDC Ottawa

Federal Partners: Public Safety Canada, Royal Canadian Mounted Police

Industry Partner: Bubble Technology Industries

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Objectives

This project aimed to design, construct, and test a portable detector for measuring the stored radiation-induced signature in common building materials using the principle of optically stimulated luminescence (OSL). This detector would support forensics investigations by providing law enforcement personnel with the capability to identify suspected former radiological-nuclear (RN) storage sites with a portable detector.

Relevance

Along with improving Canada's prevention, surveillance, and alert capabilities, this portable OSL detector also has applications to longer-term consequence management issues via retrospective OSL dosimetry of an RN-contaminated area. The OSL technique provides investigators with a presumptive indication of past storage locations of illicit radioactive material. Investigators can then link this information to a suspect by measuring certain materials in their possession, thus providing novel and compelling evidence to support a terrorist investigation. Furthermore, by taking samples from the crime scene into a laboratory for more detailed analysis, confirmatory results can be obtained for use in a court of law.

Recent Progress and Results

During the last months of the project, Bubble Technologies Industries (BTI) performed experimental work focused on sample characterization with a laboratory OSL reader. Sample characterization focused on repeatability of measurements, minimum detectable doses, and the degree of signal fading over time. These variables varied significantly with the type of material analyzed. Minimum detectable doses ranged from less than 1 milligray (mGy) for salt up to 1.5 gray (Gy) for drywall.

The field prototype was demonstrated during field trials both at DRDC Ottawa and during the CRTI exercise Maritime Response in Slemon Park, Prince Edward Island. During trials at DRDC Ottawa, the detector demonstrated the ability to detect a 30-second radiation exposure from a 10 millicuries (mCi) Strontium-90 beta source directly on a concrete floor, a feat that has never been achieved before. BTI also tested other surfaces, with measured OSL signals from each material corresponding to sensitivities measured with the laboratory OSL reader. However, during field trials it was determined that the detector needed to be made more robust and its usability needed improvement.

The project achieved or exceeded all of its objectives within the scheduled time and budget. While the fields-portable OSL detector has been a success, there are a number of items that could be improved if the detector were to be re-built or if other similar portable OSL detectors were to be built. Follow-up work must be done to define the various protocols that are needed for different groups to use the technology effectively. This work needs input from the end-users who know how they might use the technology.

Impact

The OSL detector has demonstrated the ability to detect the exposure of materials including cement, concrete, drywall, and ceramic tile to radiation. The system has demonstrated a capability that had not existed before in a portable device. The project, now complete, has seen the development of a laboratory prototype, characterization of a variety of OSL-emitting materials, and the construction of a field-portable prototype OSL detector.

The OSL detector device has potential applications in the forensics and intelligence communities concerned with radiological terrorist scenarios, as well as for other responders to radiological events and military CBRN teams. Personnel involved with ensuring radiological or nuclear compliance, such as the International Atomic Energy Agency (IAEA), are also interested in this technology as a means to identify evidence of undeclared nuclear activities. BTI has submitted a Letter of Invention as a first step in achieving a provisional patent of the portable OSL reader. BTI has also submitted a Technology Acceleration proposal to CRTI for the purpose of furthering the commercialization of technology, with applications in forensics, nuclear compliance, and retrospective dosimetry.

CRTI 02-0053TA

A Simulation-based Decision Aid for the Optimization of Detection, Protection, and Decontamination Systems with Team Structure and Procedures

Project Lead: DRDC Ottawa

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

Industry Partner: CAE Professional Services (formerly Greenley & Associates Inc.)

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Objectives

This project aims to integrate technologies to enable users to conduct full, multi-dimensional, visual simulations of CBRN responses across an area of operations. These simulations will incorporate the time-varying dispersal of a hazard with first responders, their procedures, and their equipment in a specific geographic area. Users will be able to specify, execute, and analyze scenario options, including the number and type of detectors, the protection and decontamination systems available within the operational context, and the number and type of emergency response units available and their procedures.

Relevance

The decision aid will be used to conduct trade-off analyses for acquisitions, to plan operations, and to conduct training. A CBRN decision aid would meet the requirement for decision makers to understand the CBRN protection construct across the different levels of preparedness and response, and to develop scenarios for different operations, through which alternative configurations of detection, protection, decontamination, and procedures can be simulated at the tactical level and in different environmental and CBRN-threat conditions. The aid would also enable decision makers to conduct contingency analyses at both the tactical and technical levels. Tactical contingency analyses provide decision makers with information to evaluate the costs and benefits of different configurations of detection, protection, decontamination, and procedures. Technical contingency analyses allow decision makers to change and re-evaluate the performance characteristics of different detection, protection, decontamination, and procedural systems within tactical scenarios.

Because of interdependencies across systems and levels of preparedness, decisions about acquisition, deployment, and procedure development must not be made in isolation. Throughout the project, the project team interviewed first responders from the City of Ottawa, the Ontario Provincial Emergency Response Team, the Canadian Forces Fire Marshals, the Joint Nuclear, Biological and Chemical Defence Company, the Washington DC Metropolitan Police Department, and other groups to solicit their input into the development of the application. These groups have also evaluated the application as it was developed to ensure that it meets their needs.

Recent Progress and Results

The project proper was completed in March 2006 when the prototype system was delivered. At the time, the project team felt that the system capability was not adequate to fully meet the goals for the project. As a result, final user demonstrations and training for the recipients of the system were deferred to allow for further development of the application and to investigate alternate implementation architectures.

New technical opportunities arose for the integration of the CBRN decision aid module within the framework of existing CAE simulation software applications whose technology roadmaps included the addition and integration of emergency response simulation and planning capabilities. In the past year, CAE Professional Services has continued to make an in-kind contribution to the project by migrating the CBRN decision aid capabilities into CAE's S-Mission application, which is the next generation integration of CAE's flight simulator engine with its three-dimensional (3-D) visualization interface. The majority of this year's work has been focused on the integration of entity models so that they are configurable from within the S-Mission environment; hazard-plume visualization and dispersion-data integration; hot-zone visualization and management; the addition of performance parameters relevant to emergency management; the non-real-time execution of simulations; and the development of 3-D maps of Ottawa, Ontario and DRDC Suffield.

Work will continue to complete the integration of the CBRN decision aid with S-Mission to achieve the original goal of releasing the module as part of a commercial software product. In addition, a 3-D map of the Vancouver, British Columbia area will be developed to support emergency response planning capability in that city. The S-Mission variant of the CBRN decision aid will be completed as the project's final deliverable to replace the prototype presented in March 2006. Final demonstrations and training will be completed according to the original objectives of the project.

Impact

The technology developed will continue to be pursued as a business direction by CAE Professional Services. The capability will initially be exploited internally as an offering to clients, making use of the tool to develop and evaluate emergency response procedures. Future exploitation includes sales of commercial off-the-shelf (COTS) software to the first responder community. As the first responder community continues to drive and invest in the development of more accurate models for dispersion and detection and procedures, the product will continue to be enhanced, increasing its capability and applicability to emergency response planning and training.

CRTI 02-0057TA

Canadian Radiation Alert/Expert System for Critical Infrastructure Monitoring

Project Lead: Health Canada
Federal Partner: Canada Border Services Agency
Industry Partners: Ontario Power Generation, Science Applications International Corporation Exploranium

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Objectives

This project has developed software that will be used in a wide range of existing sodium iodide (NaI) detector systems, including fixed-point monitoring network systems, mobile detection systems, and NaI detectors used to screen personnel and materials. The systems have been enhanced to do in situ, real-time isotope identification. They have been developed to use full spectrum analysis in real time with an extended library of isotopes for identification and more sensitive alarming capabilities. These developments include using Noise-Adjusted Single Value Decomposition (NASVD), an advanced spectral analysis, to greatly improve isotope identification in NaI spectra. The final deliverable of the project is a high-level, expert decision-making system with enhanced isotope identification and a low false alarm rate. This expert system will greatly enhance the capabilities of an entire family of detection equipment used in an extensive range of radiation detection applications.

Relevance

This system will assist in the mitigation of the illicit movement of special nuclear materials through airports, into harbours, across borders, and out of nuclear facilities. Rapid, accurate characterizations among natural, medical, industrial, and special nuclear material are provided so that security personnel have the necessary information to formulate a course of action. The project will support near-term consequence management of releases from nuclear facilities and nuclear weapons, and become an excellent aid for estimating and characterizing deposited radioactive and nuclear contaminants for longer-term consequence management.

Recent Progress and Results

The project team has developed software for mobile NaI detectors that allow for a broader library of industrial isotopes and illicit material to be identified, as well as for a user interface customized for security personnel. This new software has been deployed by Canada Border Services Agency (CBSA) for two years and is currently being used at their pilot project monitoring ports for illicit radiological-nuclear (RN) material within incoming cargo containers.

The capability for monitoring key Canadian nuclear facilities and major population centres using fixed NaI detectors has been improved to allow the detectors to alarm a central station. The software is currently being rolled out to upgrade the detector network.

The project team has implemented improved spectral analysis in both fixed and mobile networks based on NASVD. The team has recently developed two significant software advances leading towards the final objective of full spectral identification. The first is a spectral library creation and testing browser tool that will speed up the development and

testing of new libraries of spectral components. The second is an automatic data processing service that can perform full spectral fitting on the spectrum.

Incoming data are automatically fitted to the spectral library developed from historical data. The researchers use full spectral components from the library to determine the air kerma dose rates for each isotope. The current library contains radon and other background components, Iridium (Ir)-192, used for metallurgical testing, and Argon (Ar)-41, Xenon (Xe)-133, and Xe-135, common by-products from the nuclear generation process, for environmental NaI detectors. Libraries for mobile detectors include medical, industrial, and special nuclear materials. By identifying and quantifying innocuous and nuclear contaminant isotopes, the software has the ability to define a set of preprogrammed responses not only for library isotopes, but also for any isotopes outside the library's scope. The components have been created and verified against data archived over the last six years.

The researchers have demonstrated the improved sensitivity with the new process by finding small amounts of anthropogenic radiation in data that were previously considered free of such radiation. They have also reduced effects of cross-isotope interference, especially during measurement where there is significantly shifting background radiation. Shifting background radiation may be due to natural fluctuations or, for mobile detectors, physical changes in position of the detector. The new software is simpler, more accurate, and sufficiently reliable to make advanced decisions for the purpose of alarm verification in real time without the necessity of further, often extensive, expert spectral analysis.

Impact

This project has created a comprehensive, expert alert system that will process and evaluate continuous isotopic and radiation field measurements, and alarm with high sensitivity and low false alarm rates. It will provide event classification and efficient information distribution to assist laboratories to manage radionuclide incidents.

Automated, high-sensitivity, full spectral analysis and spectral fitting can be used to monitor RN incidents, as well as for the interdiction of illicit materials. This can be done without timely and extensive additional expert analysis and has been demonstrated to work on a variety of detectors.

CRTI 02-0066RD

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

Project Lead: Canadian Food Inspection Agency
Federal Partner: Environment Canada
Other Partners: University of Guelph, United States Department of Agriculture, Ontario Ministry of Agriculture and Food, Colorado State University

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Objectives

The major objective of this project is to develop tools for decision making and outbreak management when faced with incursions into Canada of highly contagious foreign diseases of livestock, such as foot-and-mouth disease (FMD), highly pathogenic avian influenza (AI), and classical swine fever. Researchers at the Canadian Food Inspection Agency (CFIA), the United States Department of Agriculture (USDA), the Ontario Ministry of Agriculture and Food, Colorado State University, and the University of Guelph collaborated to develop a computer-simulation model for policy development, the North American Animal Disease Spread Model (NAADSM), which was officially released on April 1, 2005. Environment Canada is developing an atmospheric dispersion model for real-time plume predictions. The CFIA is developing an emergency management system to help responders track and report on outbreaks, as well as to enable decision makers and epidemiologists to evaluate the progress of control measures once implemented.

Relevance

When dealing with the incursion of a foreign animal disease, either intentionally or accidentally introduced, the speed at which decisions are made is critical in determining the ability to control the incursion. This project seeks to develop tools to increase our understanding of the potential consequences of such incursions before they occur and the impact of various control options on the spread of the diseases among Canadian farms. This information should help decision makers make quick and effective decisions when the first case is detected. The volume of data generated by such outbreaks makes an emergency management system that can handle large volumes of data a necessity.

Recent Progress and Results

Although verification and validation are critical steps in model building, a formal method for infectious disease model validation does not exist. In an attempt to validate three simulation models used for FMD policy formulation in North America, a comparison of the NAADSM with the Australian and the New Zealand models was performed. The comparison included an evaluation of written model descriptions and a comparison of results obtained from 11 scenarios testing spread mechanisms and control measures. Government epidemiologists from Australia, New Zealand, Canada, and the United States (US) undertook the comparison study between May 2005 and September 2006. They statistically and qualitatively assessed differences among the scenarios in the descriptive statistics of selected outputs, the temporal spread, the size of predicted infected areas, and the spatial agreement of predictions.

This is the first time an international team of epidemiologists has formally agreed to collaborate on developing and validating tools for use in animal health emergency preparedness and response. The most important step in this project was to ensure that parameters assigned in each scenario were appropriately represented in the three models. Despite the different approaches used in model building, the three models produced similar results in most scenarios. All models were improved as a result of the comparison study as it enabled the modellers to assess the impact of specific programming decisions and to review and discuss the assumptions used in model building. The results show that code verification and validation are critical steps in model development and are an important step towards establishing model credibility.

The project team created a website, (www.naadsm.org), where the NAADSM model and its user documentation can be downloaded for free. A list server has also been activated and the team hopes that making the model available to the scientific community will create a community of users to share new features and enhancements.

In October 2006, the NAADSM was used to simulate an outbreak of AI in Georgia, US. Data from the simulation was used to inform a tabletop exercise organized by staff at the USDA's National Veterinary Stockpile and the Georgia Department of Agriculture. The tabletop exercise assisted participants to better understand their responsibilities and identify gaps in the federal and state response plans.

Impact

The results of verification and validation efforts support the use of NAADSM in policy formulation. NAADSM is currently being used in the development of scenarios of AI outbreak in Canada. A new phase of comparing models will start in 2007 with the intent of using real-country data and simulating policy formulation scenarios. Other models from North America and Europe will be assessed following the steps used in the first phase of comparison study. Finally, a training course on epidemic simulation modelling, with NAADSM as the main example, will be offered annually in Fort Collins, Colorado by the NAADSM development team.

CRTI 02-0069RD

Molecular Epidemiology of Biothreat Agents

Project Lead: Public Health Agency of Canada – National Microbiology Laboratory

Federal Partner: DRDC Suffield

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Objectives

The Public Health Agency of Canada's National Microbiology Laboratory (PHAC-NML), in conjunction with DRDC – Suffield, has established a national molecular typing capability for *Bacillus anthracis, Francisella tularensis*, and *Yersinia pestis*. The following objectives were completed during the project's lifecycle (September 2003 to March 2007): procuring the necessary equipment, reagents, and strain deoxyribonucleic acid (DNA) from which to develop, test, and standardize molecular-typing schemes; developing a molecular-typing scheme called multi-locus variable-number tandem repeat analysis (MLVA); typing of strains in the national collections using MLVA; developing novel-typing schemes; and establishing the capability for electronic data exchange.

Relevance

The molecular genetic techniques developed in this project provide the operational community with a national capability to conduct strain-level DNA signature identification of the human pathogens *B. anthracis, F. tularensis,* and *Y. pestis.* This capability can be used to conduct epidemiological investigations to trace the possible source of an outbreak resulting from the deliberate release of these biothreat agents and can provide a forensic investigational capability during a biocrime investigation.

MLVA is a highly discriminatory subtyping method that characterizes genetic loci that change at a high frequency. It is useful for determining whether one bacterial strain is related to another over a relatively short period of time. The project team explored novel molecular-typing schemes to develop typing methods with a discriminatory power higher than the MLVA standard to further differentiate strains. These methodologies are currently in the process of becoming accredited by the International Organization for Standardization (ISO).

Recent Progress and Results

The MLVA of *B. anthracis* was initially established using eight loci but has been expanded to 15 loci to increase the resolving power of the technique. MLVA typing for *F. tularensis* continues to use 25 loci. The number of MLVA loci used to type *Y. pestis* has been reduced from 45 loci to 19 loci allowing for a more manageable set of reactions. The project team developed a molecular typing method called single-nucleotide repeat (SNR) analysis to differentiate *B. anthracis* isolates that have the same MLVA type. SNRs are variable-number tandem repeats that display very high mutation rates. During an outbreak, SNRs allow for the differentiation of isolates with extremely low levels of genetic diversity. The resulting SNR marker system can be used as a molecular epidemiological tool in a natural outbreak or

bioterrorism event, offering the best chance of distinguishing very closely related isolates with the same MLVA type.

The project team has exploited newly acquired technology at PHAC-NML to generate sequence information from three different *F. tularensis* genomes. This information, combined with recently released genome sequences from other *F. tularensis* strains, will allow the team to rapidly identify novel SNR targets or single nucleotide polymorphisms (SNPs) in this genome that may be exploited for strain differentiation purposes.

All genotyping data are stored in a BioNumerics database located and maintained at PHAC-NML. The BioNumerics database enables real-time comparisons of MLVA or sequence results and has the potential for other laboratories to link to it as a central database of molecular results. The team is in the process of creating a secure access link for exchange of data between PHAC-NML and DRDC Suffield using a BioNumerics server. Procedures have been written according to ISO 17025 standards and will be included in the second scope of accreditation at PHAC-NML. PHAC-NML and DRDC will be performing proficiency evaluations over the next few months based on these procedures and modifying them accordingly.

Impact

The knowledge and capabilities developed under this project will be used in the event of a *B. anthracis* outbreak. The movement towards ISO accreditation for these techniques will ensure the data generated will be credible in a court of law. These methods have also been used over the last few years in public health events to track naturally occurring outbreaks of *B. anthracis* and *F. tularensis* in human and animal populations.

CRTI 02-0080RD

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

Project Lead: University of Ottawa – Institute of Population Health

Federal Partners: Public Health Agency of Canada, Canadian Food Inspection Agency

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Objectives

The Psychosocial Risk Assessment and Management (P-RAM) project was initiated in 2003 by the Institute of Population Health (IPH) at the University of Ottawa to provide decision support tools to responders, planners, decision makers, and the general public for assessing and managing the psychosocial aspects of CBRN-terrorism events. The project had two key objectives. First, the project team aimed to create a Canadian CBRN psychosocial risk management framework articulating risk assessment with public perception and psychosocial dimensions to strengthen the capacity for a rapid launch of effective response strategies to CBRN threats and attacks. Second, the team aimed to create a set of P-RAM tools and a training program with strategies, decision trees, and guidelines. The psychosocial modules were to include evidence-based literature reviews and survey results assessing the perceptions of CBRN terrorism on the general public and first responders. The work focused on various classes of agents, vectors, and target populations for both threats and actual attacks.

Relevance

In the aftermath of terrorist events worldwide, ensuring a sufficient level of preparedness for potential consequences of such events has become a priority. Research indicates that the behavioural and psychological impacts of CBRN terrorism represent the most prominent consequences, an area in which Canada must improve its ability to cope in both the short- and long-term. IPH thus initiated a P-RAM project comprising an integrated framework for assessing and managing psychosocial impacts; guidelines for assessment and communication of psychosocial risks; directives for implementing empirically-based psychosocial interventions; and a bilingual, field-based training aid enhancing the capacity of responders to mitigate psychosocial impacts of CBRN terrorist events.

Recent Progress and Results

Based on the published P-RAM framework and research, the project team developed a bilingual, prototype training program this year that was designed to provide responders with evidence-based guidance on preparing for, preventing, and managing individual and collective psychosocial effects

of CBRN terrorism in Canada. The team provided guidance in a variety of emerging areas of psychosocial research, emergency management, public health, and risk management and communication necessary to both carry out assessments of psychosocial impacts and implement appropriate interventions in preparedness and response to terrorism events.

The curriculum comprises four modules: psychosocial factors and effects; risk perception and assessment; risk communication; and population health approaches to consequence management. All modules include interactive exercises and scenario descriptions facilitating the required level of knowledge transfer. The team identified key learning needs that translated into module objectives. These were further refined into detailed learning objectives for each of the lessons within the modules. The team tested the English version in Waterloo and the French version in Ottawa over five days with various groups of traditional and non-traditional first responders, and federal, provincial, and municipal disaster response planners and decision makers. Recommendations by participants, such as a shorter and more flexible three-day version, were noted and implemented.

The team has produced a final report detailing the objectives and milestones of the project over its four years. Concurrent with the above mentioned work, the team initiated the development of a demonstration, web-based P-RAM tool, which included the development of a user-friendly prototype interface; the categorization of empirical data; and inputting data of normal and abnormal psychosocial effects manifested during past events into the prototype interface. The team has recently applied for additional funding to extend the development and population of the P-RAM tool as more evidence-based research becomes available.

Impact

The P-RAM training program will assist agencies and responders to integrate evidence-based psychosocial considerations in their preparedness and response planning for CBRN-terrorism events. The extensive consultation process with the responder community raised considerable awareness about the impact of various characteristics—ranging from the population to the hazard—on potential and actual individual and collective psychosocial responses. A national network of responders was created. The responders have remained in contact with one another, as well as project staff on psychosocial issues. The network has resulted in considerable informal sharing of expertise and resources across Canada and abroad. In addition, there have been a significant number of national and international presentation requests regarding the research. This has contributed to the recognition of IPH as a leading centre for research and programming in the psychosocial aspects of CBRN terrorism.

CRTI 02-0091TA (1)

Clostridium botulinum Type A Genomic DNA Microarray

Project Lead: Health Canada
Federal Partner: National Research Council
Other Partner: Institute of Food Research

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Objectives

This project addresses forensic needs through the development of highly discriminating typing methods for strains of *Clostridium botulinum* based on comparison of bacterial cell surface proteins and their post-translational modifications.

The new methods developed in this project have the potential to be used for *C. botulinum* typing. The project has also produced a description of the variation within the regions encoding cell surface proteins in various strains of *C. botulinum* using strategies developed by researchers at Health Canada and the National Research Council (NRC).

Relevance

This project will assist the operational community to respond to CBRNE terrorism by providing both precise and rapid methods for strain identification for *C. botulinum*. The research builds upon the deoxyribonucleic acid (DNA) microarray typing portion of the project to enhance the discriminatory potential for Group I and, potentially, Group II *C. botulinum* strains using novel mass spectroscopy-based approaches. The data obtained on the unique post-translational modifications of flagellin proteins forms the foundation for future work investigating the use of *C. botulinum* surface proteins for detection of specific strains in food matrices. This will form an important addition to the arsenal of detection and discrimination strategies developed by this project for surveillance and rapid response to *C. botulinum*.

Recent Progress and Results

The high degree of sequence conservation between botulinum neurotoxin serotypes limits the ability to differentiate between strains. The diversity among bacterial cell surface structures is used for strain differentiation in many Gram-negative bacteria. Little, however, is known about the cell surface proteins of *C. botulinum* and the potential to use these for strain differentiation. The project team focused on an initial characterization of flagellar diversity, with a detailed characterization of the post-translational modification of flagellin from a Type A strain.

Researchers isolated and analyzed flagellin proteins by nanospray mass spectrometry to determine the mass of the intact glycoprotein. They found that flagellins isolated from the highly flagellated Type A strain, FE9909ACS-Alberta, have a mass approximately 10 percent higher than predicted. They subjected this flagellin to tryptic digestion and analyzed the resulting proteolytic digest by nano liquid chromatography tandem mass spectrometry (nLC-MSMS). Peptides whose mass did not match that of the predicted flagellin peptides were *de novo* sequenced. They found the glycosyl moiety to be a single monosaccharide substitution, with up to seven sites of modification per flagellin protein. Additionally, they detected this glycosyl moiety in a number of flagellins from strains of *C. botulinum* neurotoxins (BoNT) Type A and one flagellin from a botulinium neurotoxin (BoNT) Type F strain.

