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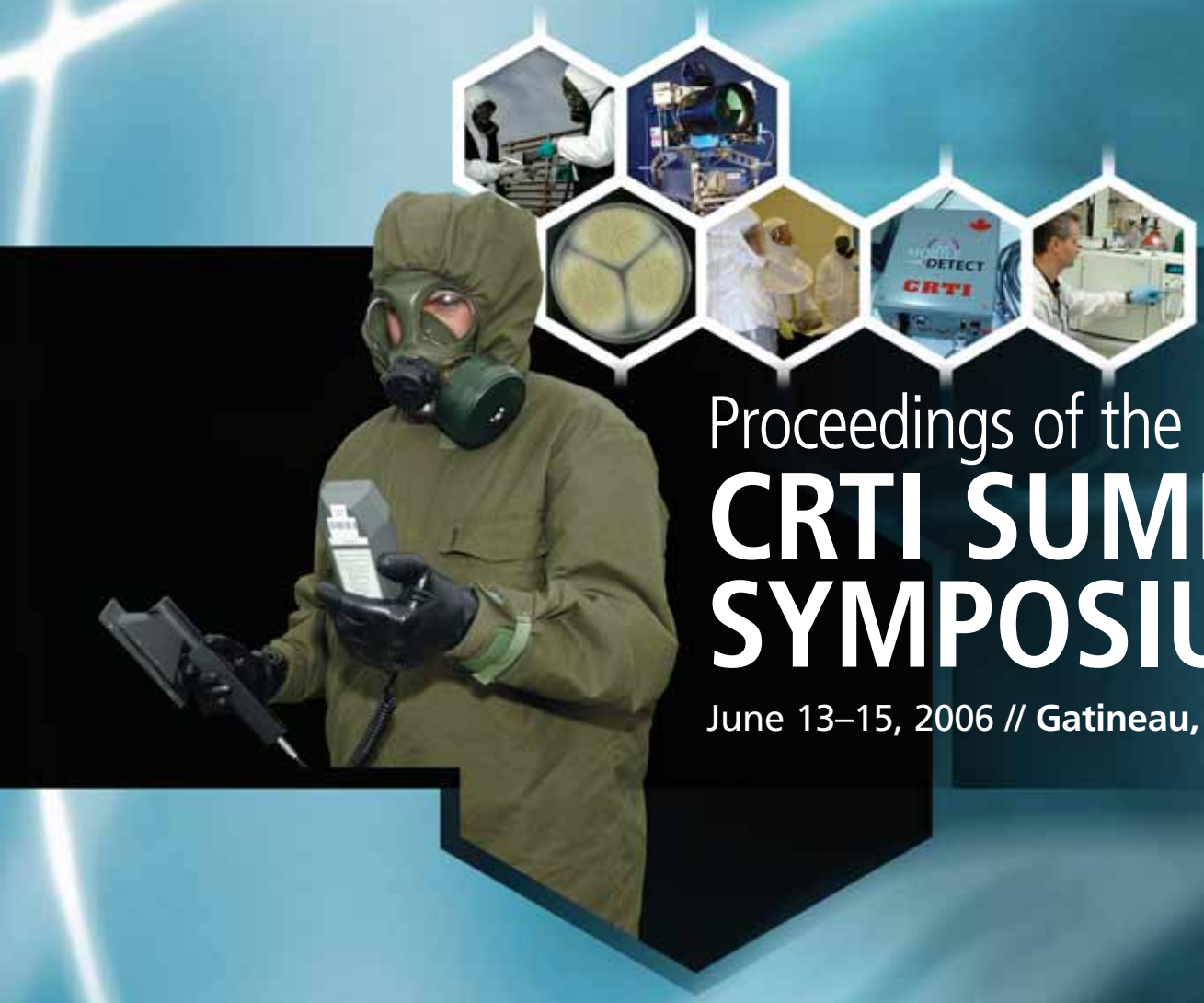

Proceedings of the 2006

CRTI SUMMER SYMPOSIUM

June 13–15, 2006 // **Gatineau, Quebec**

Canada

Foreword

The Chemical, Biological, Radiological, and Nuclear (CBRN) Research and Technology Initiative (CRTI) was launched in May 2002 as a result of the Government of Canada's Public Security and Anti-Terrorism budget in December 2001. CRTI is a unique, cross-organizational program mandated to strengthen Canada's preparedness for, prevention of, and response to a CBRN terrorist attack through investments in science and technology (S&T).

Since then, CRTI has funded 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 CBRN terrorism.

The 4th Annual CRTI Summer Symposium at the Château Cartier Resort in Gatineau, Quebec, provides an opportunity for the CRTI and broader CBRN 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 CBRN. This exchange of ideas should further contribute to building Canadian capability and capacity in CBRN S&T preparedness and response.

The following abstracts include CRTI projects selected in 2002–2005. Each project will be presented by oral or poster presentation. 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.

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ADM(PA)DMCS CS06-0121

CRTI 0006RD // Induction of Innate Immunity

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Public Health Agency of Canada – National Microbiology Laboratory

FEDERAL PARTNER:
Canadian Food Inspection Agency –
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Objectives

This project is dedicated to exploring novel approaches to protect humans and animals from the effects of exposure to highly virulent infectious agents, like the Ebola virus. More specifically, because experts anticipate that many of the infectious agents currently listed as a major threat of a bioterrorism attack would be dispersed through both airborne and waterborne pathways, the purpose of this project is to develop products and procedures that will provide immediate short-term protection to the airways and intestines against various organisms, while at the same time delivering vaccines that can provide long-term immunity.

Relevance

Previous studies on animal models with infectious diseases, allergies, and cancer have demonstrated the potential of CpG oligodeoxynucleotides (ODN) as therapeutic agents, and vaccine adjuvants and clinical trials are currently underway in humans. While CpG ODN are potent activators of the immune system, their biologic activity is often transient, subsequently limiting their therapeutic application. This project is aimed at determining whether CpG can be used to instantaneously activate the immune system of humans and animals to fight infections from dangerous pathogens before vaccination or treatment would be effective.

Recent Progress and Results

Mammal immune systems recognize synthetic ODN containing CpG sequences as a "danger" signal. As a consequence, CpG ODN stimulate innate and adaptive immune responses in humans and a variety of animal species. The project team identified and selected CpG ODN sequences, which stimulate immune cells of sheep in vitro. Based on these findings, they then evaluated the innate immune responses of the selected CpG ODN sequences following respiratory delivery into sheep and investigated whether CpG ODN would protect newborn lambs from respiratory challenge with parainfluenza-3 virus. The results indicated that CpG ODN can both stimulate an acute-phase immune response and induce the antiviral effector molecule, 2'5'-A synthetase. Also, CpG ODN-treated lambs displayed a transient reduction in viral shedding on day 2 post-infection ($p < 0.05$), which correlated ($p < 0.03$) with serum 2'5'-A synthetase levels on the day of viral challenge.

In a