The researchers' examination of the flagellins from 15 additional strains by nLC-MS showed a variety of post-translational modifications. Additionally, they were able to identify the ions associated with the flagellin and the post-translational modification in a mixed-protein sample, a discovery that shows promise as an additional method of *C. botulinum* typing methodology.

Impact

The research team's screening of *C. botulinum* flagellin proteins has revealed the potential to type strains in a manner independent of DNA. The team has used this methodology, which is based on mass spectroscopy identification of signature ions of the novel glycan moiety, to identify and discriminate the strain origin in a recent outbreak. This work was carried out in collaboration with the Botulism Reference Service of Canada. The success of this effort has demonstrated the potential to apply nLC-MSMS for the detection of *C. botulinum* contamination within the food supply as part of ongoing surveillance to circumvent potential CBRNE threats.

CRTI 02-0091TA (2)

Clostridium botulinum Type A Genomic DNA Microarray

Project Lead: Health Canada
Federal Partner: National Research Council
Other Partner: Institute of Food Research

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Objectives

This project addresses forensic needs through development of highly discriminating typing methods for strains of *Clostridium botulinum* based on comparison of whole genomes and subsets of variable genes within these genomes. Applications of the microarray for studying the behavior of *C. botulinum*, and the dynamics of botulinum neurotoxin (BoNT) production are discussed in this abstract.

In collaboration with project partners in Health Canada's Bureau of Microbial Hazards in the Health Products and Food Branch, researchers at the Institute of Food Research (IFR), Norwich, United Kingdom (UK) developed new methods of whole genome typing for *C. botulinum*. The project team also developed a way to identify variable genes within the genome. Lastly, Health Canada and National Research Council (NRC) researchers developed second-generation typing strategies based on these genes.

Relevance

This project will assist the operational community to respond to CBRNE terrorism by providing both precise and rapid methods for strain identification for *C. botulinum*. On a forensic time scale, deoxyribonucleic acid (DNA) microarray typing provides highly discriminatory gene-to-gene comparisons across whole genomes of Group I *C. botulinum* strains and identifies the genes of the flagellar glycosylation island as a diverse region of the genome. The project team established a polymerase chain reaction (PCR)-based typing scheme for *C. botulinum* based on flagellin genes. This technique can be used to identify a strain as Group I or Group II, and determine flagellar sequence type in under 24 hours, without requiring a pure culture and using established molecular typing methods.

Recent Progress and Results

The project team completed the sequencing of the Hall A *C. botulinum* genome and construction of the genomic microarray. The team used comparative genomic indexing to compare genomes of 63 clostridial strains to that of the Hall A genome by microarray. *C. botulinum* Group I strains were closely related, sharing 89 percent of all coding sequences with Hall A while non-toxic *C. sporogenes* shared 84 percent. Individual strains could be distinguished and clustered together by neurotoxin subtype. In contrast, strains did not cluster by origin (i.e. foodborne botulism). An examination of Group II *C. botulinum* and *C. difficile* genomes by microarray showed that these clostridia are not closely related to Group I *C. botulinum.*

The researchers used comparative genomic indexing to identify the genes of the putative flagellar glycosylation island as a variable portion of the *C. botulinum* genome. They found that PCR amplification of the flagellin gene *fla*A was equally applicable to Group I and Group II strains. They developed colony PCR and combined it with restriction endonuclease digestion of *fla*A for rapid differentiation of Group I and Group II strains. The *fla*A sequences from 80 strains showed that flagellar type did not correlate with neurotoxin serotype. Researchers combined colony PCR of both *fla*A and neurotoxin genes to target two genes for increased rapid discrimination between strains, analogous to dual antigen-serotyping schemes currently in use for numerous Gram-negative bacteria (i.e. *Escherichia coli* O157:H7).

Impact

The research team used microarray typing to correlate epidemiologically related strains, showing that it can be used to identify unknown strains of Group I *C. botulinum* via comparison to a genomic indexing database of known strains. Microarray typing can also be used to establish epidemiological relationships, as strains related by case history group by genomic profile. Health Canada and now have the capability to type strains by genomic microarray.

Colony PCR of neurotoxin and *fla*A represents a fast method for profiling *C. botulinum*. The *fla*A sequencing is useful for both Group I and Group II *C. botulinum*. Due to the speed and ease of use, *fla*A sequencing is being used at the Botulism Reference Service of Canada to investigate the origin of several recent clinical cases of botulism. Health Canada and IFR are currently investigating *C. botulinum* biology and toxin production by examining gene expression using the genomic microarray.

CRTI 02-0093RD

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

Project Lead: Environment Canada — Canadian Meteorological Centre

Federal Partners: DRDC Suffield, Health Canada — Radiation Protection Bureau, Atomic Energy of Canada Limited

Industry Partners: J.D. Wilson & Associates, Waterloo CFD Engineering Consulting

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Objectives

The objective of this project is to develop and validate a prototype state-of-the-science multi-scale modelling system to predict the transport and dispersion of CBRN materials in the urban environment and beyond. The project team has developed six components: a computational fluid dynamics model (urbanSTREAM) for microscale urban flow prediction; an urban parameterization in a meso-Á scale numerical weather prediction model (GEM-LAM); urbanSTREAM coupled with the "urbanized" GEM-LAM; a Lagrangian Stochastic model (urbanLS) for prediction of urban dispersion; validation of the coupled modelling system; and a methodology for source reconstruction. The last component was developed under the Public Security Technical Program (PSTP). A prototype of the modelling system has been implemented at Environment Canada's Environmental Emergency Response Division (EERD) in the Canadian Meteorological Centre (CMC).

Relevance

The prototype modelling system serves as a high-fidelity predictive tool to plan scenarios and to conduct forensic and post-event analysis, as well as for operational response. Incorporation of the capabilities of the proposed system in a government operations centre will improve emergency preparedness for and management of CBRN incidents in Canadian cities. The tool can be used for planning at events of national significance (e.g., G8 summit, 2010 Winter Olympics). The modelling system contributes to other CRTI projects such as the Accident Reporting and Guidance Operational System (ARGOS) or the Canadian Health Integrated Response Platform (CHIRP), as well as to the unified interoperability framework for improving federal, provincial, and municipal coordination in a CBRN response.

Recent Progress and Results

For urbanSTREAM and urbanLS, the project team has developed a module for the automatic generation of grids

in the computational domain when provided with detailed geometric information on the shapes and locations of buildings in the urban environment. The team has implemented modules for the prediction of urban dispersion in the Eulerian framework: urbanEU, which is a source-oriented dispersion model based on the numerical solution of the advection-diffusion equation, and urbanAEU, which is a receptor-oriented dispersion model based on the numerical solution of the adjoint of the advection-diffusion equation. The computer programming for the urbanSTREAM microscale flow model has been successfully parallelized and is executing properly on the massively parallel IBM computer platform at the CMC. The team has developed Zeroth- and first-order Lagrangian Stochastic models for urban dispersion in both the forward- and backward-time modes. The three-dimensional field of wind and turbulence statistics provided by urbanSTREAM has been successfully used to "drive" the Lagrangian (urbanLS) and Eulerian (urbanEU and urbanAEU) models for urban dispersion. The numerical simulations of Intensive Observation Period (IOP) 9 in the Joint Urban 2003 (JU2003) experiments, conducted in Oklahoma City, Oklahoma, provide an initial demonstration that the developed modelling system can correctly reproduce many features of the flow and dispersion in a real urban environment.

For GEM-LAM, its coupling with urbanSTREAM, and validation of the coupled modelling system, the team developed and successfully applied two semi-automated methodologies based on satellite imagery and vector data for the derivation of urban land use and land cover classifications over various cities. The team implemented improvements to the turbulence kinetic energy (TKE) model that better represent turbulent diffusion at the smaller scales in the Mesoscale Compressible Community (MC2) and GEM mesoscale flow models. The team completed data analysis for two successful field campaigns (called the Montreal Urban Snow Experiment [MUSE]) in 2005 and 2006, for investigation of surface energy budgets under winter conditions in an urban environment. The team also assessed the performance of the Town Energy Balance (TEB) urban parameterization, in winter conditions with different amounts of snow cover in the urban environment, using data derived from MUSE. The team validated the coupled system consisting of the urban microscale and mesoscale models using data extracted from IOP 6 and IOP 9 of the JU2003. The prototype GEM model cascade (2.5 kilometres [km] to 1 km to 250 metres) is now running experimentally over Montreal, Québec and Vancouver, British Columbia and has been fully transferred to the CMC.

For the methodology for source reconstruction, the team has developed a Bayesian (probabilistic) inferential framework and successfully applied it to the problem of source reconstruction in the case of contaminant transport and dispersion in complex environmental conditions. Sources were correctly inferred using actual measured concentration data from the JU2003 study in Oklahoma City and the European Tracer Experiment.

Impact

The modelling system can form the basis for the automated preparation of city- and location-specific decision support products for emergency response managers and decision makers. The products include timely information on area contamination and exposed facilities, population dose estimates and health effects, guidance on protective actions and response strategies, all of which can provide the single, unambiguous, coherent operational picture of an evolving CBRN hazard required for situational awareness and emergency preparedness. The modelling system is being applied to the planning of high-profile events, such as development of CBRN counterterrorism measures for the 2010 Winter Olympics. Health Canada's operational response on nuclear hazards will benefit directly from the outputs of the system, by integrating these outputs with their ARGOS system. The modelling system, when fully functional in a government operations centre, has the potential to serve as a nation-wide general problem-solving environment and reach-back resource for first responders involved with addressing CBRN incidents.

CRTI 03-0005RD

Sensor Technology for the Rapid Identification of Pathogens used as Bioweapons

Project Lead:	National Research Council – Industrial Materials Institute
Federal Partners:	National Research Council – Steacie Institute for Molecular Sciences, Public Health Agency of Canada, DRDC Suffield
Industry Partner:	Becton, Dickinson and Company
Other Partner:	Université Laval, Centre hospitalier universitaire de Québec – Centre de recherche en infectiologie

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Objectives

This project aims to develop a novel technology based on luminescent polymeric transducers that will lead to a rapid and sensitive detection system for the identification of biological pathogens. The project's key deliverable is a functional prototype, able to identify fewer than 10^3 *Bacillus anthracis* cells and spores directly, either from pure culture or from spiked test samples within one hour. In the project's final year, the research team will use the Public Health Agency of Canada's (PHAC) Level 3 laboratory to test the technology's *B. anthracis* detection. The detection process will trap differently functionalized magnetic particles as the particles diffuse through a deoxyribonucleic acid (DNA) sample. The result of the detection process will be the confinement of a number of different DNA targets, a capacity that could be extended in the future.

Relevance

The development of a sensitive, rapid, and compact technology that is capable of rapidly detecting and identifying nucleic acids without prior amplification could enable first responders and public health providers to rapidly detect and identify potential biothreats on-site; improve the capabilities of medical triage procedures and tools used to detect and classify events; and contribute to the efficient diagnosis of infectious diseases and genetic disorders.

Recent Progress and Results

The project team has successfully established proof of concept that its polymeric transducer can be used to rapidly detect *B. anthracis*. Using solution without prior polymerase chain reaction (PCR) amplification, the transducer can detect approximately 300 copies in about 10 minutes from a sequence isolated from *B. anthracis.* A new detection process tested on synthetic oligonucleotides improves the efficiency even further, allowing the detection of less than 30 copies after only a few minutes in solution. The next critical step involves the detection of DNA from *B. anthracis* using this new detection method on a solid surface, which will require isolating and detecting suitable *B. anthracis* DNA fragments. The team has tested several methods for purifying and fragmenting *B. anthracis* DNA resulting in fragments of different lengths, from which the most suitable fragments were selected for detection.

Over the last year, the researchers produced a third generation of electromagnetic traps that produce a tremendous increase in the trapping speed of magnetic probes through a mixed architecture of ring and mechanical constriction. These electromagnetic traps were then incorporated into a microfluidic device. The team continues to develop magnetic probes and has filed the final patent on a new fluorescent probe architecture that could increase the sensitivity of detection even further. In the development of cationic transducers, the researchers synthesized a number of different polymer structures to improve detection efficiency and tested them with the probes isolated from *B. anthracis* to identify the best polymeric structure.

The project's partners are confident that with all of these developments, they are approaching a final solution. The project will end in September 2007 with a technical demonstration of the technology under real conditions.

Impact

This revolutionary technology will ensure military and civilian personnel have the fastest response time to biological threats, as well as provide opportunities for Canadian biotechnology companies to develop a significant competitive edge over PCR-amplification technologies.

CRTI 03-0009RD

Caring About Health Care Workers as First Responders: Enhancing Capacity for Gender-based Support Mechanisms in Emergency Preparedness Planning

Project Lead: Department of National Defence – Bureau of Women's Health and Gender Analysis

Other Partners: University of Ottawa – Institute of Population Health, Canadian Women's Health Network, Canadian Federation of Nurses' Unions, University of Ottawa – School of Nursing, University of Toronto – School of Nursing, Health Systems Strategies, Victorian Order of Nurses, GPI Atlantic, Ontario Ministry of Community Safety and Correctional Services, British Columbia Centre of Excellence for Women's Health

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Objectives

The goal of this project is to mitigate the impact of future CBRN-contagion threats by recommending support mechanisms for health care workers as first responders. Project researchers will use the lessons learned from the Severe Acute Respiratory Syndrome (SARS) outbreaks to focus on the psychosocial impact of an infectious disease outbreak, the importance of balancing work performance and family responsibilities, and their implications on gender.

Over the three and a half years of the project's duration, researchers will review existing literature for information about the support available for health care workers as first responders, and they will survey the workers about the impact working on the front line of infectious disease outbreaks has on their family, their health, and the psychosocial aspects of their life. Together, the literature review and survey will enable researchers to identify gaps and provide recommendations for improving support mechanisms for frontline health care workers.

The project team will go beyond recommending support mechanisms and examine personnel policy and work–family conflict from a gender perspective to provide decision makers with information that will encourage the development of gender-based support mechanisms for public health care workers. A final objective will be to increase awareness and

enhance decision-making capacity among policy makers by publicizing the results of the study and facilitating discussion of the issues.

To achieve their objectives, researchers will employ a variety of data collection methods including focus groups of frontline nurses, a nation-wide web-based survey, policy analysis, and gender-based analysis. Using this data, the team will develop a risk management framework and create a policy forum for information dissemination and consultation with policy makers and stakeholders.

Relevance

Health care workers are key responders to infectious disease outbreaks, caused by either the accidental or deliberate spread of microorganisms such as bacteria and viruses. The workers' health and safety is critical during such events, as is their willingness to continue working during a large-scale outbreak, given the significant risks involved. The population depends on the capacity and willingness of knowledgeable caregivers to provide health services and manage outbreaks.

This project will highlight the importance of human resource capacity and mobility as key elements of disaster preparedness, particularly for health services, where human resource shortages already exist. Recognizing that disasters affect men and women differently and that 80 percent of health care workers are women, the project will highlight the need for gender-sensitive policy making, providing decision makers with insight into critical issues facing frontline health care workers, and the potential impact of large-scale bioterrorism events on Canada's response capacity.

Recent Progress and Results

As the project enters its final year, data collection and analysis are complete and June 2007 will bring the delivery of the risk management framework that consolidates the findings for the project. Following delivery of the framework, the Canadian Policy Research Network (CPRN) will host the policy forum.

Overall, the project findings indicate significant gaps in organizational and social support for frontline health care workers in their roles as responders during bioterrorism disasters. Results indicate that health care workers do not feel adequately prepared to respond to a large-scale infectious disease outbreak, and 40 percent of survey respondents did not know whether their health care institution had an emergency plan for infectious disease outbreaks in place. The gap analyses revealed that there is organizational support for health care workers relating to the mobilization of additional health care workers and the provision of personal protective equipment (PPE). However, the focus groups and survey results indicated a lack of confidence in systemic response capacity from the frontline health care workers. Indications that health care workers may not be willing to respond during a highly contagious outbreak, such as smallpox, is of particular concern. It is clear that health care workers are concerned about their roles as responders and coordinated efforts are needed to ensure their concerns are recognized and integrated in the development of proactive policies and procedures to enhance Canada's collective ability to combat a large-scale infectious disease outbreak.

Impact

Researchers are disseminating the knowledge gained in this project on an ongoing basis. Plans are underway to distribute the focus-group report at a national nursing conference that is expecting 600 attendees, members of the project team have made a number of presentations to organizations such as the World Association on Disaster and Emergency Medicine and the World Conference on Disaster Management, and in addition to hosting the policy forum, the CPRN will post the resulting discussion paper on its website, which typically receives 750,000 hits per year.

CRTI 03-0013TD

Early CBRN Attack Detection by Computerized Medical Record Surveillance

Project Lead:	National Research Council Canada – Institute for Marine Biosciences
Federal Partners:	National Research Council – Institute for Information Technology, Public Health Agency of Canada
Industry Partner:	AMITA Corporation
Other Partners:	University of Ottawa Heart Institute, Michigan State University, National Food and Toxicology Center, Carnegie Mellon University – School of Computer Science – Auton Laboratory, Grey Bruce Public Health Unit, South Bruce Grey Health Centre – Walkerton Site

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Objectives

Syndromic surveillance systems are designed to detect time- and geography-dependent abnormal disease occurrences. These systems can be used to alert responders to an outbreak or terrorist attack that may be in progress, and to track the progress of this event after detection. This project will build on the Real-time Outbreak Detection and Surveillance (RODS) syndromic surveillance system developed by the University of Pittsburgh. First, researchers will adapt the RODS system and use retrospective data analysis to demonstrate its utility. They will then deploy the RODS-based system known as Early

CBRN Attack Detection by Computerized Medical Record Surveillance (ECADS) for a demonstration in a Canadian setting. The project team will then determine the steps needed to integrate the ECADS system with existing and planned surveillance systems in Canada and the United States (US), along with the development of a road map for implementing syndromic surveillance in Canada.

Relevance

ECADS can provide information that will help in the early detection, characterization, and management of outbreaks caused by naturally occurring infectious diseases or bioterrorism.

ECADS addresses several of the highest risk scenarios identified by CRTI. These risk scenarios include: a covert attack on a large urban area using an agent such as anthrax; a biological attack against a critical infrastructure, food, or water supply by contamination of a localized supply with an infectious agent or toxin; a chemical attack against people in enclosed spaces, such as a covert aerosol attack with a volatile toxic agent (e.g., sarin gas); a chemical attack against people by contamination of food or water supply; and a covert attack on a large urban area using a non-explosive radiological dispersal device. In the absence of a terrorist attack, syndromic surveillance systems will also provide public health institutions with the ability to detect and manage naturally occurring outbreaks.

Recent Progress and Results

The ECADS project was successfully completed in January 2007, with all deliverables complete, including a roadmap and a Privacy Impact Assessment. The project team demonstrated the ECADS system using retrospective data from Walkerton, Ontario, in relation to the *Escherichia coli* contamination of the municipal water supply in 2000. The team accessed 396,698 emergency room records, of which 392,699 records were available in electronic format and 3,999 were manually extracted. The researchers determined that if the ECADS system had been available at the time of the *E. coli* contamination, the Walkerton outbreak could have been detected at least two days before the first alert, and possibly as early as four days before the boil-water advisory was released. The Walkerton outbreak ultimately resulted in six deaths and caused thousands to become ill.

This project demonstrated that monitoring the chief complaints of patients presenting to area emergency rooms could have provided important information regarding the Walkerton outbreak, possibly advancing its detection by as much as several days. Based on their retrospective experience with the Walkerton event, the team is adding text-mining algorithms to increase the specificity and sensitivity of the ECADS system. The Walkerton outbreak is a well-documented instance in which the accidental contamination of a municipal water supply resulted in widespread illness, but it also provides a model for what might happen following a bioterrorism attack using an enterotoxic agent.

Project partners demonstrated ECADS at three scientific exercises and meetings. The meetings brought together leading scientists from other syndromic surveillance projects to share information and ideas. In December 2005, the ECADS system was successfully installed in the Grey Bruce Public Health Unit in Owen Sound, Ontario. For six months, AMITA staff remotely monitored and maintained the system on a daily basis, as well as trained the Grey Bruce Public Health Unit personnel on the system. Since April 2006, Grey Bruce personnel have maintained the system, which is self-supporting, and there have been no significant technical difficulties. Using the ECADS system to gather and analyze data, the Grey Bruce Public Health Unit has issued several alerts to area emergency departments, including a gastrointestinal alert that was confirmed by Health Canada's over-the-counter (OTC) sales surveillance system.

Impact

The ECADS project provided two tools (a software system and a roadmap) aimed at municipal, provincial, and federal public health and safety communities, first responders, and the military. The software system processes medical data in real time and generates alerts for public health or antiterrorism first responders, better informing and preparing them for naturally occurring or terrorist-induced syndromic events. The roadmap describes the steps that must be taken and processes that must be followed to integrate the ECADS system within Canadian systems, including technical and other issues that may be encountered (e.g., privacy assessments).

CRTI 03-0017TA

Development of a Directional Gamma Ray Probe

Project Lead: DRDC Ottawa

Federal Partners: Canadian Nuclear Safety Commission, Department of National Defence – Joint Nuclear, Biological and Chemical Defence Company, Royal Canadian Mounted Police

Industry Partner: Bubble Technology Industries

Other Partner: United States Coast Guard

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Objectives

The isotropic nature of conventional radiation detectors makes it difficult to remediate areas with dispersed radiological materials. Conventional detectors require first responders to consider trends in the dose rate to identify the source of the emission, prolonging the time they spend in potentially high dose-rate areas, increasing their exposure, and reducing the effectiveness of the remediation efforts.

This project addresses these issues by incorporating directionality into a portable gamma ray spectrometer. The project team developed two detectors. The first detector, a directional gamma ray probe (DGRP), is used in high-level radiation fields to localize the source of radiation and rapidly remediate radioactive material spread over an area. The second, a sensitive directional gamma ray probe (SDGRP), is used in low-level radiation fields (i.e., outside a hot zone) to detect, localize, and identify lower radiation activity or shielded sources. The project team sought input from first responders into the design and testing of the devices, ensuring the detectors met their needs.

Relevance

The use of the DGRP and the SDGRP improve response capability to CBRN-terrorist events by enabling responders to locate, identify, and determine the activity level of single or multiple radiation sources more rapidly and accurately. Following the completion of the project, the detectors will initially augment the responder community's suite of

radiation detection devices, but with time, the devices are expected to replace current hand-held spectroscopic units that cannot identify a single source of radiation in the presence of multiple sources.

Recent Progress and Results

Initial testing of the completed devices allowed users to identify necessary modifications to the detectors, leading to several months of hardware and software improvements on both detectors. The DGRP was tested in March 2006 at Exercise Maritime Response (EXMR) and the SDGRP was tested in August 2006 at DRDC Ottawa. In November 2006, DRDC Ottawa was the site for a series of field trials to thoroughly evaluate the functionality of the detectors in both a laboratory and an operational-field environment.

The laboratory trials focused on the ability of the detectors to accurately report dose-rate measurements at varying distances in comparison to measurements taken with an IONEX ionization chamber. Both detectors were assessed for lower detectable limits and dose-rate linearity. The laboratory trials highlighted the need for software improvements and for replacing some defective components in the detectors.

The field trials focused on the ability of the detectors to accurately localize and identify a variety of radioisotopes of differing activities. The research team devised four tests to assess the performance of the DGRP, the SDGRP, and the comparison device, the commercially available Exploranium GR-135 by Science Applications International Corporation (SAIC). Project partners from all of the responder communities operated the detectors. In the first test, detectors were used to perform the isotopic identification of seven different radioactive sources of approximately the same activity. In this test, the SDGRP was comparable to the GR-135; however, the DGRP was out of calibration due to a defective photomultiplier tube (PMT). The second test was devised to assess the ability of the detectors to localize multiple sources of the same isotope, while the third test was used to assess the detectors' ability to localize multiple sources of different isotopes. The results from these tests showed that, on average, the DGRP and SDGRP reduced the localization time by a factor of two. In the last test, users attempted to localize a single radioactive source hidden in one of two transport containers with each of the three detectors. Users of the DGRP and the SDGRP were able to locate and identify three different radioactive sources, while GR-135 users were able to locate all three radioactive sources, but they were only able to perform isotope identification on one of these sources.

Impact

Both the low- and high-field radiation detectors indicate the direction of the radioactive source—a feature not available in any commercially available detector—and the development of hand-held spectroscopic detectors that incorporate directionality represents a breakthrough in radiation detection technology. The improved detection and identification capability of both detectors will improve the safety of responders by reducing the time spent in a radiation field and thereby reduce the radiation dose to which responders are exposed. The participation of responders from several operational communities in the development of these detectors has ensured that the detectors are relevant, easy-to-use, and meet their needs. The project finished in December 2006 following end-user testing, which highlighted improvements necessary for bringing the detectors to the commercial market. The detectors will become commercially available following the issuance of a patent.

CRTI 03-0018RD

Experimental Characterization of Risk for Radiological Dispersal Devices

Project Lead: DRDC Ottawa

Federal Partners: DRDC Valcartier, Health Canada, Environment Canada

University Partners: Royal Military College of Canada, Carleton University, University of Ontario Institute of Technology, University of British Columbia

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Objectives

The effectiveness of radiological dispersal devices (RDDs) has been the subject of considerable debate over the past few years. Expert opinion on the risks of RDDs varies wildly—some experts completely discount RDDs as a risk, while others greatly overstate their impact. The purpose of this project is to conduct experiments that address gaps in our knowledge of the risks associated with the dispersal of radiological material by explosive and non-explosive means. The project team will predict the potential biological effects of an RDD after quantifying the amount and physical form of the radiological aerosol generated by an RDD. Based on the outcomes of these experiments, researchers will then refine the consolidated risk assessment and probabilistic risk assessment tool for RDDs developed under a separately funded CRTI project (CRTI 02-0024RD: Probabilistic Risk Assessment Tool for RDDs).

Relevance

Strategies and decisions to protect first responders, the public, and critical infrastructure against the effects of a detonated RDD must be made in the planning stage, not in the early period just after an attack. By the time it is known that an attack has occurred, there will likely be casualties, all the radioactive material will have been released, plume growth will be progressing, and there will be no time left for evaluating possible countermeasures. The development of emergency response procedures and guidelines for first responders dealing with radiological terrorism incidents requires experimentally verified data on the effects of RDDs. The project team will quantify the probability and impact of the RDD scenarios provided in CRTI's Consolidated Risk Assessment through experimental trials. The results of these experiments will enable the team to then develop databases of aerosol properties and models for the prediction of such properties for both explosive and non-explosive RDDs.

Recent Progress and Results

The project team characterized the explosive dispersal of radiological material, using non-radioactive ceramic simulants supplied the University of British Columbia (UBC), at DRDC Valcartier. DRDC Valcartier has an explosives range and is capable of performing these experiments in both closed and open environments. The DRDC Valcartier team carried out indoor testing in June and November 2006, for two weeks on each occasion. These tests were complementary to those performed earlier in the project and conditions were varied to assess other parameters (e.g., high humidity). The indoor tests are being used to determine both the amount and the particle-size distribution of the RDD-generated aerosols. To complement the source terms determined from the indoor tests, the researchers conducted another series of outdoor tests in February 2007. The outdoor tests used benign tracer materials, characterized in indoor explosive testing, to simulate release in real atmospheric conditions. The generated plume was tracked using a Light-Imaging Detection and Ranging (LIDAR) system and project participants at the Royal Military College (RMC) and Environment Canada used the plume-evolution measurements to validate atmospheric dispersal models. LIDAR was also used during an important two-week trial done in October 2006 in New Mexico, in collaboration with Sandia National Laboratory. The tests were performed to assess the effect of dirt entrainment in the fireball, which is believed to have an effect on aerosol dispersion. This collaborative trial, which also included participants from the United Kingdom (UK) and visitors from Australia, generated a wealth of data.

The project team is characterizing the non-explosive dispersal of radiological material at the University of Ontario Institute of Technology (UOIT). These tests involve characterizing the spray mechanisms for both liquid and powdered sources, as well as methods for source preparation (both mechanical and chemical). UOIT researchers have developed a methodology for generating dispersible powders from ceramic pellets. Particle size distributions are determined using a laser-based particle sizer, as well cascade impactors and other aerosol samplers. Powder spray testing began in the summer of 2005 and is ongoing. Particle sizing has been characterized as functions of temperature and relative humidity. In addition, the researchers investigated the charge effects on the ceramic powders. In addition to the experimental work, the UOIT team is performing spray nozzle modelling using computational fluid-dynamic (FLUENT) models to allow prediction of large-scale dispersal.

Researchers at Health Canada's Radiation Protection Bureau, Carleton University, and Acadia University are assessing the health effects of RDD-generated aerosols. Chemical analysis of the air samples taken during the indoor explosive tests allows the researchers to characterize the aerosol generated. Depending on the type of sample taken, this determines either the fraction of the original source that is aerosolized or the particle-size distribution. Other analyses determine the morphology of aerosol particles. This gives insight into the physical mechanism involved in the generation of the aerosol, and allows predictive models to be developed that can be used to generalize the results of these experiments to other materials.

Impact

By September 2007, the project will be complete and the team will have developed databases of aerosol properties, which will include data on the toxicity of the aerosols. The team will also have developed models for the prediction of such properties for both explosive and non-explosive RDDs, enabling end-users to verify atmospheric-dispersal models. By identifying scenarios that are of greatest concern, and verifying, through experiments, data on RDD consequences, Canada's emergency preparedness and response communities will be able to properly prepare for such incidents. Using these data and models, first responders and decision makers will be able to quantify the probability and impact for known and emerging RDD threats and update CRTI's Consolidated Risk Assessment. Such data and models will also be useful for assessing general CBRN threats, not just radiological ones.

CRTI 03-0018TD

Airport Radiological Surveillance System

Project Lead:	Health Canada – Radiation Protection Bureau
Federal Partner:	Transport Canada
Industry Partners:	McFadden Technologies, Mobile Detect
Other Partners:	Ottawa Police Service, Ottawa International Airport Authority

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Objectives

The purpose of this project was to deploy a fully integrated radiological surveillance system in the Ottawa International Airport. The system provides sensitive, real-time detection of gamma radiation with sensors deployed in covert static and mobile locations and transmits data to a central server and database via the airport's telecommunications network. The system transforms radiological data into meaningful information through a customizable graphical-user interface (GUI) that is integrated with the airport security and emergency response systems and operations. Using sensor readings, the system creates profiles of the normal radiological environment for the approach, public, passenger, baggage, airport operations, tarmac, staff, and air crew areas of the airport that are under 24-hour, seven-days-a-week (24/7) real-time surveillance. The system uses novel data-analysis algorithms to identify signatures of anomalous radiation sources with low false-negative and false-positive rates. Alerts are developed and reported in real time.

Relevance

A security system to address threats from radiological exposure devices and radiological dispersal devices (RDDs) is one of CRTI's key investment priorities. Air transportation is a particularly high-value radiological-terror target because of the numbers of travellers, the role of air transportation in the economy, and the vulnerabilities associated with a public space.

The radiological surveillance system developed during this project provides the earliest possible and reliable detection and assessment of illicit radiation sources and practical

incident-management assets for airport-security operations. The system enables responders to quickly interdict radiological attacks and mitigate the health and economic effects of actual or alleged attacks. The project has resulted in a practical and production-ready technology for an airport radiological security system that is now available to the air transport industry. In the event of a radiological attack, the system provides key information to a national or international common operating picture to assist other airports in prevention and mitigation.

Recent Progress and Results

The project team has developed a production-ready, mobile, real-time radiological surveillance system for field use in airports. The team also developed two key complements to the technological components of the system: a radiological-security analysis of the air terminal, and a concept of operations (CONOPS) and standard operating procedures (SOPs). The project represents the first 24/7 radiological surveillance system to fully integrate with the routine operation of airport passenger and luggage systems, pre-existing airport security operations, and airport incident response CONOPs and SOPs.

The system GUI has user options relevant to incident management and can be used to view real-time or historical radiation data overlaid on mapping or aerial images. Users may select from static and video image options for output files to share electronic information with cooperating agencies and develop the common operating picture. The system normally operates in the background, accumulating and updating data to create profiles of the normal radiological environment in the areas under surveillance. It generates alerts by comparing real-time radiation data with pre-defined alert criteria. Users define the alert criteria to achieve the optimal balance between the cost of false positives and the required system sensitivity, and adjust alert criteria to respond to a variety of radiological-terror threat levels. Methods of communication between the remote sensors and the central server include wide-area wireless networks, satellite, local-area wireless networks, and Ethernet.

At responsibility-appropriate levels, security staff receives basic radiation security background information and training on the system's use. In an alert situation, the system transmits the alert type, the location of its occurrence, time, and supporting information to airport security operations. The security watch officer is the first to receive the alert through both audio and visual notification, followed by senior security staff. Airport security and the Ottawa Police Service define SOPs for response to and management of the alert. The system makes the alert status and other related information available to key security personnel on an individual basis. The information made available to each of these individuals is defined by both airport security and the Ottawa Police Service.

The project ended in March 2007 with the handover of the system to the Ottawa International Airport Authority. Live demonstrations of the system will be presented at the Ottawa International Airport.

Impact

The system provides autonomous, 24/7, cost-effective, and practical radiological surveillance and radiological threat agent identification without affecting routine airport operations such as passenger and luggage routing. The impact of the system is significant enhancements in radiological security and safety for the travelling public, airport staff, and security teams, and airport operations. The availability of this counterterrorism tool ensures the continuous operation of the air-transport sector as a whole and of the economy. It will increase the profile and recognition of radiological threats to the transportation system, and will catalyze the development of a new CONOPS and SOPs among cooperating incident response and management agencies.

It is anticipated that other airports in Canada and abroad will soon adopt the system. The open-architecture technology that the system employs makes it widely adaptable, allowing it to integrate with critical infrastructure and adjust to changing environmental settings such as those related to public events. The technology is also being used in the intelligent traffic system of the city of Colorado Springs, Colorado.

CRTI 03-0019TD

Real-time Biosurveillance and Response Readiness Using an Interconnected, Electronic Information Infrastructure: A Region-wide Technology Demonstration Project at the Winnipeg Regional Health Authority

Project Lead: Public Health Agency of Canada
Industry Partner: IBM Canada
Other Partner: Winnipeg Regional Health Authority

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Objectives

The Public Health Agency of Canada (PHAC) developed the Canadian Early Warning System (CEWS) within the Canadian Network for Public Health Intelligence (CNPHI) platform, and in collaboration with the Winnipeg Regional Health Authority (WRHA). There are two main goals for this system. The first goal is to consolidate and integrate health data and information from many points of care, such as emergency rooms telehealth (a 24-hour, seven-days-a-week health help-line) labs and over-the-counter (OTC) drug sales data, to decrease delays in public health event detection and response. The second goal is to reduce the impact of a bioterrorism event by minimizing delays in detection, increasing the speed of characterization, and decreasing response time. Although several real-time syndromic biosurveillance systems have been developed in North America, the effectiveness of these systems in infectious disease and bioterrorism surveillance is widely debated and comprehensive evaluations are necessary.

Relevance

Early event detection is recognized as a potential prevention and mitigation strategy for both intentional and unintentional disease events. CEWS offers a web-based, multi-data feed platform that provides public health first responders and frontline workers access to real-time data sources. Using this data, these individuals have the ability to detect public health disaster events early and to assess and manage event impacts at municipal, provincial, and federal levels. The integration of many data sources and interoperability between public health stakeholders at the municipal, provincial, and federal levels allows for a collective response capacity, as well as a comprehensive evaluation of the necessity and effectiveness of a system such as CEWS.

Recent Progress and Results

Launched in January 2006, CEWS represents the only online, real-time, role-based, multi-data syndromic surveillance system in Canada. Three real-time data sources contribute to the system. These sources are emergency room data from all Winnipeg acute-care facilities, phone calls to telehealth call centres, and OTC sales of pharmaceutical drugs from most

major retailers in Winnipeg. In November 2006, CEWS became the vehicle for the Alternative Surveillance Alert Project (ASAP), a national OTC surveillance pilot and, as a result, CEWS receives OTC data for surveillance purposes from all major Canadian retailers. Currently, eight pilot cities across Canada, including Winnipeg, are utilizing CEWS for OTC data surveillance.

Four years of retrospective data have been analyzed. The evaluation of CEWS focuses on surveillance for acute respiratory and gastrointestinal events, and includes descriptive analysis of data sources, simulation studies testing algorithm performance, and end-user surveys. Descriptive analysis determined that the patterns of use between telehealth and emergency rooms differed and that temporal patterns were seen in all data sources. Simulation studies showed that tuning an algorithm to a particular data source was more important to algorithm performance than algorithm selection. Evaluation studies revealed several key gaps in system design and utilization; namely, a lack of standards, a high false-positive rate, a lack of contextual information, and information overload.

Overall, CEWS shows promise, but evaluation results reflect the need for continued research with syndromic data and systems. An emergency room-chart review study is planned to investigate system sensitivity and specificity. A retrospective assessment of the performance of CEWS during the August 2006 outbreak of *Escherichia coli* in Winnipeg is underway.

Impact

Over the final months of this project, the primary goal is to evaluate the benefits of real-time syndromic surveillance intelligence to regional health authorities, beyond what is already provided through traditional public health information sources, in particular, laboratory results. To date, the project has generated considerable interest within Winnipeg, across Canada, and internationally. With the eight pilot cities evaluating OTC data provided by CEWS as a surveillance tool and Winnipeg's multi-data evaluation, the project team expects to provide, with some certainty, the importance of an integrated multi-data platform to bioterrorism event detection and response. To date, WRHA end-users and all OTC end-users are impressed by CEWS capacity and its ability to transfer surveillance knowledge. The date for completion of this project is September 2007.

CRTI 03-0021TD (1)

Assay Development and Production Team for the Identification of Bioterrorism Agents: Detection and Identification of Bacillus anthracis Protective Antigen and Biological Threat Agents by Electrochemiluminescence Immunoassay

Project Lead: Public Health Agency of Canada – National Microbiology Laboratory

Federal Partners: DRDC Suffield, Canadian Food Inspection Agency – National Centre for Foreign Animal Disease

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Objectives

The focus of this project was the formation of the Assay Development and Production Team (ADAPT). ADAPT is a group of scientists dedicated to developing immunodiagnostic reagents and assays, for human, animal, and zoonotic biothreat agents that can be validated, produced, and distributed to first responders should a biothreat event occur. Once formed, the group will work to transition the immunoreagents developed in the project to a sensitive and rapid immunoassay system using an electrochemiluminescence (ECL) platform, the M-SERIES M1MR analyzer from BioVeris Corporation. The group will also compare antibodies developed by the Public Health Agency of Canada (PHAC) and DRDC Suffield to antibodies available from DRDC collaborators in the United States (US) and the United Kingdom (UK), for utility in the M1M ECL assay.

Relevance

The availability of rapid and sensitive diagnostic assays during a biothreat event is critical to the safety and protection of populations in the affected area. The microplate enzyme-linked immunosorbant assay (ELISA) is the current standard, against which all other immunoassays are compared. However, in today's high-threat climate, frontline first responders to biothreat events require assays that outperform ELISA in terms of speed, sensitivity, throughput, ease-of-use, and robustness. The ECL detection and identification system is believed to be such a system.

The M1M ECL immunoassay is a magnetic bead-based assay utilizing a sandwich-type format that consists of capture antibody labelled with biotin coated on streptavidin magnetic beads, a detector antibody labelled with ruthenium (II) tris-bipyridal chelate, and an analyte. When compared to ELISA, the ECL system has a number of distinct advantages, including high sensitivity, wide dynamic range, rapid determination of results, automation for field applications, and excellent stability of labelled reagents.

ADAPT is developing the ECL-detection system to enable the rapid detection and diagnosis of biothreat agents in a format that is field-portable and requires minimal training. The ECL system has undergone preliminary testing in the US Department of Defense and is ranked highly on performance criteria.

Recent Progress and Results

To date, the project milestones and timelines are on schedule. DRDC Suffield has developed ECL immunoassays on the M1MR analyzer for *Bacillus anthracis* protective antigen (PA) and several other biothreat agents. A number of different monoclonal antibody (mAb) and polyclonal antibody (pAb)

configurations and combinations were evaluated. For anthrax PA, a total of 12 antibodies and over 100 combinations of antibody pairs were tested for utility in the ECL assay. The results demonstrated that the most sensitive antibody combination utilized a biotinylated mAb and ruthinylated mAb pair. Under optimal conditions, the PA assay sensitivity was 5 picograms or 0.1 nanograms per millilitre, and the highest signal-to-background (S/B) value was 538. Although mAb pairs gave significantly higher S/B values than combination mAb and pAb pairs, the limit of detection (LOD) was similar for all antibody pairs. The anthrax-PA assay was specific to anthrax PA as evidenced by the absence of cross-reactivity with 23 bacterial, viral, and toxin agents, including *B. anthracis* lethal factor (LF) and edema factor (EF). The assay used 50 microlitres of sample per test and required a one-minute per assay reading time (96 tubes per tray maximum) and a 15-minute incubation period. This assay holds a significant advantage over the standard microplate ELISA in terms of its sensitivity, detection time, and because it is automated, its ease of operation. ECL assays for several other biological agents, including Venezuelan equine encephalitis (VEE) virus, *Burkholderia mallei*, and *Francisella tularensis* are currently under development at DRDC Suffield.

Impact

The project team anticipates that the M1M-ECL assays developed under this project will improve the ability of first responders to rapidly detect and identify biothreat agents. The detection and identification of biothreat agents is the first critical step in responding to a biothreat event, preceding the administration of countermeasures. This improved ability to respond to a biothreat event will contribute to public confidence in the effectiveness of Canada's response efforts. The project is expected to be complete by December 2007.

CRTI 03-0021TD (2)

Assay Development and Production Team for the Identification of Bioterrorism Agents: Hybridoma Development Capacity at DRDC Suffield

Project Lead: Public Health Agency of Canada – National Microbiology Laboratory

Federal Partners: DRDC Suffield, Canadian Food Inspection Agency– National Centre for Foreign Animal Disease

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Objectives

The focus of this project is the formation of a team of scientists responsible for the identification, development, and validation of reagents and assays that first responders can use to identify biothreat agents. A specific goal of this project is the establishment of a hybridoma development capacity at DRDC Suffield capable of producing monoclonal antibodies (mAbs) that can be used in novel immunoassays to detect and identify bacterial, viral, and toxin biothreat agents.

The development of this capacity involves several activities for the project team. First, it involves upgrading the DRDC Suffield hybridoma facility, which is leveraged through another CRTI project, "Upgrade of Hybridoma Facilities" (BIO019AP). Second, it involves cross-training DRDC scientists at the Public Health Agency of Canada's National Microbiology Laboratory (PHAC-NML) in protocols and techniques for the generation of hybridomas. Third, it involves an assessment of DRDC Suffield's existing hybridoma repertoire, which was acquired from a variety of sources including in-house and contracted research and the United States (US)/United Kingdom/Canada/Australia Memorandum for the Research, Development, and Acquisition of Chemical, Biological, and Radiological Defence Material (CBR MOU). And fourth, it involves the production of novel hybridomas and mAbs.

Relevance

The increasing threat of terrorist attacks involving biological agents has led to a corresponding increase in research into methods and reagents capable of identifying these agents. The ability to rapidly and effectively respond to biothreats is essential to minimizing the impact of an event on first responders and the general public. The project team is working to ensure that Canada has the capacity to quickly and adequately supply high-quality reagents and assays that allow the rapid and specific determination of the existence of a biological agent, and the scale of a related event, in a format that is field-portable and requires minimal training for military personnel and first responders.

Recent Progress and Results

The milestones and timelines for this project are on schedule. Over the past year, the team has upgraded the hybridoma facility at DRDC Suffield, established a dedicated laboratory for hybridoma and mAb development, and have cross-trained a technician and a biologist from DRDC Suffield in protocols and techniques for the generation of hybridomas. In addition, the team researched the availability of pertinent monoclonal antibodies and antigens from commercial and other sources; conducted a physical inventory of hybridoma clones at DRDC Suffield; summarized characterization data on each clone; and published *Monoclonal Antibodies to Priority Bioterrorism*

Agents: Way Ahead for Hybridoma Development at DRDC Suffield (December 2006), a way-ahead document for hybridoma development at DRDC Suffield. The team is now working to develop mAbs from existing hybridoma stocks and produce new hybridomas and mAbs for recognized deficiencies.

Based on previous characterization data, three DRDC hybridoma clones for *Francisella tularensis* were selected for expansion and further analysis. These clones are F30-29, 179.9.1, and 9TCC8. After preliminary analysis, the mAbs produced by these clones were purified for immunoglobin G (IgG) and tested further. All three mAbs were found to be highly reactive and specific for *F. tularensis* when tested by indirect enzyme-linked immunosorbant assay (ELISA) against a panel consisting of *Bacillus anthracis*-Ames, *B. anthracis*-Sterne, *B. cereus, B. subtilus* var. *niger (B. globigii), B. thuringiensis, B. abortus, B. melitensis, Escherichia coli, F. tularensis*-Schu4, *Klebsiella pneumoniae, Yersinia pseudotuberculosis, Y. pestis*-Java9, and *Y. enterocolitica.*

When tested by indirect ELISA against *F. tularensis* lipopolysaccharide (LPS), *E. coli* LPS, and *Salmonella* LPS, all three mAbs reacted specifically with *F. tularensis* LPS. These mAbs are currently being tested in competitive ELISA (cELISA) studies to determine if they bind like or different epitopes on LPS, and whether they are functional in western blot analysis. The characteristics of these mAbs are also being compared to a mAb and a polyclonal antibody (pAb) acquired from the US Department of Defense (DOD) and one mAb developed at PHAC-NML. These three mAbs, the PHAC mAb, the DOD antibodies, and two other pAbs, are currently being down-selected in a rapid field-portable electrochemiluminescence (ECL) assay. Several hybridoma clones specific for *Brucella spp*. or *B. anthracis* spores have also been selected, are currently undergoing expansion, and will be analyzed by similar methods.

Other project activity currently ongoing at DRDC Suffield is new hybridoma development and cell fusions for *Y. pestis* (F1 negative), *Y. pestis* (F1 positive), *Coxiella burnetii* (Phase 1), and several types of *Clostridium botulinum* toxoid (A, B, C, D, E, and F).

Impact

With a functional hybridoma development capacity, DRDC Suffield can now develop new hybridomas and quickly produce mAbs in sufficient quantities to respond to national or international emergencies. Antibodies generated from both pre-existing and novel hybridomas are already being streamlined into field-deployable rapid immunoassays for use by first responders during bioterrorist events. The development and production of antibodies will ensure that Canada has a ready supply of necessary reagents and assays that may not be available from other countries in times of emergency. Although this project officially ends in October 2007, mechanisms for sustaining the capabilities established through this project at DRDC Suffield are currently being investigated.

CRTI 03-0021TD (3)

Assay Development and Production Team for the Identification of Bioterrorism Agents: Development of Multiple Immunoassays Using a Single Antibody against *Bacillus anthracis* Protective Antigen

Project Lead: Public Health Agency of Canada – National Microbiology Laboratory

Federal Partners: DRDC Suffield, Canadian Food Inspection Agency– National Centre for Foreign Animal Disease

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Objectives

The goal of this project is to develop immunodiagnostic assays capable of detecting human, animal, and zoonotic biothreat agents that can be validated, produced, and distributed to first responders should a biothreat event occur. One of the more specific objectives of this project is to develop immunoassays that can detect toxins produced by *Bacillus anthracis*, the causative agent of anthrax, and identify those who have been inoculated against or infected by *B. anthracis.*

Relevance

B. anthracis remains a high-priority agent of concern for use in a potential bioterrorism attack, and has been successfully used as an agent of bioterror within the recent past. The intentional release of anthrax, whether on a small- or large-scale, is capable of causing widespread fear and panic, and placing significant burdens on human health, the health care infrastructure, and the economy of an affected area. With the continued threat that *B. anthracis* poses, a method for first responders to rapidly detect and identify *B. anthracis* and other biothreat agents is needed, allowing them to quickly and appropriately take action should a bioterrorism event occur.

Recent Progress and Results

In the past year, multiple monoclonal antibodies (mAbs) have been developed against several bacterial biothreat agents and toxins, including the protective antigen (PA), lethal factor (LF), and edema factor (EF) of *B. anthracis; Yersinia pestis*

F1/V fusion protein; whole, inactivated *Francisella tularensis* cells; and *Clostridium botulinum* neurotoxins. Several of these antibodies have been distributed to national and international collaborators for performance assessment and validation, and development into immunodiagnostic assays using various technical platforms. Others have been directly developed into assays of various formats including enzyme-linked immunosorbant assays (ELISAs), antigen microarrays, and Western blots and immunodotblots.

Prior to this project, a team of researchers from the National Microbiology Laboratory (NML) at the Public Health Agency of Canada (PHAC) and DRDC Suffield collaborated on "The Development of Recombinant Monoclonal Antibodies for the Treatment and Detection of Bioterrorism Agents: Development of Neutralizing Monoclonal Antibodies to Anthrax Toxins" (CRTI 0091RD), and developed Canada's first protective anti-anthrax toxin mAbs. One of these, mAb F20G75, was transferred it to the Assay Development and Production Team (ADAPT) for development into several immunoassays. This mAb binds *B. anthracis* PA and neutralizes lethal toxin both in vivo and in vitro, and the researchers used it to develop direct and indirect format competitive ELISAs (cELISAs) that can be used to identify epitope-specific antibodies in the serum of individuals who have received the United States (US)-licensed vaccine, Anthrax Vaccine Absorbed (AVA). Conjugating mAb F20G75 to the horseradish peroxidase enzyme (HRP) allowed for the development of a direct ELISA that can detect PA with excellent sensitivity and specificity. A capture ELISA is in development that uses a PA domain IV specific mAb to capture PA, and HRP-conjugated ELISA for F20G75 (HRP-F20G75) to detect the captured antigen. HRP-F20G75 was also used to develop a direct Western blot and immunodotblot, and was assessed for its suitability as a probe for high density, manually printed-antigen microarrays. The development of multiple immunoassays from a single mAb demonstrates the utility and cost-effectiveness of using mAb reagents for immunoassay development.

Through the US Department of National Defense's Critical Reagents Program and the US National Institute of Allergy and Infectious Diseases' (NIAID) Biodefense and Emerging Infections Research Resources Repository, ADAPT and the Bioforensic Development Section at NML have access to important immunoreagents related to both bioterrorism and public health threats that have proven highly useful in the development of mAbs and other immunoreagents. The relationship between these organizations and an invitation for PHAC scientists to participate in the CANUKUS Detection and Diagnostics Reagents Working Group have strengthened PHAC's ties with US and United Kingdom (UK) counterparts and collaborators, and will contribute to a more efficient bidirectional transfer of immunoreagents and immunoassays between Canada and its allies. Overall, strengthening these collaborations and relationships will help ADAPT fulfill its mandate of creating, assessing, and distributing immunoassays where there is a critical need.

Impact

The work performed in this project will provide validated immunodiagnostic assays for detecting and identifying *B. anthracis* and other biothreat agents of concern, and identify individuals who have been inoculated against or infected by *B. anthracis.* The development and production of Canadian assays will ensure the national availability of high-quality reagents to the Canadian first responder and health care communities at times of critical need, without the need to procure these reagents from foreign sources. This project will not only increase the Canadian capability to provide first responders with the necessary response tools if a bioterrorist or major infectious outbreak event occurs in Canada, it will contribute to maintaining public confidence in Canada's ability to respond to such events. The project is expected to be complete in winter 2007.

CRTI 03-0025TA

Defender Nuclear Detection Web

Project Lead: Health Canada

Federal Partners: Canada Border Services Agency, Canadian Police Research Centre, DRDC Ottawa, Transport Canada

Industry Partners: Bubble Technology Industries, xwave, Raytheon Company – Integrated Defense Systems

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Objectives

The goal of this project is to develop an ultra-sensitive, low-cost nuclear detection web for the rapid and accurate detection of radiological-nuclear (RN) materials. The nuclear detection web is based on the Defender™ neutron detector developed by Bubble Technology Industries (BTI), which provides the immediate detection and measurement of neutrons emitted from RN materials.

For this project, BTI is equipping Defender detectors with instrumentation to provide an automatic readout of neutron exposure, global positioning system (GPS) information, user alarms, and wireless data communication. In parallel, xwave is developing a flexible network application to manage and present the data to a variety of users via the Internet. Health Canada, the Canada Border Services Agency (CBSA), DRDC Ottawa, Transport Canada, the Canadian Police Research Centre, and Raytheon Company are participating in the project by providing user input and conducting field tests of the Defender Nuclear Detection Web across a wide cross-section of applications.

Through CRTI supplemental funding, the project scope was expanded to include participation in cargo-monitoring trials hosted by the Canada-United States (US) Cargo Security Project (CUSCSP). CUSCSP is a project of the National Infrastructure Institute in the US that, according to the CUSCSP website, is dedicated to securing the northeastern supply chain through its public-private partnership of federal, provincial, state, and local US and Canadian members operating in northeastern North America.

The high-neutron sensitivity, low-power consumption, and low cost of the Defender sensor package makes it suitable for adaptation to cargo-security applications. As a result, BTI has developed the nFormant—a dual Defender reader that can be installed inside a cargo container and monitor for neutron radiation. Each nFormant system contains two Defender detectors equipped with automatic readout and recompression capabilities. Cycling between the two Defenders allows for extended, continuous monitoring. With the new funding and development of the nFormant, the expanded project objectives now include working with CUSCSP to develop a requirements document for the nFormant; testing the current capability of the Defender detectors in a lab environment, and identifying any requirements gaps; performing engineering modifications, especially in the areas of environmental ruggedization, detector recompression, and integration with suitable communication devices; fabricating a prototype nFormant system for the trials; working with CUSCSP to successfully deploy the system in cargo-security trials; and summarizing the performance of the nFormant in a final report.

Relevance

This project addresses the CRTI investment priority to improve opertational capabilities for prevention, surveillance, and warning against CBRNE events by providing an unparalleled, low-cost neutron detection system. The system will have the sensitivity and broad coverage to successfully detect illicit RN materials before weapon assembly takes place. Through its flexible and readily-tailored network, it improves command, control, communications, coordination, and information (C4I) capabilities through managed communication of critical data between local and federal authorities and among federal agencies. The project also provides technology in support of first responders and operational authorities, by providing simple-to-use, real-time neutron detectors with low false alarm rates compared to gamma detectors and other traditional neutron detectors.

Recent Progress and Results

Instrumented Defender detectors were delivered to the federal partners and to Raytheon Company in February 2006 for user testing. Based on the results of these tests, several new features and design improvements were implemented, including: a continuously-displayed neutron dose measurement; increased ruggedization for mechanical and electromagnetic interference; improved GPS reporting; user-defined parameters for detector sensitivity, efficiency, and reporting frequency; and enhanced scalability of the server software. Incorporating all of these improvements, BTI manufactured an enhanced set of instrumented Defender detectors. These detectors were delivered to the federal partners in February 2007 for further testing, which is currently underway.

BTI has completed the nFormant requirements document, gap analysis, and engineering modifications, and has successfully fabricated an nFormant system. Characterization of the system's performance in controlled conditions is currently underway and the CUSCSP trials are scheduled to occur in 2007.

Impact

This project will result in both the technological advancement of a unique, highly sensitive neutron detector and the development of a flexible data-management network. As part of the project, all five federal agencies participating in the project will retain the instrumented Defender detectors for ongoing use. In addition, the results of the CUSCSP cargo-container trials using the prototype nFormant system will be summarized in the final report. From a broader perspective, the Defender Nuclear Detection Web offers Canada the unique opportunity to deploy a radiation detection system that provides the type of mobile and extensive coverage needed to prevent and defeat a terrorist attack using RN materials. The project will be completed in December 2008.

CRTI 03-0060RD

Protective Markers for Anthrax Serodiagnosis

Project Lead:	DRDC Suffield
Federal Partners:	Public Health Agency of Canada – National Microbiology Laboratory
Industry Partner:	Cangene Corporation
Other Partner:	University of British Columbia – Department of Microbiology and Immunology

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Objectives

The focus of this project is to express selected domains of *Bacillus anthracis* protective antigen (PA) in *Caulobacter crescentus* as either secreted or cell-surface immobilized proteins, where the purified secreted domain IV of anthrax PA will be used as an antigen source for the design and validation of mouse serum and human serum enzyme-linked immunosorbent assays (ELISA) and toxin neutralization assays (TNA). Additionally, the secreted and immobilized *C. crescentus* anthrax proteins, and co-expressions of known immunostimulatory proteins on the *C. crescentus* cell surface will be tested as vaccine candidates in a mouse model of fully virulent anthrax.

Relevance

Domain IV of anthrax PA is widely viewed as a target of many protective antibodies against the protein. With functional and fully validated ELISA and TNA assays for serum antibodies against PA domain IV, it will be possible to screen for individuals exposed to anthrax and for those who have received the anthrax vaccine. For individuals exposed to anthrax, measuring the level of anti-PA antibodies will aid in identifying those requiring further treatment. Meanwhile, identifying those given the anthrax vaccine will allow screeners to confirm their immune status and evaluate their need for booster shots. Finally, successful vaccination against anthrax using *C. crescentus* secreted or immobilized PA will

promote the development of a vaccine without the side effects commonly experienced with the existing alumina-adsorbed anthrax vaccine, anthrax vaccine absorbed (AVA).

Recent Progress and Results

The researchers have displayed domain IV of PA, which corresponds to a 144 amino-acid segment (recombinant PA-IV [rPA-IV]), and domain II, corresponding to a 230 amino-acid segment (rPA-II), as fusions to the rsaA gene of *C. crescentus*, which encodes the crystalline surface-layer protein. Both rPA-II and rPA-IV have been co-displayed on the same host. Additionally, the rPA-IV display has been combined with other displayed proteins, including T-cell activating epitopes, fibronectin-binding segments, murine granulocyte-macrophage colony-stimulating factor (mGM-CSF) and immunoglobin G (IgG) binding segments to determine whether these will enhance the vaccine efficacy of rPA-IV. Both PA domains have been prepared as secreted proteins by fusion to the rsaA secretion signal and purified from culture supernatants as soluble protein for use in assays or as subunit vaccine candidates.

Cangene researchers have used soluble rPA-IV to create validated ELISA assays for screening mouse or human serum for IgG antibodies reactive to rPA-IV. The mouse assay will be ideal for supporting experimental vaccine trials, while the human assay can be used to evaluate seroreactivity after a possible anthrax exposure or to measure an individual's response to anthrax vaccinations. The human rPA-IV ELISA was found to have a coefficient variation of less than or equal to 10 percent across the tested dilutions and a serum-specific range of 0.17 to 2640 micrograms per millilitre (µg/ml) of IgG. It did not display non-specific binding. A validated TNA assay for human serum has also been developed to measure antibodies that functionally prevent anthrax lethal toxin activity. These assays will be transferred to the Public Health Agency of Canada's National Microbiology Laboratory (PHAC-NML) for future experimental and clinical use.

PHAC researchers tested the serum from individuals vaccinated with six doses of AVA and found that it reacted with rPA, rPA-IV, and rPA-II when measured using ELISA. Similar results were found with serum from rabbits inoculated with rPA. These results demonstrate that the two species develop serum antibodies against domain IV and II. Cangene researchers tested rPA-IV affinity-purified human antibodies in the TNA assay and found that they neutralized intact rPA. This confirms that an immune response directed to the rPA-IV domain is effective and further validates rPA-IV as a viable vaccine target. Performing these assays has ensured that the validated and ruggedized assays developed by Cangene can be streamlined into validation at PHAC-NML with minimal effort.

DRDC Suffield researchers isolated serum from AVA-vaccinated mice to support assay development. In addition, they designed an intranasal virulent anthrax model for testing vaccine candidate effectiveness against inhalational anthrax. This model is currently being used to test soluble rPA-IV and rPA-II, as well as the various *C. crescentus* surface-displayed proteins.

Impact

The two challenges related to anthrax exposure are determining which individuals have been infected with anthrax and require treatment, and which previously vaccinated individuals are sufficiently protected. The validated ELISA and TNA assays created by this project will quantitatively address both of these challenges by measuring the serum antibody levels of anti-PA domain IV. For vaccine recipients, the production of assays that can measure the recipient's immune response to the vaccine can show whether the individual is mounting a protective humoral immune response against anthrax. This will ensure that the vaccinated first responder is fully protected against anthrax, providing vital medical protection and the psychological preparedness necessary to respond to a threat as effectively as possible. The same assays can be used after a possible anthrax incident to identify exposed individuals, ensuring that adequate post-event countermeasures are provided where most needed. In addition to the assays, this project has provided a fully virulent inhalational anthrax model for testing vaccine for therapeutic effectiveness. The model is now being used to assess new subunit vaccines, which could lead to the next generation of anthrax vaccines.

CRTI 04-0004RD

Canadian Animal Health Surveillance Network

Project Lead: Canadian Food Inspection Agency

Federal Partners: Public Health Agency of Canada

Industry Partner: TDV Global Incorporated

Other Partners: Government of British Columbia, Government of Alberta, Government of Saskatchewan, Prairie Diagnostic Services, University of Saskatchewan–Canadian Cooperative Wildlife Health Centre, Government of Manitoba, University of Guelph, Government of Québec, University of Montréal, Government of New Brunswick, Government of Newfoundland and Labrador, University of Prince Edward Island, Government of Nova Scotia

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Objectives

The purpose of this project is to establish the Canadian Animal Health Surveillance Network (CAHSN), a formal network of federal, provincial, and university animal health diagnostic laboratories. The network is intended to enhance Canada's ability to detect in real time emerging animal disease threats that could have zoonotic potential, and provide a rapid response to minimize the human health and economic consequences to the country. The network will collaborate with the Canadian Network for Public Health Intelligence (CNPHI) to facilitate the rapid exchange of animal and public health intelligence. A secure web-based system will collect and process targeted surveillance data, and disseminate the intelligence for rapid exchange of information and decision-making to support a response capability.

Relevance

It is not possible to prevent the introduction of all agroterrorist agents into Canada: the most effective defence against bioterrorist biological events threatening livestock production and potentially also affecting the human population is by early detection and rapid response. The large volume of international trade in animal products makes it impossible to effectively monitor and prevent the illegal importation of these products from countries that have major epidemic diseases, such as highly pathogenic avian influenza (AI), foot-and-mouth disease (FMD), classical swine fever and Newcastle disease, that could threaten Canadian domestic food production and export markets. Early detection of these diseases is essential to prevent the widespread dissemination that would occur within days if infected animals were sold and transported across the country.

It is estimated that 60 percent of all new diseases and nearly all bioterrorism-related risks are zoonotic in nature and therefore, effective zoonotic disease surveillance and response requires integration of human and animal health intelligence. The integration of surveillance intelligence, laboratory interoperability, and national and international networking between technical and scientific staff into a comprehensive infrastructure contributes to bioterrorism preparedness by providing the framework for animal health biosecurity, early disease detection, a national early warning system, and rapid response.

Recent Progress and Results

This project was launched in October 2005 and is now 18 months into its 36-month project plan. The project team continue their ongoing efforts in negotiating a Memorandum of Understanding (MOU), expanding the diagnostic capabilities of the provincial, federal, and university laboratories to assist in diagnosing specific foreign animal diseases (FAD) and, developing the system design and "smart engines."

The collaboration of federal and provincial laboratories and the need to share data is being addresssed with the MOU and the draft agreement is currently in the final stages of negotiation.

The lab strategy for Canada under the *AI Pandemic Preparedness Plan* brought forward the priority, in early 2006, to accelerate the plans and timelines for network lab interoperability and to establish a national early warning system for perceived risks of AI. Within the following six months, four federal and seven provincial labs were trained, equipped, and approved for testing the presence of AI virus via polymerase chain reaction (PCR) and able to accept samples from the field. This same initiative introduced a new FAD Diagnostic Containment level into the diagnostic laboratories to increase FAD-testing capacity. As a direct result, the provinces required additional support for infrastructure requirements and for the development, implementation, and oversight of quality assurance (QA) management programming. Organizing is underway for an three-day network workshop on internal laboratory systems for FAD. A total of 43 lab analysts have been trained in five different assays at the Canadian Food Inspection Agency's (CFIA) National Centre for Foreign Animal Disease (NC-FAD) during the FAD diagnostic training courses. As an added scope, onsite training courses on the five assays will be initiated this year. Planning is already underway to add to the scope of tests with additional FAD training in 2007.

CNPHI has been working with the surveillance team and concentrating their efforts on the CAHSN system design, the "smart engines," and lab interconnectivity. Fifty percent of the network labs are presently interconnected with CNPHI. Some labs have been slower to commit, pending negotiations for sharing data. Two provincial labs are submitting electronic data. The initial electronic surveillance application for bovine spongiform encephalopathy (BSE) has been developed with the rollout at the Manitoba lab as the pilot site. The electronic application for AI is in the final stages of development and, in the event of an AI outbreak, an interim manual online data-entry system has been enabled utilizing the CNPHI toolset EpiAssist. The secure web-based communication tool, CAHSN Collaboration Centres, has been constructed for both the Canadian Animal Health Laboratory Network and chief veterinary officers (CVOs) and continues expanding memberships with ongoing registration and training processes for national working groups. The project team epidemiologist is presently visiting each provincial lab to operationalize the toolsets and to facilitate the process for lab interconnectivity.

A draft CD featuring a CAHSN overview has been compiled to aid as a project communications tool. The CD is presently under review by the CAHSN Steering Committee.

Impact

The final outputs of CAHSN will be a national early warning system for animal disease threats to the food supply, food safety, or public health; a federal-provincial laboratory network for the rapid diagnosis of serious infectious animal diseases; and an information-sharing network linking federal and provincial agencies and departments of animal and human health.

This system will provide not only seamless integration of human and animal health intelligence, but also a comprehensive solution set, from data exchange to analysis, and from surveillance to alerting and event management.

As first responder laboratories, the provincial laboratories will have the capacity and capability to rapidly diagnose serious and infectious animal diseases, having been trained in FAD-test methods and receiving the necessary supports towards lab infrastructure, required equipment and supplies, and QA management.

Although project completion is scheduled for September 2008, the plans for long-term sustainability will be explored in the second year of the project.

CRTI 04-0018RD

Development of Standards for Decontamination of Buildings and Structures Affected by Chemical or Biological Terrorism

Project Lead:	Environment Canada
Federal Partners:	Public Health Agency of Canada, DRDC Suffield
Industry Partner:	Science Applications International Corporation Canada
Other Partners:	United States Environmental Protection Agency, University of Ottawa, University of Leeds, Research Institute of Hygiene, Toxicology and Occupational Pathology

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Objectives

The goal of this project is to develop cleanup standards for decontaminating buildings after a chemical or biological attack. Using data generated from exposure experiments, the focus of the project is on the development of a generic approach to decontamination and the determination of specific guidelines for ascertaining "How clean is clean?" To this end, standards for chemical and biological agents that represent a real or potential risk for terrorism will be developed using three methods. First, the project team will establish the relationship between the magnitude of exposure and the expected health effects. Next, by identifying individuals at risk of exposure and considering all routes of exposure (i.e., contact, inhalation, ingestion), the team will asses the real and potential exposure risks. Finally, the team will characterize the risk to determine the potential for toxicity (i.e., chemical exposure) and infectivity (i.e., biological exposure).

Relevance

Decontamination of facilities following acts of biological or chemical terrorism is designed to mitigate hazards to the extent that the facilities can be recommissioned, usually to their former use. However, no suitable standards exist for determining the levels of exposure to agents that are safe for reoccupancy. Pertinent laboratory data, mainly from animal exposure models, will be used to establish cleanup standards and to help determine whether lowering exposure levels necessary for rehabitation are practically attainable; the expected cost of decontamination to acceptable levels, and whether the cost is justifiable; and, if the facility is fit for rehabitation, whether its usage needs to be restricted to certain types of activities with respect to its expected inhabitants and their associated toxicological or pathogenic risks.

Recent Progress and Results

Thus far, the project team has completed an extensive literature search, an interim draft report, and an in-depth analysis of all existing clearance levels, including criteria based, in part, on a report by the United States Environmental Protection Agency (USEPA), "*World Trade Center Indoor Environment Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks*" (May 2003).

With an applicability and consensus-based approach, various formulae from a number of sources were used to calculate preliminary clearance criteria. Where possible, assumptions included constant values for parameters, which, among others, included contact surface, inhalation volume, and susceptibility. For instances where few or no data were available, an uncertainty factor (UF) of 0.1 was used to allow for extrapolation from species to species, among age groups, among other differences in target susceptibility, and among end-points. Although requiring further development and analysis, attempts were also made to provide standards for acute, chronic, and semi-chronic exposure. Three standards were set for each agent based on the risk each poses to the target population—the planned inhabitants of a decontaminated facility. The first standard applies to those at greatest risk, where the agent used has a high level of toxicity or infectivity; the second applies to those at an intermediate risk, where the agent used has a moderate level of toxicity or infectivity, and the third applies to those at the lowest risk, where the agent used has a low level of toxicity or infectivity.

With the preliminary set of standards developed, chemical agent clearance levels will be tested using animal models and other laboratory manipulation at the Emergencies Science and Technology Division of Environment Canada, and at the Research Institute of Hygiene, Toxicology and Occupational Pathology (RIHTOP) in Volgograd, Russia. Additional testing of surface-to-air transfer rates has also begun to better understand desorption patterns, and the relationship between surface contamination and airborne and contact hazards. Testing of infectious agents has commenced at Public Health Agency of Canada laboratories in Winnipeg and Ottawa, and at the Centre for Research on Environmental Microbiology at the University of Ottawa. This testing also includes an assessment of the transfer rates from surface-to-surface, surface-to-air, and surface-to-sampling device to alleviate levels of uncertainty that can be attributed to sampling methodology.

Impact

The interim report provided a solid foundation, from which experiments will evolve. The preliminary experiments will evaluate the validity of the first set of standards, which target those chemical and biological agents most likely to be used in an intentional release. Following the experimental work, these standards will be used by a broad range of personnel, from first responders to top-level decision makers. Special emphasis will be placed on using standards and associated models for the post-remediation clearance of facilities, and for determining the potential use of facilities following contamination events. This emphasis will lead to the development standards for use in emergency response scenarios, where the standards will be presented in a condensed format and include more detailed analysis, including risk models for determining post-remediation use, or for comparing the cost of remediation with that of facility destruction. These standards will be available for use by the end of the 2008–2009 fiscal year.

CRTI 04-0019TD

Field Demonstration of Advanced CBRN Decontamination Technologies

Project Lead: Environment Canada

Federal Partners: DRDC Suffield – Counter Terrorism Technology Centre, DRDC Ottawa, Public Health Agency of Canada

Industry Partners: Allen-Vanguard Corporation, Science Applications International Corporation Canada

Other Partner: United States Environmental Protection Agency

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Objectives

The goal of the project is to demonstrate building decontamination technologies for chemical, biological, and radiological counterterrorism. Field trials are conducted at DRDC Suffield. Prior to trials, detailed work plans, analytical plans, and health and safety plans are developed. Three test buildings, one for each group of agents, have been erected and finished with common construction materials. Weapon agents or their simulants are disseminated to contaminate the surfaces. The interiors of the buildings have been used in chemical and biological trials and exteriors will be used in radiological trials. The buildings are decontaminated using commercially available technologies. Researchers analyze concentrations of the agents or simulants on surfaces and in the air before, during, and after the decontamination, and evaluate technology performance for different surface materials and trial conditions. They also calculate associated costs and material and labour requirements. The results will be used to develop decontamination manuals and guidelines.

Relevance

The study seeks to improve technologies for decontamination of CBRN-contaminated materials. The project contributes to the development of a concept of operations for response to events and to the inclusion of CRTI's laboratory clusters and field teams in federal and provincial emergency response plans. It is developing test protocols for evaluation of CBRN detectors, including performance and specification standards and operational guidelines. The project is also developing techniques that offer advantages over existing technologies in CBRN detection.

Recent Progress and Results

Chemical and biological trials were held in August 2006. The radiological trial has been scheduled for the fall of 2007. Researchers at DRDC Suffield designed and manufactured two identical test buildings. The outside dimensions of the buildings were 9.6-metres (m) long, 2.4-m wide, and 2.7-m high. The buildings were mounted on a metal tray to collect decontamination wastewater and equipped with ventilation systems. Each building had a corridor and three partial rooms with ceiling tiles: one had brick walls and ceramic tile flooring; one had painted drywall walls and carpeting; and another had wood panelling and vinyl flooring.

Researchers took samples of surface materials prior to and after agent dissemination, and after decontamination. The samples were analyzed for the presence of the chemical or biological agent simulants. Researchers also monitored and analyzed simulant concentrations in the air.

For the chemical trial, malathion, an organophosphorus pesticide, and diethyl malonate (DEM) were used as surrogate chemical agents. They were disseminated on the building interior using a pneumatic sprayer. Surface concentrations of the simulants varied from 2.8 grams per square metre (g/m^2) to 12.4 g/m^2. Decontamination was carried out using the Surface Decontamination Foam (SDF) developed by DRDC under the CRTI project "Accelerated Consequences Management Capabilities" (CRTI 02-0043TA). Decontamination was followed by de-foaming.

Analytical methods and instrumentation included real-time air monitoring with a Trace Agent Gas Analyzer (TAGA), Chemical Agent Detection System (CADS II) stations, and

volatile organic chemical (VOC) meters; air sampling tubes, witness cards, and other chemical indicators; and solvent extraction followed by gas chromatograph/mass spectrometry (GC/MS) analysis of surface sample extract.

Results of the trial suggest that SDF was effective in decontaminating building surface material. Actual levels of decontamination varied depending on initial concentrations of the simulant and the type of surface material and its position (vertical or horizontal). The decontamination of malathion ranged from 40 percent for ceiling tiles to more than 90 percent for brick. DEM decontamination reached 60 percent for wood panel to almost 100 percent for brick and drywall. Reduced decontamination rates in some areas were attributed to higher initial concentrations.

Researchers used on-site instruments to monitor air concentrations of DEM and malathion, as well as byproducts released during simulant dissemination or decontamination. Air samples were taken and analyzed in laboratories at Environment Canada and the United States (US) Environmental Protection Agency (EPA). Results of air analyses showed a good correlation between the timeframe and nature of specific operations and the concentrations of targeted compounds in the air.

For the biological trial, the building was contaminated with a powderized form of *Bacillus atrophaeus* spore using a point source in each of the three rooms. The facility was then exposed to a single round of decontamination with vaporous hydrogen peroxide (VHP) at a concentration of over 100 milligrams per cubic metre (mg/m^3) for more than three hours.

Environmental sampling was conducted prior to contamination to assess background flora, post-contamination to determine the dispersal pattern and concentration of *B. atrophaeus* in the structure, and post-decontamination to assess the effectiveness of the decontamination cycle. Sampling methods included the use of air samplers and surface collection tools. In addition, several coupons of each building construction material were inoculated with more than 10^6 spores of *Geobacillus stearothermophilus* and positioned adjacent to their like materials in the structure, and standard biological indicator strips, containing more than 10^6 spores of *G. stearothermophilus*, were strategically placed throughout the structure prior to VHP exposure.

B. atrophaeus was recovered from more than 90 percent of the surface samples. Coupons of non-porous materials such as ceramic, PVC tile, wood panelling, and drywall yielded a greater than 6 log10 reduction of spores of *G. stearothermophilus*. The decontamination was less effective against *G. stearothermophilus* inoculated onto porous materials like carpet, ceiling tile, and brick. Ceiling tile coupons ranged from 1.5 to 6 log10 reductions. Carpet coupon reductions ranged from 2.9 to 5.5 log10. Efficacy on brick was the poorest, ranging from 1.0 to 2.7 log10 reductions. With one exception, all biological indicator strips were negative for growth after one week of incubation.

Impact

The project generates valuable field data on the efficiency of advanced full-scale decontamination technologies on different building construction materials. Researchers are developing concepts of operations to deal with CBRN decontamination of buildings and structures. They are optimizing and verifying the effectiveness of relevant analytical instruments and methods, and calculating associated costs, including labour, material, and equipment. The information will be used to develop manuals and set up training for first responders and decontamination teams.

CRTI 04-0022RD

Rapid Separation and Identification of Chemical and Biological Warfare Agents in Food and Consumer Matrices using FAIMS-MS Technology

Project Lead: National Research Council

Federal Partners: Canadian Food Inspection Agency, DRDC Suffield – Chemical and Biological Defence Section

Industry Partner: Thermo Fisher Scientific, formerly Thermo Electron Corporation

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Objectives

Chemical warfare agents, toxic agrochemicals, and biotoxins introduced into food or consumer products by a terrorist attack pose serious health threats. The goal of this project is to develop methodology based on high-field asymmetric waveform ion mobility spectrometry (FAIMS) mass spectrometry (MS) for the rapid, selective identification of chemical and biological warfare (CBW) agents. The first phase of the project, in collaboration with DRDC Suffield, focused on chemical warfare agents. In collaboration with CFIA, the second phase focuses on biotoxin detection.

Relevance

Sensor-based, field-deployable technologies serve as early warning systems, but because of their inherently low selectivity provide no conclusive identification of warfare agents. Conclusive identification of the chemical or biological agent requires chromatography or MS-based methods that are slow because of the extensive sample preparation required and the low throughput of the setup. A FAIMS-based technology would provide quick quasi real-time separation of the relevant industrial chemicals, chemical warfare (CW) agents, their decomposition products, and selected mid-spectrum agents. In addition, because of its inherent selectivity, this technology may reduce the amount of sample preparation required, providing savings in time and cost.

Recent Progress and Results

The experimental work of the researchers focused on developing flow injection-atmospheric pressure ionization-FAIMS-based methods for the separation and identification of CW hydrolysis products (methylphosphonic acid [MPA], ethylphosphonic acid [EPA], thiodiglycol [TDG], ethyl methylphosphonic acid [EMPA], isopropyl methylphosphonic acid [iPrMPA], pinacolyl methylphosphonic acid [PinMPA]),

simulants (triethyl phosphate acid [TEP] and tributyl phosphate [TBP]) and agents (mustard, sarin, soman, tabun, and cyclohexylsarin). The researchers evaluated three atmospheric pressure ionization methods: electrospray ionization (ESI), atmospheric pressure chemical ionization (APCI), and atmospheric pressure photo-ionization (APPI). The CW simulants were used for all initial method development. Mustard and TDG were poorly ionized by all techniques so no further work was done with them.

The FAIMS device separated the hydrolysis products over an almost 30 voltammetric (V) range and separated isobaric fragment ions from hydrolysis product ions. The simulants were well-separated in the FAIMS device. The CW agents could not be separated.

The results indicated that the hydrolysis products were poorly ionized by APCI, but well ionized by the other techniques. The observed detection limits by ESI-FAIMS-MS were 0.09–0.3 microgram per millilitre (µg/mL) in bottled water, 0.4–10 µg/g in cornmeal, and 0.2–180 µg/mL in canola oil. Honey proved to be the most challenging matrix and MPA could be detected with a limit of detection of 3.8 µg/mL. The detection limits by APPI-MS were in the range.

Sarin and cyclohexylsarin were well detected by APPI-FAIMS-MS, but tabun and soman were poorly detected. APCI-FAIMS-MS offered the best and most universal detection of the CW agents. The observed limits of detection (LODs) were 3–15 µg/mL in bottled water, 1–33 µg/mL in oil, 1–34 µg/g in cornmeal, and 13–18 µg/g in honey for the intact agents.

The observed detection limits were comparable to those obtained with conventional liquid chromatography/mass spectrometry (LC/MS). However, the use of the flow injection-API-FAIMS-MS significantly reduced the analysis time (three minutes per sample versus 30 minutes for the conventional method) and reduced the complexity of sample preparation (a strategy of dilute, filter, and shoot was used throughout).

Future plans for this project involve the development of methods based on API-FAIMS for the detection of biotoxins (aflatoxins, ochratoxins, and zeuralenone) in wheat, maize, and peanut butter/peanut meal. The researchers will compare these methods with conventional methods. A second aspect of the project involves interfacing an atmospheric matrix assisted laser desorption/ionization (MALDI) source to the FAIMS device and its application to the study of biotoxins and pesticides.

Impact

In a chemical or biochemical attack or emergency, an analytical system that can screen samples and provide results in minutes rather than days or weeks is essential to rapidly assess and mitigate health, economic, and environmental impacts. The flow injection-FAIMS-MS methodology may increase the speed of analysis, more selectively identify which agent has been used, and better support medical and forensic interventions. The deliverables for phase one included a developed FAIMS separation protocol (April 2006), followed by an evaluation of the protocol compared to conventional methods, and peer review and transfer to Department of National (DND) end-users (November 2006). The deliverables for phase two include a FAIMS-MALDI interface (June 2007), followed by an evaluation of the developed FAIMS protocols compared to conventional methods (October 2007), and peer review and transfer to CFIA end-users (November 2007).

CRTI 04-0029RD

Development of an Electronic Neutron Dosimeter

Project Lead: DRDC Ottawa

Federal Partners: Canadian Nuclear Safety Commission, Department of National Defence – Joint Nuclear, Biological and Chemical Defence Company

Industry Partner: Bubble Technology Industries

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Objectives

No currently commercially available electronic-neutron dosimeters (ENDs) meet all military or civilian performance specifications. Past experimental evaluations of existing and prototype devices have pointed out many deficiencies relative to the desired properties of a good END. Specifically, a viable END will be a small wearable device that has appropriate sensitivity, a wide energy response, low power requirements, total neutron and gamma (n/g) discrimination, and adequate environmental stability. In preparation for this project, a thorough assessment of existing sensor technologies and advances in technological development was performed, resulting in the conception of an alternative approach to producing a viable END. Successfully developing an END that meets all of the desired specifications is the objective of this three-year project. The project began with a conceptual design phase that included input from all project partners, followed by the current phase of constructing and testing a laboratory prototype. The last two phases of this project will focus on the fabrication and thorough testing of the final field-ready prototype.

Relevance

Neutron-emitting radioactive sources, specifically plutonium beryllium (PuBe) and americium beryllium (AmBe), commonly used in oil-well logging and density gauges, are employed globally, and often with limited security precautions. With the deliberate explosion of even a small number of these devices, for instance through a terrorist weapon such as a radiological dispersal device (RDD), large urban centres could be crippled as several square kilometres are exposed to radiation levels well in excess of regulatory limits. Such contamination is particularly serious because of the transuranic compounds involved, which are a major health threat upon entering the body. In such a scenario, any readily available commercial electronic personal dosimeter (EPD) of the type deployed with

first responders will only measure the gamma ray dose, which is a small fraction (perhaps as low as 10 percent) of the total effective dose from external radiation. This project addresses the CRTI's investment priority to develop science and technology (S&T) in support of equipping and training first responders.

Recent Progress and Results

The project is in the second of four phases: constructing and testing a laboratory prototype. The initial concept for the prototype was to affect n/g discrimination by exploiting the relative ranges and stopping powers of recoil protons and Compton electrons using a sparse array of small scintillating fibres, with diameters matched to recoil proton ranges. The result is the efficient detection of neutron energy deposition with only a small amount of energy deposited by the secondary electrons generated from the gamma rays.

This concept works well in the simple scintillation spectrometer (SSS), which comprises an array of scintillators of a few millimetres diameter mounted on a photomultiplier tube (PMT). It measures neutrons from four- to 20-mega electron volts (MeVs) without gamma interference. Scaling the concept to smaller scintillator pieces to achieve performance for neutrons below one MeV has proven very difficult. Both fibre arrays and thin discs have been investigated; however, the high surface-to-volume ratio required results in unacceptable leakage of recoil protons from the surfaces. This difficulty, coupled with light collection, fabrication, and optical transparency problems, has led to a new approach made possible by recent advances in scintillator and electronics technology.

The introduction of a new scintillator with good light output and excellent n/g pulse shape discrimination (PSD) has led to the re-examination of the electronic PSD approach and the project team is now developing a new PSD circuit. This circuit incorporates recent advances in low-power electronics and a special ultra-low power, high-voltage PMT supply design to produce a system capable of meeting the stringent operational requirements for a personal END. Performance of a prototype assembly has been successfully tested with monoenergetic neutrons at the DRDC Ottawa Van de Graaff accelerator. The team will present the test results.

Impact

Many first responders currently wear alarming EPDs, and often the alarm on these dosimeters is the first indication of the presence of gamma-emitting radioactive material. In addition to providing responder communities with the ability to detect the presence of neutron sources, the END being developed for this project will also monitor their associated exposure, ultimately improving their response capability. To enable an easy transition to the new END and ensure the development of a relevant product, end-users from the responder communities are included on the project team. Completion of the project is expected for June 2008 with the delivery of two field-ready END prototypes.

CRTI 04-0030TD

Nuclear Forensic Response Capabilities and Interoperability

Project Lead: DRDC Ottawa

Federal Partners: Canadian Nuclear Safety Commission, Health Canada, Public Safety Canada, Royal Canadian Mounted Police

Other Partner: Science Applications International Corporation Canada

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Objectives

Following an radiological-nuclear (RN) terrorist event, on-site evidence recovery and analysis will likely be complicated by widespread radiological contamination. With these concerns in mind, this project focused on three main objectives: to establish protocols for forensic identification specialists to achieve attribution despite an RN-contaminated site; to develop and test nuclear forensic laboratory analysis methods to further attribution capabilities; and to create links between expert responders (e.g., Canada's Federal Nuclear Expert Response Team) and forensic identification specialists, thus paving the way for information sharing in the field. These objectives were addressed through two field exercises and two laboratory intercomparisons involving the participation of all project partners in the exercise response or in the discussion and implementation of lessons learned or both. The project also considered nuclear forensic programs in the United States (US) and United Kingdom (UK).

Relevance

This project developed the knowledge base required for forensic identification specialists to achieve attribution despite an RN-contaminated site. This knowledge will be used to improve upon the RN portion of Canada's first responder training program. The project also improved nuclear forensic lab analysis to ensure that analysis of an unknown sample will yield information for attribution, while being admissible in a court of law. Ultimately, this work moved forward Canada's nuclear forensic response capability by addressing the cradle-to-grave issues associated with radiologically-contaminated forensic evidence, from sampling to transport, and laboratory analysis to presentation in court.

Recent Progress and Results

The last year of this project focused on improving the gaps identified during the first round of exercises, followed by organizing and executing the second field and laboratory exercise. The combined field-and-laboratory exercise began

in December 2006 with responders from the Toronto CBRN Response Team. Investigators processed the crime scene as outlined in existing protocols, documenting the scene and collecting evidence. Evidence was removed from the scene (appropriately packaged), which led to discussions between the responders and forensic scientists present to determine how contaminated evidence analysis might be conducted in a real event. The field portion of this exercise elicited significant international interest, with observers present from Canada, US, Mexico, Australia, and Japan. Discussions among the observers during and following the exercise focused on similar gaps in response capabilities in each country, which led to agreements of future collaboration in this area.

Radiological samples were also taken from the crime scene in the form of swipes and powdered material and these were subsequently switched with laboratory-prepared samples of known isotope and activity. The Incident Commander, with advice from a Canadian Nuclear Safety Commission (CNSC) Inspector, determined an appropriate method to transport the samples to RN laboratories for analysis. Upon arrival of the samples at the participating RN laboratories (DRDC Ottawa, CNSC, and Health Canada), a month-long laboratory exercise commenced with reporting requirements set at 24-hours, one-week, and one-month interval. Scientific Applications International Corporation (SAIC) Canada compiled the final results into a report that compared overall results by each lab. The report concluded that all laboratories correctly identified the isotopes in the samples and provided an activity estimate within one order of magnitude of the actual activity.

Impact

All of the knowledge products and capabilities developed as a result of this project will be incorporated into end-user systems. Protocols for forensic identification specialists are being incorporated into the RN portion of the CBRN First Responder Training Program (FRTP) and will be adopted by the Royal Canadian Mounted Police (RCMP) and federal expert response teams. Collaboration with the US Federal Bureau of Investigation (FBI) and UK New Scotland Yard allowed for a comparison of international techniques, helping to ensure interoperability. Prioritized laboratory techniques were tested and implemented by the laboratory network. Ultimately, since this project is largely focused on procedural issues, end-user implementation costs are negligible.

CRTI 04-0045RD

Development of Collections, Reference/DNA Databases, and Detection Systems to Counter Bioterrorism Against Agriculture and Forestry

Project Lead: Agriculture and Agri-Food Canada

Federal Partners: Canadian Food Inspection Agency, Natural Resources Canada – Canadian Forestry Service

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Objective

The objectives of this three-year project are to obtain samples of critical fungal plant pathogens that are possible risks as bioterrorism agents against Canadian crops, forests, or the food supply; create multi-gene deoxyribonucleic acid (DNA)-sequence databases to develop molecular diagnostics; and complete on-line databases documenting plant pathogens in Canada. Agriculture and Agri-Food Canada (AAFC) will be the repository for cultures and specimens, through the Canadian Collection of Fungal Cultures and the Canadian National Mycological Herbarium, with import permits secured and biosecurity issues addressed by the Canadian Food Inspection Agency (CFIA). AAFC and the Canadian Forestry Service (CFS) will develop the DNA databases and CFS will design and undertake the preliminary testing of molecular assays. CFIA, in collaboration with international partners such as the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS), will be responsible for validating the assays. AAFC researchers will develop the pest-host database from historical records and publications.

Relevance

CFIA are first responders for quarantine outbreaks or bioterrorism attacks on agricultural systems. Vigilance and monitoring by Canada are critical for maintaining agricultural and forestry trade with partners who have already established new plant biosecurity measures.

This project will result in significant improvements to the documentation of plant pathogens that normally occur in Canada, including close relatives of high-risk pathogens, and new tools for recognizing suspicious outbreaks and establishing their non-Canadian origin.

Recent Progress and Results

The acquisition of specimens and cultures is at, or near, completion for high-risk pathogens and relatives, including a large international collection of *Fusarium graminearum* (Fusarium head blight), which causes significant losses in Canada each year (approaching $100 million in epidemic years) and *Phytophthora ramorum* (sudden oak death), which causes approximately US $60 million in damage each year in California and, as a result Canada spends millions annually in monitoring. For specimens that are difficult to retrieve because of import or export restrictions or both, such as *Synchytrium endobioticum* (potato wart), work is proceeding using infested soil.

To identify novel genes for diagnostic-marker development, the research team conducted volatility analysis on all sequenced genomes with gene annotations. An approach to identifying single nucleotide polymorphisms (SNPs) in microsatellite-rich regions is now being validated for those genomes where sequencing and annotation is proceeding at a slower than anticipated rate. Markers are being developed from available expressed sequence tag (EST) libraries for those organisms where genomic sequences are still unavailable.

The researchers have been developed a *P. ramorum* three-gene test, which was recently shown to be the most accurate available test in an international blind trial. The test is now in active use at CFIA.

In support of the project, lab space at CFS has been doubled to accommodate additional project staff. As well, the sequencing capacity at AAFC has quadrupled and approximately 12,000 CRTI sequences have been generated. Sequencing for most pathogens is now proceeding at high throughput (in 96-well formats) and common laboratory protocols have been implemented. All project sequences have been loaded into a database built for the project, and regular automated analysis of the data is being established. The newly created 90,000-record Canadian plant-pathogen database is now in use at CFIA and new software is facilitating updating.

Impact

This project is generating multi-gene DNA-sequence databases for the development of molecular assays to be used by first responders following introductions of high-risk plant pathogens to Canada. These same molecular assays will be amenable for subsequent development of automated, high-throughput assays. The pest/host database is already an essential reference for first responders to determine the known distribution of plant diseases in Canada, a prerequisite for recognizing suspicious outbreaks. For the most critical diseases already occurring in Canada, the technology and information developed will assist in determining the geographic origin of plant pathogens or matching different strains involved in suspicious outbreaks. The completion date for the project is September 2008, although results are already available. For instance, the *P. ramorum* assay and the updated host/pest database have already been made available to CFIA and international partners who will be brought into this project more formally in the near future.

CRTI 04-0047TD

CBRN Incident Database

Project Lead:	Royal Canadian Mounted Police – Explosives Division and Technology Section
Federal Partners:	Canadian Security Intelligence Service, Canadian Food Inspection Agency, Department of National Defence – Radiological Analysis and Defence Group, Canadian Nuclear Safety Commission, Natural Resources Canada
Industry Partner:	AMITA Corporation
Academic Partner:	Carleton University – Human Oriented Technology Lab
International Partners:	CBRE Defence Group Singapore Armed Forces, Australian Federal Police Bomb Data Centre

Authors

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Objectives

The purpose of this project is to develop and demonstrate a state-of-the-art hazardous materials incident database, the CBRN Incident Database (CID), for data exchange between national and international agencies. The Royal Canadian Mounted Police's (RCMP) ten years of explosive incident experience history and existing incident database will form the rich technical knowledge base of the system in Canada.

CID will provide a capability to enter and share incidents (real and hoax) among a large community of responders. In addition, the incidents will be shared internationally through a pre-defined protocol. The database will be built as rugged commercial off-the-shelf (COTS) software and designed to be inexpensive to acquire and maintain. The database will then be offered free of charge to governments of other countries by the RCMP Canadian Bomb Data Centre (CBDC). Additionally, RCMP-CBDC will offer CID to governments of any level in Canada, as well as other police agencies and the military.

The system will be developed based on the collective input and collaboration of expertise in the CBRN-bomb field. The project will go through a requirements-collection phase involving experienced systems analysts and field experts defining how the system will provide critical incident information to bomb technicians.

Relevance

CID is a Canadian and international project that will capture CBRN incidents against critical infrastructure, people, and agri-food targets. CID will facilitate incident preparedness, prevention, and response by sharing vital data on threats, precursors, and dissemination. Information tracked will include hazardous device-making materials, incident (hoax) details, dissemination methods, and so on. CID will be accessible by municipal, provincial, national, and international law enforcement and regulatory agencies. It is estimated to be used by over 500 points across Canada, creating a new capacity to share CBRN information, for the first time in near real-time.

Recent Progress and Results

The project team has made significant progress to date. The software development phase has been completed and deployed for demonstration. The initial phase of this is a proof-of-concept deployment that works with a restricted user base that will assist in testing the system to ensure it meets the project requirements as planned. The technology demonstration will be completed by the end of October 2007.

In addition to established partnerships with Singapore and Australia, the project has generated international interest, most notably from Colombia. Under the assistance of a contribution grant from Canada's Department of Foreign Affairs and International Trade (DFAIT), the CID system will be converted into Spanish for their use. Interest has also been shown from Argentina, Brazil, Costa Rica, Ecuador, Mexico, and Panama.

CID has also generated interest from agencies in policing and defense. A briefing was given to the Secretary General of the International Criminal Police Organization (INTERPOL). The Secretary General will be sending a letter to the Commissioner of the RCMP requesting electronic data transfer system (EDTS) assistance to implement CID on a server at INTERPOL Headquarters in Lyon, France, with the capacity for all 175 member countries to add or retrieve information on incidents online. Officials at Canada's Department of National Defence (DND) are viewing CID to determine if an militarized version of CID can be implemented that is interoperable with the "civilian" version of CID.

The scope and definition of CID has changed with a charter amendment made to include explosives, in addition to the other CBRN elements that are already addressed by the system. Explosives are inherently connected to CBRN threats, thus it was a natural extension to have CID operate as a system to handle all CBRNE threats.

Impact

CID will create a new level of interoperability between all levels of policing in Canada as it relates to counterterrorism-incident reporting and investigations, as well as provide a means for international information sharing. One of the great features of CID is that it is flexible and adaptable in its ability to operate in an inexpensive environment (Open Source) as well as in a sophisticated and rigorously secure infrastructure such as the RCMP.

The effectiveness of response will be dramatically improved through 24-hour, seven-days-a-week (24/7) information availability to a broad network of first responders. The project will enhance the ability to spot patterns and make incident linkages that are not currently possible given the manual method of incident data submission. Linkages will be made as an incident is entered. Online photographs of parts and the knowledge database will support better identification in the field and the system will be able to facilitate training of bomb technicians. One of the most interesting featuring of CID is the ability to create an incident in the system, load in media (video or pictures), and immediately send the incident unique ID to a technician in the field. This revolutionary feature would give police agencies almost real-time capability, aiding them in the most stressful of scenarios.

Ultimately the end-user community—Canada's first responders—will be better armed to respond to CBRN threats by utilizing a common body of knowledge not currently shared across the country.

CRTI 04-0052RD

On-site Composting for Biocontainment and Safe Disposal of Infectious Animal Carcasses and Manure in the Event of a Bioterrorism Attack

Project Lead: Canadian Food Inspection Agency – Ottawa Laboratory

Federal Partners: Canadian Food Inspection Agency – National Centre for Foreign Animal Disease, Agriculture and Agri-Food Canada

Other Partners: Alberta Agriculture, Food, and Rural Development, Iowa State University – Agriculture and Biosystems Engineering

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Objectives

The purpose of this project is to develop composting methods that can be applied on farms or at other sites to ensure the biocontainment of infected poultry or livestock carcasses and their manure in the event of a bioterrorism attack employing foreign animal disease viruses.

Relevance

Current stamping-out policies for managing outbreaks of foreign animal diseases in major livestock-producing countries have the potential to spread disease and are environmentally undesirable. The composting methods developed in this project will address these issues. In addition to the potential bioterrorism application, the methods may be used in routine farm operations to prevent the spread of endemic animal diseases and to eliminate food- and water-borne pathogens threatening public health.

Recent Progress and Results

Since the project began, Canadian Food Inspection Agency (CFIA) collaborators have been studying the survival of Newcastle disease virus (NDV) and avian influenza (AI) virus during the composting process. Specimens to be composted consisted of 20 grams (g) of manure, feed, used litter, or the contents of embryonated eggs mixed with wood shavings or corn silage. Each specimen was contained within a mesh bag and was inoculated with 1~10 $X10^7$ embryo lethal $doses_{50}$ of a NDV strain or with an AI virus strain (H6N2). In all, 768 specimens were buried in the compost and were then tested for virus for up to 21 days. The researchers determined that both viruses could be killed within 3 days when composting temperatures exceeded 40°Celsius (°C). At ambient temperatures, which ranged from 13°C to 27°C, the AI virus and NDV survived in some specimens for up to seven and 10 days, respectively. Based on real-time reverse transcription polymerase chain reaction (RT-PCR), the ribonucleic acids (RNAs) of the AI virus and NDV were only detected in some of the composted specimens for up to seven days. At ambient temperatures, the RNA of the viruses was detected, with only minor variation in the amount, throughout the 21-day test period.

Iowa State University researchers have been investigating biosecure composting procedures for emergency disposal of swine carcasses. Using solid-phase microextraction and analyzed using gas chromatography-mass spectrometry (GC-MS), the group collected the volatile organic chemicals (VOCs) produced during animal tissue decomposition carried out under strictly aerobic or anaerobic conditions in the laboratory. Under these controlled conditions, the most consistent indicators of animal tissue decomposition were sulphur-containing compounds (carbon disulphide, dimethyl disulphide, trisulphide dimethyl, methyl mercaptan, and 1,4-dimethyl tetrasulphide) and nitrogen-containing compounds (indole and skatol). The results from the first year of monitoring for VOCs produced in replicated full-scale test units containing 225 kilograms (kg) of 45–65 kg swine carcasses indicated that, under the more diverse and less controlled conditions prevalent at this scale, nitrogen-containing compounds were not detected, while sulphur-containing compounds were readily detectable. Second-year monitoring will focus on identifying and correlating sulphur-production patterns with swine carcass decomposition. The results from first-year performance testing of full-scale composting indicated that internal temperatures, moisture content, and oxygen (O_2) concentrations are significantly affected by the type of plant material used to envelop the carcasses, spacing, and the operation of passive ventilation devices. Corn silage produces temperatures that can be 30°C higher than those measured in test units using ground cornstalks or oat straw, thereby improving potential for pathogen inactivation. At the same time, silage exhibits high compaction during composting, impeding ventilation and contributing to low-O_2 concentrations (less than 4 percent) and incomplete carcass decomposition. Cornstalks and oat straw, which do not become highly compacted, have higher O_2 levels (approximately 20 percent) but also show evidence of excessive carcass drying that contributes to incomplete decomposition of external carcass tissues. The researchers will focus second-year field testing on testing passive ventilation-system design and operating strategies that have the potential to improve airflow control and composting performance.

Researchers with Agriculture and Agri-Food Canada (AAFC) have been collaborating with Alberta Agriculture, Food, and Rural Development on developing suitable methods for composting cattle carcasses and manure in bins in cold or warm seasons. The team constructed duplicate biocontained compost structures containing 16 freshly dead feedlot cattle (average weight approximately 343 kg) per pile, and placed them in a single layer on a 30-centimetre (cm) layer of barley straw and overlaid them with a 100-cm layer of manure from beef feedlot pens. They then embedded replicate tissue and microbial samples and continuous-read temperature probes in the piles in retrievable cages placed at depths of 40 cm and 100 cm in the piles, which were later removed at intervals over 5 months. Samples included pre-weighed bovine brain, hoof, and bone (rib) in porous 53-micromillimetre (µm) nylon bags, and a three-strain mixture of nalidixic acid-resistant *Escherichia coli* O157:H7 suspended ($10^{6.4}$colony-forming unit [CFU]/g) in autoclaved manure and sealed in polypropylene tubes, or in non-autoclaved manure and enclosed in nylon bags. The researchers found that compost heated more quickly and to higher temperatures

(55 to 65°C) at the 40-cm depth than at 100-cm, but it also cooled more quickly. At the 100-cm depth, the temperature peaked at 55°C, but temperatures of 40 to 55°C persisted for four months, exceeding the 40-cm temperatures from three months onward. When exposed only to heat, the *E. coli* O157:H7 in sealed tubes survived for up to two weeks at 40-cm depth, and two to four weeks at 100-cm depth. In the dynamic composting environment (nylon bags), the bacterium was completely non-viable within one week at both depths. Dry matter disappearance (DMD) of bovine tissues was estimated gravimetrically. The speed of tissue degradation ranked brain greater than hoof and hoof greater than bone ($P < 0.05$). Over 80 percent DMD was observed at one week and eight weeks for brain and hoof, respectively, whereas less than 20 percent degradation of rib bone was recorded after five months. Depth of placement (40 cm versus 100 cm) did not affect ($P < 0.05$) tissue DMD.

Impact

The knowledge and technology that is being cooperatively developed in this project will give countries the capability to limit the spread of highly contagious animal diseases in the face of introductions through bioterrorism. The completion date for this project is March 31, 2009.

CRTI 04-0082TA

Radio Frequency and Electronic Countermeasures-compatible CB Blast Protective Helmet

Project Lead: Royal Canadian Mounted Police
Federal Partners: DRDC Suffield
Industry Partner: Med-Eng Systems

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Objectives

The purpose of this project, led by the Royal Canadian Mounted Police (RCMP) Explosives Disposal and Technology Section in partnership with Med-Eng Systems, was to design, develop, and evaluate a new radio frequency (RF) and electronic countermeasures (ECM)-compatible chemical or biological (CB) blast protective helmet. Researchers used the existing technology developed under the CRTI project "Chemical and Biological Blast Protective Helmet" (CRTI 02-0161TA) as the mechanical platform for RF-shielded electronics. The improved design will enable first responders to work in harsh RF environments using state-of-the-art ECM equipment while maintaining the required functionality currently used as a standard by most first responders in North America, Europe, and Asia.

The helmet has two unique, interchangeable visors suited for improvised explosive device disposal (IEDD) involving CB agents, and conventional explosive ordinance disposal (EOD)/IEDD threats. The helmet was subjected to man-in-simulant (MIST) testing and vapour testing at the Royal Military College of Canada (RMC) in Kingston, Ontario, to assess its ability to protect against chemical agents. Respiratory testing and live ECM testing using a jamming device were conducted at the RCMP Technical and Protective Operations Facility (TPOF), while blast performance was tested at DRDC Suffield.

Relevance

With the emergence of wireless communications systems as the preferred means of initiation in terrorist bombings throughout the world, it is likely that any large-scale improvised explosive device (IED) attack in North America will follow the same trend. The abundance of available components and the proliferation of knowledge via the Internet make radio-controlled improvised explosive devices (RCIEDs) a very likely threat scenario. Existing equipment and standard operating procedures need to be modified or upgraded to combat this emerging threat. Other real, emerging threats facing first responders are CB agents attached to explosive devices. To protect them against this threat, first responders need personal protective equipment that combine CB and EOD protection.

Recent Progress and Results

The researchers tested the CB blast protective helmet against Military Standard 461E and Defence Standard 59-41 to determine its compatibility with ECM-jamming devices. Live MIST tests and respiratory tests were conducted involving human volunteers dressed in full gear under highly representative environmental conditions. These tests concluded that the helmet is effective at stopping CB agent penetration. The helmet was also subjected to reliability testing to confirm its functionality in a wide range of conditions, and for an extended period of use.

In the fall of 2006, the RCMP Explosive Disposal and Technology Section received an advanced functional prototype of the RF and ECM-compatible CB blast protective helmet. Med-Eng also provided them with all related training.

Impact

During this project's development, Med-Eng researchers identified new opportunities to extend the helmet's capabilities. In particular, they explored ways to reduce the weight of the helmet to increase the user comfort and have since implemented these into the new design.

The RF- and ECM-compatible CB blast protective helmet can be used in harsh RF environments without the worry of inadvertently activating an IED or the possibility of its electronics not functioning properly due to the RF field being emitted by a jamming device in the area. As such, the RCMP now owns one of the world's first ECM Class A EOD helmet.

CRTI 04-0127RD

Canadian Health Integrated Response Platform

Project Lead: Health Canada – Radiation Protection Bureau

Federal Partners: Public Health Agency of Canada, Health Canada, Environment Canada – Canadian Meteorology Centre

Other Partners: Prolog Development Centre, DBX Geomatics

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Objectives

The Canadian Health Integrated Response Platform (CHIRP) project will integrate two decision-support platforms that are currently in use in the CBRN communities: the Canadian Network for Public Health Intelligence (CNPHI) currently in use at the Public Health Agency's National Microbiology Laboratory (PHAC-NML) for public health-related emergencies and the Accident Reporting and Guiding Operational System (ARGOS) currently in use for radiological-nuclear (RN) emergencies at Health Canada's Radiation Protection Bureau (RPB).

CHIRP's integrated approach to surveillance, monitoring, alerting, and response has significant implications for a comprehensive platform development across clusters and with international partners.

Relevance

The CHIRP project will enhance RN-event detection, response, and preparedness throughout the RN response and public health communities in Canada. It will also strengthen and preserve the jurisdictional boundaries, while pooling Canadian resources and infrastructure in new and innovative ways for the direct benefit of local, regional, and federal decision makers.

Recent Progress and Results

Although this project began significantly later than originally expected, due to contracting delays at Public Works and Government Services Canada (PWGSC), real and immediate progress has been made. The CHIRP project leverages both ARGOS (CRTI 0080TA: Information Management and Decision-Support System for Radiological-Nuclear Hazard Preparedness and Response) and CNPHI (CRTI 02-0035RD) to provide an integrated tool box for CBRN-emergency response.

CNPHI is an integrated monitoring, alerting, data gathering, analysis, decision support, and information exchange system used by the public health community. It gathers relevant public health intelligence into a common national framework to support coordination between multi-level jurisdictions. This form of coordination and information sharing must occur to identify risks, initiate response, and build response capacity.

The ARGOS system-of-sytems is the premier tool kit of the Federal Nuclear Emergency Plan (FNEP), which is administered by the Nuclear Emergency Preparedness and Response Division (NEPRD) of Health Canada's RPB. ARGOS significantly improves coordination and interoperability amongst the FNEP partners during a RN emergency by facilitating a coordinated and rapid response to a radiological or nuclear incident, effective decision making, and distribution of critical information to the operational community, first responders, and ultimately, the public.

CHIRP will leverage the integration of these disparate resources channelled by the CNPHI system to support the ability of decision makers to react to an unexplained biological event that may be the result of a radiological agent and to do so as a partner in the national CBRN response framework. Over the past few years, CNPHI has made major progress in developing comprehensive tools for public health surveillance, alerting, and response with best of breed alerting modules and program watch modules.

While the project is still in the early stages, the ability to notify and alert the public health community in a focused, timely, and concise manner was exercised during the Canadian response to the recent polonuim-210 events in London, England, in December of 2006. During this event, Health Canada issued focused alerts to the public health community and distributed these alerts through the CNPHI system through the CHIRP-system framework. The alerts were sucessfully received and viewed by more than 400 relevant health care professionals.

In the months to come, the project will continue to build on the successful framework that has been developed and is expected to be completed on time in late 2009.

Impact

This project will greatly improve the exchange of intelligence information, as well the ability of the mandated coordinating and operational communities to notify and alert the public health community, in a focused, timely, and concise manner in the event of a biological or RN incident. The project team expects that this new tool set will be incorporated into the coordination and operation communities as the project develops.

CRTI 05-0006TA

Optically Stimulated Luminescent Radiation Sensor for Long-Dwell Detection in Transit Applications

Project Lead: DRDC Ottawa
Federal Partners: Canada Border Services Agency, Transport Canada, DRDC Atlantic
Industry Partner: Bubble Technology Industries

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Objectives

The smuggling of nuclear weapons, components, or other illicit radiological materials represents one of the most critical terrorist threats faced today. Effectively screening the millions of cargo containers destined for North America each year requires a multi-layered defence to cut off potential terrorist pathways and push the perimeter of detection as far away from our borders as possible. The goal of this project is to develop an innovative, near-commercial radiation sensor, based on optically stimulated luminescence (OSL) that can be installed inside a cargo container to detect the presence of even low levels of radiation during shipment. By leveraging the long-signal integration time provided during the container's transit, the radiation sensor can detect the presence of even heavily-shielded radioactive sources.

Relevance

The long-dwell detection-in-transit (LDDT) radiation sensor under development is uniquely suited for the detection of low-activity nuclear materials and radioactive materials in shielded configurations, and is therefore directly applicable to the prevention and interdiction of a nuclear or radiological attack. The federal partners included in this project represent the key stakeholders in preventing the smuggling of illicit nuclear or radiological materials into the country. Their participation in the program ensures that the technology developed will be highly relevant to their defence and security missions.

Recent Progress and Results

DRDC Ottawa and Bubble Technology Industries (BTI) developed a prototype radiation detector during a previous CRTI project (CRTI 0072RD: Nanodosimeters Based on Optically Stimulated Luminescence). This prototype detector used a passive OSL dosimeter whose radiation level could be periodically read using a tiny laser diode.

The scope of the current project is to further develop the prototype OSL dosimeter into a more sensitive, robust, commercially-viable device specifically for LDDT applications. The researchers will combine the radiation sensor with specialized communication hardware, analysis software, and command and control software into a deployment-ready LDDT cargo-monitoring system. As the LDDT system design progresses, DRDC Ottawa, Canada Border Services Agency (CBSA), and Transport Canada will provide technical and operational input to ensure that the LDDT system will meet end-user requirements. BTI will fabricate and assemble a prototype LDDT system, which will then be field-tested in collaboration with DRDC Atlantic, aboard a research vessel in early 2008.

In this first year of the project, BTI has achieved significant technical advancements in modifying the original OSL sensor design. Exact positioning of the laser and thermo-luminescent dosimeter (TLD) increased total counts by 25 to 30 percent. The researchers have also improved detection efficiency by implementing power control of the laser, reducing the

photomultiplier tube (PMT) switching time, and improving the light collection between the TLD and the PMT. Based on data collected at BTI, the project team has developed an algorithm for dose conversion, including temperature correction, for the OSL sensor. BTI performed extensive testing on the sensor to identify any requirements gaps. The results indicate that the temperature dependence from 0°C to 50°C varied by less than 5 percent and tests of the system in magnetic fields up to 30 Gauss showed no observable effect. Dose-dependence measurements gave a linear curve from background to beyond 8.76 millisieverts (mSv). In addition, the absolute dose value measured by the OSL sensor was in good agreement with the value obtained with a commercial dosimeter.

Transport Canada, CBSA, and DRDC Ottawa developed and reviewed a concept of operations (CONOPS). Both CBSA and Transport Canada stressed the importance of a robust mechanical design to withstand the harsh conditions within an operational cargo container. Based on this feedback, BTI developed a rugged mechanical concept for the sensor enclosure and has completed a preliminary mechanical design.

Impact

The successful development and deployment of this sensor in maritime, road, and rail cargo shipments will significantly increase Canada's capability to detect, interdict, and therefore prevent potential radiological and nuclear attacks. The researchers will demonstrate and field-test a protoype LDDT system in January 2008. The system will be delivered to DRDC Ottawa, along with a final report summarizing the technical achievements of the project, the results from the field trials, and the steps to achieve full commercialization. The project will be completed in March 2008.

CRTI 05-0016RD

Development of a Canadian Standard for Protection of First Responders from CBRN Events

Project Lead: Public Works and Government Services Canada

Federal Partners: Public Safety Canada, Transport Canada, Royal Military College of Canada, National Research Council, Royal Canadian Mounted Police

Industry Partners: Canadian Professional Police Association – Labour Services, Canadian Healthcare Association, Canadian Public Health Assocation, Canadian Association of Fire Chiefs

Standards Development Partner: Canadian Standards Association

Other Partners: Canadian Council of Health Services Accreditation, International Association of Fire Fighters – Canadian Office, Paramedic Association of Canada, Canadian General Standards Board, Canadian Standards Association

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Objectives

The objective of this project is to develop a national standard of Canada for personal protective equipment for first responders (i.e., emergency medical, fire, and police services) in the event of a CBRN incident. The aim of this new national standard is to assist first responder organizations in the selection, care, and use of CBRN personal protective equipment (PPE), enabling them to do their jobs more safely with greater protection and functionality. The standard will address requirements for both respiratory protection and protective clothing, and provide valuable guidance on key issues, such as the interchange ability and interoperability of equipment. A key objective of the standard is to provide guidance on the capabilities and limitations of protective equipment.

The major milestones in the standards development process include evaluating the standards guidance document, *Selection and Use of Personal Protective Equipment for the Canadian First Responder to a CBRN Terrorism Event*, developed under a previous CRTI project, "Protecting First Responders Against Chemical and Biological Threats" (CRTI 0029RD); establishing the Technical Standards Committee; preparing working drafts; convening approximately eight committee meetings; managing a public review period; implementing quality and procedural reviews; issuing a letter ballot on the final consensus standard; translating, editing, and publishing the standard; and developing an implementation strategy to promote the standard's use and adoption.

Relevance

To protect Canadians, as well as our public and private infrastructure, it is critical that first responders have access to the right equipment that combines functionality with sufficient protection, and tools and information to help them do their jobs most effectively. Currently, there is no comprehensive standard in Canada that provides first responders with the critical information and guidance necessary to ensure that the appropriate suite of protective equipment or systems are selected and used in CBRN terrorism events. The standard developed over the course of this project will assist first responder organizations in the selection, care, and use of CBRN personal protective equipment (PPE), enabling them to do their jobs more safely with greater protection and functionality.

Recent Progress and Results

The Canadian General Standards Board (CGSB)/Canadian Standards Association (CSA) Standards Committee for the Protection of First Responders from CBRN Events was established in early January. Stakeholders on the committee include all levels of government, public health and safety organizations, first responders, manufacturers, research and testing organizations, and public and private organizations, as well as those organizations involved in the evaluation of CBRN agents.

The committee's first meeting convened over a three-day period beginning January 23, 2007 in Gatineau, Québec. This first meeting was largely an information session designed to orient committee members on the project's objectives, the standards development process, Canada's national standards system, relevant directives, policies, and procedures, the scope of the proposed standard, and the roles and responsibilities of committee members. As well, the committee was introduced to the guidance document upon which the proposed standard will be built. Committee members discussed the roles of the first responders and receivers and other items for possible inclusion in the standard, as well as the scope of the standard. The committee agreed that the standard should contain: the role of the responder or receiver; guidance to the responder to deal with events; details on the level of protection required; description of PPE and the capabilities and the limitations of the equipment; and equipment or standards for levels of protection where they exist. Also suggested was the possibility of a list of performance requirements or specifications for areas where there are gaps.

The committee met again in April 2007 and began discussions on the structure of the standard, terminology, and the development of a lexicon. The members will continue to gather information for the development of the standard through presentations by first-responder and first-receiver groups, as well as presentations by other standards development organizations working in the same or related areas, such as International Organization for Standardization (ISO), National Institute for Occupational Safety and Health (NIOSH), American National Standards Institute (ANSI), National Fire Protection Association (NFPA), American Society for Testing and Materials (ASTM), and National Institute of Standards and Technology (NIST).

Impact

The development of a single recognized national standard will bring together relevant stakeholders with world-class expertise in protective-equipment development and evaluation for CBRN agents. The standard will support the needs of all levels of government, industry, and first responders directly and in a unique way, with the capabilities and expertise linked together through the establishment of a national technical committee. The development of this standard will also accelerate the use of technologies. The project team hopes to have the standard ready for publication in February 2009.

CRTI 05-0043RD

Economic Impact of Radiological Terrorist Events

Project Lead: DRDC Ottawa

Federal Partners: Canadian Nuclear Safety Commission, Canadian Security Intelligence Service, Atomic Energy of Canada Limited

Industry Partner: Battelle Memorial Institute – Pacific Northwest National Laboratories

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Objectives

The objective of this project is to conduct a study that provides quantitative data on the economic consequences of a radiological dispersal device (RDD) event. It is generally accepted that the main consequences of a radiological terrorist event will not accrue from short-term casualties and fatalities, but from its associated widespread contamination. Some of the qualitative consequences of RDD events are clear—denial of public access to large tracts of land, long-term health effects, public paranoia, and extremely difficult decontamination. However, until now, there has been no consolidated study to quantify these effects on an economic basis.

To achieve its objective, the project team will conduct its study by progressing logically through the RDD event phases of placement, release, laydown, response, and recovery. The team will bring key Canadian experts from the intelligence, research and technology development, regulatory, and decontamination fields together with their counterparts from the Battelle Memorial Institute that recently completed a similar study on nuclear weapon consequences.

Relevance

As part of the process for determining its investment priorities for CBRNE counterterrorism projects, CRTI performs a matrix-based analysis of over 50 scenarios using its consolidated risk assessment. One of the parameters in the matrix is cost. This study will give validity to the cost-based entries in the matrix, where previously only guesses were possible. The result will be greater legitimacy to the consolidated risk assessment and similar tools.

Recent Progress and Results

Any number of scenarios are imaginable for radiological terrorism; however, for the purposes of this study, a few scenarios, considered to be typical, were selected to represent the larger set. At the outset of the study, the researchers made decisions to address different isotopes and isotope activity, various types of Canadian geographical locations, active versus passive sources, and meteorological conditions.

In the isotope selection process, the project team selected isotope sources that are commercially available and include alpha, beta, and gamma radiation types. Spanning the various radiation types allows the team to address the different biological threats and cleanup problems that each presents.

To evaluate the consequences of the RDD events at various types of locations across Canada, the team selected five locations as hypothetical ground zero locations. These locations are BC Place Stadium in Vancouver, British Columbia; the CN Tower in Toronto, Ontario; the Louis-Hippolyte-La Fontaine tunnel in Montréal, Quebec; Parliament Hill in Ottawa, Ontario; and the Ambassador Bridge between Detroit, Michigan, in the United States (US) and Windsor, Ontario.

To address the differences between active and passive RDD event scenarios, the team selected several RDD sources to evaluate which sources make sense at each of the selected ground zero locations. These sources are 1,000 curies (Ci) of Cesium-137 for an active outdoor explosion, an active indoor explosion, passive placement in a water reservoir, and passive building release in a heating, ventilation, and air conditioning (HVAC) system; 1,000 Ci of cobalt-60 for passive radiological exposure device (RED) population exposure; and 20 Ci americium-241.

Finally, the team obtained annual average meteorological values from the Canadian Wind Energy Atlas. Both Canadian and US databases were examined to determine typical weather patterns, with an emphasis on wind for input to the calculations.

Recently, state-of-the-art computer codes, such as Hotspot and the GENII system, have been used to predict event chronology for active devices leading to laydown or deposition patterns. Dose-rate isocontours have been developed for passive devices. To evaluate the economic impact of an RDD event, efforts have begun to incorporate additional factors to the patterns. These factors include unit cleanup cost factors, based on a given residual contamination level; population density (e.g., worried well, actual casualties); and lost economic activity. The Battelle Memorial Institute will incorporate these factors into the patterns using computer codes, such as Sandia's RADTRAN; its long history of on- and off-site decontamination efforts; and relevant data from incidents, such as the World Trade Center catastrophe on September 11, 2001. The methodology will be filtered using Canadian data before starting partner input, resulting in the end product.

Impact

A primary impact of this study is to add important information to risk assessment processes, such as CRTI's Consolidated Risk Assessment. In addition, the study will provide the resources for decision makers, at various levels of governments, to determine whether decontaminating or demolishing a site is the best economic decision. Finally, by providing the study findings in table format for several specific Canadian contexts, pre-planning for RDD events can occur, assisting in the protection and safety of personnel and assets. The project is scheduled for completion March 2008.

CRTI 05-0058TD

Unified Interoperability Solution Set to Support CONOPS Framework Development: Municipal-Provincial-Federal Collaboration to CBRNE Response

Project Lead:	DRDC Ottawa – Future Forces Synthetic Environment Section
Federal Partners:	Environment Canada – Canadian Meteorological Centre, DRDC Suffield – Counter Terrorism Technology Centre, Department of National Defence – Canadian Forces Experimentation Centre, Department of National Defence – Synthetic Environment Coordination Office, Royal Canadian Mounted Police E-Division
Industry Partners:	CAE Professional Services (Canada), EmerGeo Solutions, Justice Institute of British Columbia
Other Partners:	Vancouver Police Service, Vancouver Fire and Rescue Services, British Columbia Ambulance Service

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Objectives

This project will produce a simulation-based, scenario-driven, capability analysis methodology that can be used to evaluate response capabilities to all hazard types. The project team will test this methodology against real response operations at all levels of government and geographically position the scenario to ensure a degree of likelihood resulting in a true demonstration of the value of the approach.

The simulation-based, scenario-driven training capability will be delivered to the Justice Institute of British Columbia (JIBC), therefore ensuring future benefits to the local and provincial first-responder community.

Relevance

The ability to evaluate technology advancements within response operations and to quantifiably examine the impacts of changes to the response procedures using simulation becomes a powerful capacity for understanding the complexities of multi-jurisdictional emergency-response activities. The project is relevant to current threat-risk profiles, using Vancouver and Burnaby, British Columbia, as incident

locations in the scenario. The incident types included for the project's scenario are a potential chemical release and an explosion, virtual threats that are realistic and relevant to the normal operations of the first-responder organizations involved in this project.

Recent Progress and Results

The project partners approved the project charter in May 2006 and the project kick-off meeting occurred at JIBC in Vancouver in June 2006. The project is divided into five phases: developing an interoperability framework based on the Department of National Defence Architecture Framework (DoDAF) to support municipal-provincial-federal interoperability for CBRNE-related response in the City of Vancouver (Phase A); developing a sharable, geo-spatial dataset for the selected area of study and analysis (Phase B); developing and integrating an environmental and CBRNE model (Phase C); developing a simulation construct, based on interoperability architecture (Phase D); and demonstrating the technology (Phase E).

The project team has made considerable progress in developing an interoperability framework (Phase A) since the start of the project, beginning with a visit to Vancouver to interview a host of subject-matter experts (SMEs) from the partner organizations (local-municipal-provincial-federal responders). The team has integrated the information gathered into a series of architecture products to represent the different views to establish an interoperability framework and define a concept of operations (CONOPS) for municipal-provincial-federal interoperability in a CBRN response. The project's response partners will validate the operational architecture in Vancouver from April 30 to May 1, 2007.

The capability methodology developed as part of this project is already being applied to analyze industry capability enhancements to emergency response procedures based on a biological incident on critical infrastructure.

The development of a common, shared geo-spatial dataset (Phase B) will support simulation-based analysis across the diverse municipal-provincial-federal CBRNE response organizations as defined within the architecture development in Phase A. The project team has acquired two-dimensional (2-D) and three-dimensional (3-D) data from the City of Vancouver and is presently integrating the geo-spatial dataset into the geographic information system (GIS)-based Common Operating Picture Environment (COPE) that will be used by all participants in the demonstrations at the end of the project. EmerGeo has started developing an interface that allows for the acquisition of relevant simulation data from the simulation environment and an interface of the 3-D viewer with their software.

The development of a distributed simulation methodology (Phase C) will enable the project's participants to conduct CBRNE-related scenarios within the COPE in a distributed fashion and integrate enhanced CBRNE dispersion models and atmospheric effects. Environment Canada, in conjunction with DRDC Suffield, is developing the atmospheric models for the project.

The project team plans to start Phase D (developing a simulation construct based on the interoperability architecture) and Phase E (technology demonstrations) later in the year.

Impact

This project will have significant impact on the analysis of capabilities related to emergency response operations for complex high-consequence incidents. Currently, response organizations limit training to yearly exercises with larger groups of emergency responders. The resulting analysis framework will allow organizations to test changes to their own response procedures in coordination with other virtual partner response organizations. This will accelerate the training cycle for critical local first responders under multiple virtual-threat types and provide quantitative analysis of the response characteristics of participants.

CRTI 05-0069RD

Development of PEGylated Granulocyte-Macrophage Colony Stimulating Factor for Acute Radiation Syndrome

Project Lead: Health Canada
Federal Partner: DRDC Suffield
Industry Partner: Cangene Corporation

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Objectives

This project aims to further research on the granulocyte-macrophage colony stimulating factor modified with polyethylene glycol (PEG-GM-CSF) that was developed during a previous CRTI project, "Evaluation of GM-CSF for Acute Radiation Syndrome" (CRTI 0085TA). The project partners will work to confirm the efficacy of the PEG-GM-CSF in stimulating hematopoeisis in the early treatment of low-lethal dose acute radiation exposure.

The project's key objectives are to develop a final formulation of the product, including synthetic conditions and purification parameters, and to establish the exact dosing requirements to alleviate severe neutropenia in irradiated monkeys as a model of acute radiation syndrome (ARS).

Relevance

Based on preliminary studies with irradiated monkeys, weekly doses of PEG-GM-CSF prevent severe neutropenia in the early stages of ARS, a result that daily doses of non-modified GM-CSF have thus far not been able to achieve. This is of particular significance to first responders, since it implies that a victim or patient would only require one immediate treatment and fewer follow-up treatments compared to the daily injections that would be necessary with GM-CSF. Given the stability of PEG-GM-CSF, the operational community would need to stockpile less material and possibly be able to keep it for longer.

Recent Progress and Results

The project is in its first year and most of the progress has been in developing conditions for PEG-GM-CSF production. The project team is currently finalizing the production parameters of PEG-GM-CSF in an effort to be able to prepare batches in the hundreds-of-milligrams scale to support much larger animal studies and to transfer production to a good manufacturing practice (GMP) facility, thereby enabling production for treatment of humans in the event of nuclear terrorism.

The researchers have completed the preliminary animal study on two monkeys. Two larger studies are currently ongoing to confirm the results observed in the first study and to determine the optimal dosing regimen going forward. In the most recently completed study, PEG-GM-CSF dosed at 0.3 milligrams per kilogram (mg/kg) on days one and seven improved the outcome for one animal relative to a control untreated monkey, shortening duration of severe neutropenia in the crucial first two weeks. The researchers will continue to study the effects of decreasing the required dose and instituting a third dose at day 10 to keep the absolute neutrophil count above threshold levels for a longer duration.

Impact

Having a stockpile of ready-for-use PEG-GM-CSF product may well be a valuable asset among the therapies available for treatment of ARS in the event of a nuclear terrorism incident in Canada. The product developed during this project is expected to be available for facile administration as a subcutaneous dose in individual vials in about two years.

CRTI 05-0078RD

Development of Live Replicating Viruses as Vaccines and Therapies for Viral Haemorrhagic Fever Viruses

Project Lead: Public Health Agency of Canada
Federal Partner: Health Canada – Health Products and Food Branch
Industry Partner: Impfstoffwerk Dessau-Tornau GmbH
Other Partner: United States Army Medical Research Institute for Infectious Diseases

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Objectives

The objective of this project is to use live, attenuated recombinant vaccine vectors based on vesicular stomatitis virus (VSV) as innovative prophylactic and therapeutic vaccines that can reliably be produced in sufficient quantities for use in the event of a bioterrorist attack with Ebola (EBOV) or Marburg (MARV) viruses. Partnered with Health Canada's Health Products and Food Branch (HPFB), the United States Army Medical Research Institute of Infectious Diseases (USAMRIID) and the vaccine production company Impfstoffwerk Dessau-Tornau (IDT) GmbH, the Public Health Agency of Canada (PHAC) will develop good laboratory practice (GLP) stocks of the vaccines and a small, current good manufacturing practice (cGMP) stock of recombinant VSV expressing the glycoprotein (GP) of *Zaire ebolavirus* (ZEBOV) or VSV_G/ZEBOVGP. With HPFB and the United States Food and Drug Administration (US FDA), PHAC researchers will determine the immune correlates of protection in rodent and non-human primate models of ZEBOV infection. The project team will also show that cGMP stocks of vaccine are as effective as current experimental stocks. This data is essential for future licensing of the vaccine.

Relevance

Infection with filoviruses, in particular ZEBOV or MARV, causes a highly virulent, severe haemorrhagic fever (HF) in humans and non-human primates that is often fatal. ZEBOV and MARV are considered serious threats as agents of biological warfare for a number of reasons, which include: that there have been reports that the former Soviet Union produced large quantities of MARV in a formulation directed to large-scale aerosol dissemination; the simple addition of glycerine to the virus preparation makes MARV as stable as the influenza virus in aerosol phase; it has been shown experimentally that ZEBOV is infectious following oral and ocular exposure of non-human primates, as well as by aerosol; and lastly, at this time, there is no preventive vaccine or post-exposure treatment option available for human use.

The replicating recombinant vaccines based on VSV developed in this project are currently the most effective post-exposure treatment, as well as being extremely effective vaccines. There is now a much greater potential to protect responder communities from a significant biological threat.

Recent Progress and Results

The project team generated live, attenuated recombinant VSV expressing the transmembrane GPs of ZEBOV (VSV_G/ZEBOVGP) and MARV (VSV_G/MARVGP) and the glycoprotein precursor (GPC) of Lassa virus (VSV_G/LASVGPC) and results showed that these gave complete protection to cynomolgus macaques against lethal challenge with the corresponding filoviruses and arenaviruses. The team developed vaccine candidates for EBOV and MARV, based on live, attenuated recombinant VSV vectors expressing the relevant glycoproteins. Single intramuscular injections of each vaccine were administered to naïve non-human primates (n=4 per vaccine), and 28 days later, the animals were challenged with at least 1,000 plaque-forming units of virulent EBOV or MARV. Single dose, oral and intranasal immunization of mice and guinea pigs and non-human primates were also tested for protective effect. Finally, the researchers tested the ability of the VSV Ebola and VSV Marburg vaccine to protect animals when administered as a post-exposure vaccine at 30 minutes to 24 hours after infection with the virulent agent. None of the animals developed fever or other symptoms of illness following vaccination. Immunization elicited protective immune responses in all of the non-human primates against otherwise lethal challenges. The EBOV vaccine induced strong humoral and cellular immune responses in all vaccinated monkeys, while the MARV vaccine predominately induced a humoral response. Mucosal immunization resulted in protection of rodents from challenge with up to 1,000,000 LD_{50} and non-human primates from 1,000 LD_{50}. All non-human primates infected with Marburg virus and 50 percent of the non-human primates infected with Ebola virus survived when treated 30-minutes post-exposure.

Impact

The deployment of these vaccines will provide Canada with a world-leading operational ability to protect the responder community from these hitherto untreatable threat agents. The ability to use these vaccines after exposure, rather than having to administer the vaccine months or years before, makes them more responsive to the threat environment. Viral haemorrhagic fever agents are a highly significant threat because they are virtually untreatable. However, the likelihood of their use is low, so mass vaccination prior to an event is economically and medically difficult to justify. The vaccines developed through this project fill this capability gap.

Data suggests that these vaccine candidates are safe and highly efficacious in highly relevant animal models. Furthermore, there is an unprecedented potential for use as a post-exposure vaccine.

CRTI 05-0090TA

Adaptation of Recently Developed DNA Microarrays to NanoChip Microarray Technology for Detection of Agroterrorism Agents

Project Lead: Canadian Food Inspection Agency
Industry Partner: Nanogen

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Objectives

The purpose of this project is to develop new capabilities for rapid detection and typing of foot-and-mouth disease (FMD) virus and avian influenza (AI) virus. Canadian Food Inspection Agency (CFIA) and Nanogen researchers are adapting DNA slide microarray technology to the more portable NanoChip platform, which can be easily and practically used by first responders. NanoChip technology is a fully automated system with an open platform that uses electronic printing and hybridization. The researchers will adapt or redesign the existing microarray probes in the first phase of this project. Concurrent with probe redesign is assay design and layout on the NanoChip array. The second phase of the project involves optimizing electronic printing and hybridization conditions and data reporting. The final phase is test validation, including field testing by the end-user (i.e., CFIA's district veterinary officers).

Relevance

The NanoChip electronic arrays for FMD and AI represent novel detection and typing technology, to be used at the farm site in a mobile diagnostic unit. This allows rapid testing and effective management in the event of a real outbreak, and a minimum quarantine period for the farm in the case of a suspected, but false, outbreak. The project's ultimate aim is to make this automated, portable technology available to first responders and train them to use the instrumentation.

Recent Progress and Results

The project team has made substantial progress in assay design and layout on the NanoChip platform. The capture probe down format, in which biotinylated probes are electronically printed on the electrode chip array, has been demonstrated to be a successful format for the detection and

discrimination of FMD virus serotypes and AI hemagglutinin subtypes. This format appears to be more suitable than the alternative, amplicon down format, in which the amplicon is printed.

The researchers found it necessary to modify the capture probes to optimize their melting temperatures for the NanoChip platform and, in the case of AI, probes were re-examined against the ever-expanding database of available sequences. Primarily due to concerns of a possible human pandemic arising from an AI strain such as the H5N1 Asia virus, there are numerous large-scale surveillance and sequencing projects, which have significantly expanded the number of new sequences in the AI sequence database.

The researchers' work on selecting capture probes for use in the NanoChip is ongoing. The probes have high-sequence conservation for individual serotypes and subtypes with discriminatory power, as well as superior performance in the assay itself. Very good signal-to-noise ratios have already been achieved with capture probes, thus optimization of assay conditions may require minimal adjustments.

Reporter probes have been designed and incorporated in the assay to replace the direct labelling of the amplicons to streamline the assay for first responders, making labelling an automated function rather than a manual one. The team will continue to make improvements in design to meet both end-user and system requirements.

Impact

FMD and AI are highly infectious diseases that, if introduced into Canada's naïve animal populations, inadvertently or intentionally by terrorism, can spread quickly and have catastrophic consequences to the nation's agricultural industry and a significant deleterious impact on its economy. Thus, there is an urgent need for rapid on-farm testing by first responders in case of a suspected outbreak (i.e., district veterinary officers). Measures to promote vigilance among the producers themselves are needed, but cooperation of the entire community is more likely if quarantine situations are employed for a minimal time in cases where the outbreak proves to be false. With rapid, on-site testing, the quarantine period can be kept to a minimum. NanoChip electronic array technology satisfies the requirements of portability and highly multiplexed detection needed to deal with the high genetic variability of these viruses. A unique feature of the technology will be distinctly Canadian: the probes to be used in the NanoChip are intellectual property owned by CFIA. The project is expected to be completed in September 2008.

CRTI 05-0092TA

Integrated Personal Cooling for Chemical and Biological Protective Undergarments

Project Lead: Royal Canadian Mounted Police,
Federal Partners: Royal Military College, DRDC Suffield
Industry Partner: Med-Eng Systems
Other Partner: University of Ottawa – School of Human Kinetics

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Objectives

Explosive ordinance disposal (EOD) first responders are often required to wear chemical protective undergarments (CPUs) beneath their EOD ensembles, resulting in additional heat stress. Personal cooling systems (PCS) are therefore often essential in addition to CPUs, to mitigate heat stress. Currently, this protective-equipment combination adds extra steps and time related to donning, doffing, and decontamination procedures. It also introduces additional bulk and possibly discomfort to an already burdened operator. The current project proposes to obtain two types of protection (chemical and cooling) out of only one layer, resulting in decreased staging time, increased mobility, reduced thermal burden, and easier decontamination procedures.

The Royal Canadian Mounted Police (RCMP) provides overall guidance and volunteers for fit trials, while the Royal Military College (RMC) and DRDC Suffield contribute to chemical protection testing. Human testing of the PCS will occur at the University of Ottawa.

Relevance

The successful completion of this project will improve the operational capabilities for the prevention and response to a CBRN event, by safely extending mission time through personal cooling for the first responder equipped with CPU underneath EOD personal protective equipment (PPE). In addition, decontamination procedures will be simplified, with one less layer.

Recent Progress and Results

At the project's outset, researchers at Med-Eng Systems introduced moisture management into the design concept for better thermal comfort and possibly improved thermal performance of the cooling function. This required an optimum integration of the chemical protective layers with the cooling and moisture management layers. The team sourced appropriate raw materials and preliminary tested them for the intended purpose, in the most effective configurations (i.e., sequencing of various layers). As a result of these investigations, the CPU with integrated cooling will provide significant thermal comfort, minimizing the discomfort associated with sweating.

The researchers built swatches of CPU systems using chemical protective materials from three different manufacturers, combined them with different moisture management layers, and used two methods to affix the tubing for the cooling application (i.e., sewing or lamination). The swatches were used for two types of tests: chemical protection against live agents (carried out at a Netherlands Organisation for Applied Scientific Research [TNO] laboratory) and sweating hot plate testing (carried out at Med-Eng) for cooling properties, as well as insulative and moisture absorptive capabilities. The

sweating hot plate testing was customized based on an existing American Society for Testing and Materials (ASTM) standard, since no cooling standard exists for swatches of materials. The testing at TNO, which involved vapour testing, was aimed at ensuring that affixing cooling tubes to the CPU (either laminated or sewn to the fabric) did not affect the level of chemical protection. Both types of tests were successful.

Med-Eng researchers are now building prototype garments, incorporating the layers from the best performing swatches, as identified from chemical and cooling tests with the material swatches. This will be followed by testing in the garment configuration: dry mannequin testing for cooling at Med-Eng, chemical protection testing (man-in-simulant test [MIST] vapor at RMC, and the chemical/biological (CB Plus) exposure chamber at DRDC Suffield). Finally, the team will conduct thermophysiological tests involving human subjects at the University of Ottawa to confirm the cooling effectiveness and to collect additional human factors data.

Impact

When the project is completed in March 2008, three to four fully functional prototypes with demonstrated effectiveness will be provided to the RCMP for immediate use. This integrated PPE could be disposable, and has potential for cost savings as compared to having separate garments.

CRTI 05-0106TA

Development of Field-ready Nucleic Acid Detection Techniques for Category 1 and 2 Biological Agents

Project Lead: Public Health Agency of Canada – National Microbiology Laboratory

Federal Partner: DRDC Suffield

Industry Partner: Cepheid Incorporated

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Objectives

The purpose of this project is to develop real-time nucleic acid detection assays for Category 1 and 2 biological weapons (viral and bacterial) in a readily available and accepted commercial format. The project team aims to identify suitable Scorpion-based primer-probe combinations for all agents by August 2007, and to optimize the assays for use on the Smartcycler real-time polymerase chain reaction (PCR) system by April 2008. The team will further develop selected assays for the GeneXpert platform by the project's completion in August 2008. The assays will be evaluated during CRTI-sponsored field exercises. Federal partners will provide nucleic acids, containment facilities, and assay optimization, and Cepheid researchers will provide assay design, expertise, hardware, and reagents for development.

Relevance

Assays currently available to frontline personnel are targeted to detect important biological threat agents such as *Bacillus anthracis*, *Francisella tularensis*, *Yersinia pestis*, and Variola virus. Tests for the high-consequence viral agents, such as Ebola and Lassa viruses, along with many other viral and bacterial agents of concern, are currently lacking. The development of new real-time assays for the broader scope of Category 1 and 2 viral and bacterial threat agents will allow rapid, sensitive, and accurate testing for a greater range of potential biological agents in the hands of the response and monitoring communities and, thus, greatly enhance Canada's response capacity.

Recent Progress and Results

The production of quantified nucleic acid stocks to be used in the evaluation of primer-probe combinations requires the complete inactivation of biological agents prior to their removal from containment level 3 or 4 (CL3 or CL4) facilities followed by safety testing to ensure inactivation has occurred. This step is now complete.

Real-time (5′ nuclease) probe sets that allow for sensitive and specific detection have been identified for all agents. These were modified, with Cepheid's expertise, to Scorpion probes to ensure optimal functionality with the Smartcycler and GeneXpert. The Scorpion probe format provides very rapid cycling times, allowing assays to be completed faster. The team evaluated the first trial conversions at the

Public Health Agency of Canada's National Microbiology Laboratory (PHAC-NML) and determined that the assays detected Ebola and Marburg viruses with equally high sensitivity to the 5' nuclease probe sets. Conversion of the remaining probe sets to Scorpion probe format is ongoing and should be completed by August 2007.

Cepheid provided upgrades for two Smartcycler systems that will allow the team to develop multiplexed primer sets compatible with Cepheid's next generation GeneXpert systems.

Impact

The tool box available to first responders and the CBRN community has grown considerably over the past few years. Real-time nucleic acid amplification and detection assays with high sensitivity, specificity, and speed are available for a limited spectrum of biological agents. The assays developed in this project will enhance the capability of responders to rapidly detect a much broader range of biological agents. At the completion of this project in August 2008, assays will be available to the PHAC-NML and joint national CBRNE teams, at a minimum, that will complete the coverage of Category 1 and 2 biological agents.

CRTI 05-0108TD

National Nuclear Emergency Laboratory Network and Interoperability

Project Lead: Health Canada – Radiation Protection Bureau

Federal Partners: DRDC Ottawa, Royal Military College, Department of Fisheries and Oceans

Other Partners: Ontario Ministry of Labour, BC Centre for Disease Control, Trent University

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Objective

The objective of this project is to develop a framework for the national laboratory network for radiological or nuclear (RN) emergency preparedness. In the first two years of the project, researchers will develop, test, and then implement a collection of laboratory protocols and an information technology (IT) solution for laboratory results networking and reporting in the participating laboratories. In addition, Health Canada and the Ontario Ministry of Labour will develop, test, and implement gamma-ray spectra interoperability. In the project's final year, the research team will conduct a proficiency test exercise, followed by an emergency readiness exercise in the network laboratories.

Relevance

Following an RN emergency, hundreds or thousands of field samples need to be measured in a very short period of time. Quality data and fast delivery of the results are essential to plan protective actions for the public and to ease concerns of the worried well. It is essential to have well-established laboratory protocols and an efficient channel for sharing and reporting measurement results. The networking solution for laboratory protocols and results developed in this project will be implemented in the current participating laboratories and can be shared with other laboratories, collectively enhancing the national response capability and capacity to an RN emergency.

Recent Progress and Results

In July 2006, project partners attended a workshop on typical RN scenarios and requirements for laboratory analysis. Based on the outcomes of this workshop, the laboratory protocols to be developed were repackaged, and planned exercises were reorganized and rescheduled.

The project team then collected, reviewed, classified, and consolidated the laboratory methods and procedures

currently employed in each of the participating laboratories. The pilot protocol for the measurement of field samples by gamma spectrometry will be developed in the first quarter of 2007–2008 fiscal year. This protocol will be tested and approved by all project partners with gamma-spectrometry capability before subsequent protocols are developed.

The researchers are currently finalizing the formats for standard protocols, data, and reports that will be used by participating laboratories. These formats will be used in the development of the networking solution for laboratory results.

The development for gamma spectra interoperability between Health Canada and Ontario Ministry of Labour has been intensive. The solution development will be completed soon and implemented in both laboratories.

Impact

Upon the completion of this project in March 2009, the laboratories in this network will have a package of standard protocols—subject to minor modification to fit specific laboratory needs—for RN emergency response. The IT networking solution for lab results will increase interoperability by enabling data exchange between laboratories that share the standard format. As a result, information reported to decision makers will be simple, clear, and in a standardized form so that the results can be readily interpreted. The knowledge, capabilities, and applications resulting from this project will significantly enhance the national overall effectiveness and efficiency of RN emergency response operations.

CRTI 05-0121RD

Evidence-based Risk Assessment of Improvised Chemical and Biological Weapons

Project Lead: Public Safety Canada

Federal Partners: DRDC Suffield, Department of National Defence, Royal Canadian Mounted Police – Forensic Laboratory Services

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Objectives

There are currently several well-known sources of information relating to improvised chemical and biological weapon (CBW) technologies within the open literature and on the Internet. While some of this information is easily assessed as technically unsound, much of it has not been fully assessed with respect to its technical feasibility and impact. The first objective of this project is to conduct a thorough review of this information and of information contained in classified sources that relates to terrorist interest in CBW. Project team members will then use this review to identify a set of scenarios for which there are knowledge gaps pertaining to technical feasibility and impact, and for which there are also indications of terrorist interest.

The project team will experimentally assess scenarios, when deemed necessary. This will involve constructing, testing, and thoroughly characterizing the technology in question. Issues to be addressed include: the nature of technical gaps or inaccuracies in the information; the level of expertise needed to recognize or overcome these gaps and successfully execute the technology; threats to the safety of those attempting to implement the technology; availability of required materiel (including improvised equipment); the yield, purity, toxicity, and stability of the product; the efficacy of dissemination; the potential for scale-up; potential signatures of activity; the most appropriate target; and finally, impact assessment.

The knowledge generated from this work will be shared among the project partners, within the Canadian counterterrorism community, and with allied counterterrorism agencies.

Relevance

The scientific information obtained during this project will fill gaps in the current knowledge of the quality of information that is available to terrorists. It will provide a sound basis for the assessment of risk associated with these scenarios. Accordingly, this information is critically important to the identification of significant terrorist threats, the understanding of their impact, and the development of technologies for prevention and consequence management. The project team also expects that there will be other benefits from the knowledge generated in this project. For example, the identification of signatures associated with the improvised CBW technologies in question will benefit those agencies involved in investigation or attribution of terrorist CBW activities.

Recent Progress and Results

The project is structured to be completed in five sequential phases. These include a review of information sources; prioritizing the technologies to be assessed; a technical assessment of the technologies identified; the development of scenarios; and the production of a final report. The project team has now completed phase two, the prioritization of the technologies to be assessed. DRDC Suffield's technical and scientific staff have now started the technical assessments of the prioritized list of technologies.

Impact

This project will address the significant knowledge gaps that are recognized by the Canadian and international counterterrorism community. Accordingly, the knowledge generated by this project will be unique in the world. This project will also establish new capabilities and methodologies for the technical assessment of the risks associated with improvised CBW technologies that will serve as a model for future assessments of such technologies. This work will set a new standard in CBW-terrorism risk assessment by furnishing hard data relating to technical feasibility and an objective impact assessment. It will provide those who must assess and prepare for the CBW-terrorist threat with a solid foundation upon which to base their assessment and preparations. The project is expected to be completed during the second quarter of 2009.

CRTI 05-0122TD

CBRN Crime Scene Modeller

Project Lead:	Royal Canadian Mounted Police – Forensic Identification Research Services
Federal Partners:	Canadian Police Research Centre, DRDC Ottawa – Radiological Analysis and Defence Group, Royal Canadian Mounted Police – Explosives Disposal and Technology Section
Industry Partner:	MDA Space Missions
Other Partners:	Toronto Police Services, Emergency Management – Toronto CBRN Team, Toronto Police Services – Forensic Identification Services, Vancouver Police Department Forensic Services Station, York University – Department of Computer Science and Engineering

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Objective

The objective of this project is to develop a multi-sensor three-dimensional (3-D) modelling system for collecting evidence at crime scenes contaminated with CBRN agents with minimum exposure to first responders. The CBRN Crime Scene Modeler (C2SM) will be used as a hand-held device or will operate automatically on board a mobile robot.

Led by the Royal Canadian Mounted Police (RCMP), the project involves first responders from RCMP and police departments from Toronto and Vancouver, and experts in radiological threat assessment and policing technologies. MDA Space Missions and York University provide expertise in 3-D modelling and sensor fusion and visualization.

Relevance

Investigating crime scenes where CBRN agents have been deployed poses great dangers to first responders. Radiologically contaminated crime scenes present the most difficult challenges of all, where personal protection is next to impossible to achieve. As any prior decontamination of a crime scene may result in the destruction of potentially vital evidence, it is essential to develop technologies that will reduce the need for the first responders to enter the scene, maximize their productivity and thus reduce their exposure, and allow them to conduct their tasks from relatively safer stand-off distances or by using mobile platforms.

The C2SM system addresses this need by rapidly recording the CBRN scene in 3-D as it existed when the first responders arrived; recording and mapping the contamination levels

of CBRN agents and registering them with the 3-D model; making the data available to staff at safe locations; and allowing investigators and courts to view the scene and evidence in its "pure" state.

Recent Progress and Results

The project started as a result of a joint field trial that involved first responders from RCMP and police, and engineers and scientists from MDA and York University. The C2SM architecture and concept of operations (CONOPS) were jointly developed by the project team following these trials.

The C2SM uses stereo cameras to record images and to create 3-D models of the scene. Additional sensors provide complementary and CBRN-specific information that the C2SM registers with the 3-D model. These sensors include a directional gamma ray probe (DGRP), supplied by DRDC Ottawa, which provides information on the spatial distribution and characteristics of radiological and nuclear contaminants; a chemical detector that provides information on the presence and concentration of airborne chemical contaminants; an infrared (IR) camera that provides information on the thermal distribution and signature of observed objects; and a high-resolution camera that provides detailed images of the object of interest.

C2SM will be used either in a hand-held mode or in an automatic mode on board a mobile platform. The mobile robot version will include DGRP and chemical detectors.

The project team plans to use Allen-Vanguard's MK-2 robot for field trials and demonstrations; however, C2SM can be deployed on other robots as well.

A prototype of the hand-held unit has been integrated and interfaced with a computer, and is currently undergoing laboratory tests. The unit includes, in addition to cameras (stereo, high-resolution, and IR) and lights, a screen with an input device and an embedded computer. A remote operator can access the hand-held unit computer (via a wireless link) and assist the unit operator in his operations.

Impact

The prototypes developed in the project will allow the first responders during CBRN events to create 3-D models of event scenes on site; automatically register data from CBRN detectors interfaced with C2SM; annotate the interactive model and link gathered evidence, visualize the 3-D model and make interactive measurements; and store complete event data.

Two versions of C2SM prototypes will be developed and tested in field trials with first responders in August 2007 and July 2008. The first responders will receive three copies of the second prototype and training to operate them.

CRTI 05-0123TD

All-hazards Sample Receiving and Storage Capability

Project Lead: DRDC Suffield

Federal Partners: Public Health Agency of Canada, Public Safety Canada, Royal Canadian Mounted Police, DRDC Ottawa

Other Partners: Metro Toronto Police, Ontario Provincial Police, Toronto Emergency Management Services, Centre for Forensic Sciences

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Objectives

Responders are often called upon to handle samples of unknown composition. Although such samples are often subjected to on-site field screening tests, definitive identification of materials must be conducted by certified personnel within accredited laboratories. To protect their facilities and personnel, the gold standard laboratories will only accept certain classes of hazards. Thus, samples must be triaged. Currently, there are no triage facilities within Canada for all-hazards materials. This project will deliver the capability for an all-hazards sample receiving facility and the standard operating procedures (SOPs) and equipment to be used within it. A prototype facility will also be constructed, equipped, and demonstrated at the Counter Terrorism Technology Centre (CTTC) at DRDC Suffield.

The project team's work will be divided into six phases: developing a the list of specialized laboratory equipment and instrumentation for the facility; developing the technical specifications for the facility; developing SOPs for the facility; procuring specialized laboratory equipment for the facility; constructing and installing the facility; and demonstrating the facility complete with all its equipment and instrumentation.

The development of the specialized equipment list and technical specifications will involve consultation with several end-user support groups (both laboratory and first responders), to ensure their needs are met. When the specifications for the equipment and facility are completed, work will begin on developing the SOPs for the facility for the following tasks relating to the samples: receiving (i.e., packaging requirements); processing (equipment and technique-based protocols); decontaminating, if necessary; and forwarding to the appropriate laboratory for confirmatory analysis. In parallel to the above processes, procurement of the equipment for the facility will be ongoing. Finally, the construction of the facility will be occurring simultaneously to being installed and demonstrated in an international exercise involving several first responder groups.

Relevance

This project will provide Canada with a more efficient response by ensuring that samples are properly triaged and directed to the appropriate analytical facilities in a timely fashion, while ensuring the safety of the facilities and laboratory personnel. The establishment of validated, forensically-sound SOPs, the use of standardized equipment, and the provision of storage for contaminated material will all ensure that the integrity of any investigation is preserved.

The prototype will serve as the basis for the construction, equipping and operation of similar facilities elsewhere in Canada. The establishment of such standardized facilities will permit forensically sound analysis and identification of unknown or mixed CBRN materials and the storage of CBRN-contaminated evidence, while protecting the analytical laboratories and their personnel.

Recent Progress and Results

Recent progress on the project includes an agreement for collaboration between DRDC Suffield and the United States (US) Army's Forensic Analytical Center's Mobile Laboratory and Kits Team at Edgewood Chemical and Biological Center (ECBC), in Aberdeen Maryland. ECBC has recently fabricated two all-hazards receipt facilities (AHRFs), which are very similar to the facility defined in this project's objective, and these were funded by the Department of Homeland Security (DHS). The AHRF is a mobile and modular platform designed to ensure safe in-processing and pre-screening, and accurate and decisive assessment of samples of unknown or dubious origin that may contain chemical, biological, radiological, highly-explosive residue, or toxic industrial materials. This design precludes contamination of the sample, the operator, the facility, and the environment, while meeting the needs of public health and the requirements of law enforcement by protecting the forensic evidence. This system encompasses the integration of primary and secondary containment (Biosafety Level [BSL]-2 and BSL-3, along with chemical filtration) with robust analytical methodology that provides a fail-safe system for unknown materials assessment.

The project team has also identified the equipment (specialized and generic) and type of analysis that will be conducted in the AHRFs and procurement is ongoing. In addition, a recent visit to the United Kingdom has initiated collaborative efforts to acquire protocols and information on the National Network of Laboratories (NNL) that has been established there. The NNL is much further defined and, in fact, five facilities are in place and operational to allow for effective sample screening and transition from the field to the downstream analytical laboratory. A similar capability is desired in Canada and this project will produce the prototype for this capability to be replicated. The entire project is envisioned to take approximately three years.

Impact

Currently, there are no facilities within Canada that will allow samples and other hazardous materials, regardless of their nature, to be received, triaged, documented, sampled, and stored in a standardized, forensically-sound fashion. In filling this gap, this project will provide Canada with a more efficient response by ensuring that samples are properly triaged and directed to the appropriate analytical facilities in a timely fashion, while ensuring the safety of the facilities and laboratory personnel. The establishment of validated, forensically-sound SOPs, the use of standardized equipment, and the provision of storage for contaminated material will all ensure that the integrity of any investigation is preserved.

BIO021AP

Creating National Centres for Secure Biological Resources for Canada

Project Lead:	Public Health Agency of Canada – National Microbiology Laboratory, Agriculture and Agri-Food Canada
Federal Partners:	Canadian Food Inspection Agency, DRDC Suffield, Environment Canada, Health Canada, Industry Canada, National Research Council, Natural Resources Canada
Industry Partner:	Sporometrics Incorporated
Other Partners:	Provincial public health laboratories and universities

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Objectives

The objectives for this technology acquisition project were three-fold. The first of which was to evaluate the requirements for the implementation of a national culture collection network for Canada, using decentralized European collections as models. The project team also conducted a survey of existing microbial culture collections in Canada and compared their results with previous surveys to determine whether various collections still exist, where they are located, and what type of infrastructure is in place. The final objective was to acquire or replace minor equipment to ensure immediate long-term preservation and security of potential biowarfare or bioterrorist (BW/BT) agents and important human, animal, and plant pathogens in the laboratories of the Biology Cluster.

Relevance

The 2001 anthrax attacks in the United States (US) caused an increase in security in all industrialized countries and effectively closed the door to exchanging cultures of microorganisms traditionally used for scientific research. Valued strains require secure facilities, platforms to facilitate long-term storage, and the information technology (IT) for strain tracking. This infrastructure is rare in Canada except for small collections, such as the anthrax collection at the Public

Health Agency of Canada's National Microbiology Laboratory (PHAC-NML) or several larger, but under-resourced collections (e.g., the University of Alberta's microfungus collection). To address this gap, the project partners studied the creation of the National Centres for Secure Biological Resources (NCSBR) to preserve valuable biological materials for future generations of Canadian scientists and ensure that national and international safety, security, and quality control standards are maintained.

Recent Progress and Results

The project team purchased equipment, such as liquid nitrogen tanks, ultra-low freezers, and lyophilizers, to address immediate and urgent needs. In early 2006, the team initiated a survey of existing Canadian culture collections. The survey, made available in paper and online form, was sent to curators of collections identified during a previous survey (mid-1990s), with adjustment made for the fact that the older survey had under-reported collections of medically relevant bacteria and viruses. The survey process was advertised on websites and at meetings of Canadian microbiological societies or professional organizations (e.g., Canadian Association for Clinical Microbiology and Infectious Diseases, Annual Public Health Agency of Canada Research Forum, Canadian and American Phytopathological Societies).

In November 2004, the project team held a national meeting to define initial expectations of a national network for microbial culture collections. Implementation of the complete feasibility study was delayed during 2005–06 and the remaining funds were rolled over for use in 2006–07. In late 2006, Sporometrics Incorporated was contracted to manage the feasibility study. Information was gathered at a February 2007 workshop, which was attended by 50 invited scientists and other professionals from a broad range of microbiological disciplines and regulatory organizations. International (Belgium, the Netherlands, and Australia) and Canadian curators and information specialists participated in the workshop. Key departments or groups that could not send representatives to the February workshop were briefed at a second meeting in March 2007 (particularly CRTI, Industry Canada, and Environment Canada). Links were established between the present initiative and other existing international biological resource organizations of which Canada is a member (Organization for Economic Cooperation and Development [OECD] and its Global Biological Resource Center Network [GBRCN]). Information gathered from all relevant sources, including the survey, was used to develop the final report, and to provide hard data for use in a Treasury Board or equivalent submission. The survey will continue to register collections with enhanced presence on the PHAC-NML website, as an in-kind contribution.

The report outlines the definition of, and recommendations for, essential investment for existing core collections, identified by the survey. These include established but under-resourced collections and endangered small collections. It details governance models for a decentralized NCSBR with proposed staffing of executive, managerial, administrative, and quality assurance/quality control (QA/QC) positions. A central office will link core collections into a network by IT and other means, and ensure effective interaction with relevant federal government departments and agencies, international partners, the World Federation of Culture Collections, and other related networks. (The business plan will include a small cost recovery component [maximum 15–20 percent revenues]). It also documents mechanisms for distributing resources for the network once the funding is allocated and strategic funds to rescue orphaned collections or those at risk of being orphaned by retirement of the collection manager or changed host institutional priorities.

Impact

In summary, the project team documented a national consensus for the NCSBR, proposed governing and funding structures for the network, and described up-front costs to address immediate infrastructure gaps. The initiative now needs to acquire resources to create infrastructure for the NCSBR, followed by establishment of a governance structure. CBRN response capabilities will be permanently enhanced on many levels by its creation. Canadian compliance with the OECD and GBRCN-related counterterrorism and other initiatives will then be assured.

International In-Situ Gamma Spectroscopy Mobile Laboratory Intercomparison

Project Lead: Department of National Defence – Director General Nuclear Safety

Federal Partners: Health Canada – Radiation Protection Bureau, Royal Military College

Other Partners: International Atomic Energy Agency, ARC Seibersdorf Research GmbH, Austrian NBC Defence School

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Objectives

The goal of this project was to assemble a multi-federal agency team, lead by Director General Nuclear Safety (DGNS) that would train together in radiological monitoring techniques and participate in an international intercomparison exercise using in-situ gamma spectrometry and dose-rate measurements equipment from a mobile facility in a simulated emergency situation. The objectives of this project are to improve the accuracy of radiological monitoring and enhance the skill-set of the responders, to strengthen inter-departmental working relationships, and to foster and complement international collaborations.

The scenario, which was organized by the Austrian Research Centre Nuclear Engineering Seibersdorf GmbH (NES) in cooperation with the International Atomic Energy Agency (IAEA), took place on April 16, 2007. Health Canada supplied the mobile nuclear laboratory (MNL) that was deployed to Austria and used during the field exercise component of the program.

Relevance

As part of its nuclear emergency preparedness mandate, Health Canada has strategically placed MNLs equipped with radiological monitoring devices across Canada. In case of a radiological or nuclear emergency, a MNL would be moved to the location of the emergency and teams from DGNS and DRDC Ottawa or Atomic Energy of Canada Limited (AECL) or both would travel to that location and operate the MNL. This exercise will provide an opportunity to test this concept of operation (CONOPS), whereby an MNL is shipped to the location of the exercise and the DGNS Technical Assistance Team (TAT) and its partners use it during the exercise.

Recent Progress and Results

The determination of soil contamination, dose-rate measurements, and in-situ gamma spectrometry are well established and widely used measurement procedures, especially after large-scale nuclear incidents. In recent years, the organization of international campaigns with active participation of measurement teams from various countries has improved the accuracy of in-situ gamma spectrometry and the exchange of experience in this field.

The TAT and its partners from Health Canada and the Royal Military College (RMC) have collaborated on numerous lab and field-based trainings resulting in a competent and cohesive team that was capable of executing the tasks laid out in the international exercise. The team has developed protocols for safe practices, field sampling, radiological monitoring instrumentation, and MNL functionality during the time leading up to the exercise.

The exercise focused on the cooperation of teams in in-situ gamma spectrometry and dose-rate measurements and their evaluation for emergency situations. As there were more than 50 teams representing 23 different countries, the exercise encompassed an intercomparison of best practices among participating countries. The multinational nature of the exercise allowed for collaboration with world leaders in gamma spectrometry and dose-rate measurements during emergency situations.

Results from the exercise will be presented and discussed at the Summer Symposium. The results will include a synopsis of the performance of the Canadian team and a summary of the performance of the other participants.

Impact

The DGNS, RMC, Health Canada team's participation in this exercise resulted in improved communication, response time, and overall skill-set of the team members. Lessons learned from participating in this exercise will be communicated to the Radiological/Nuclear (RN) Cluster, so that they can benefit other members of the Cluster. The resultant findings will have a direct impact on RN emergency planning processes and response procedures. To support decision makers and first responders with a more comprehensive and accurate overview immediately after a large-scale nuclear or radiological emergency, such as acts of terrorism or a satellite crash, accurate qualitative and quantitative measurement are crucial in determining appropriate emergency and remedial response. Thus, by focusing on the accuracy of gamma spectrometry and dose-rate field measurements, this exercise improved the performance of the DGNS, RMC, Health Canada team in emergency situations.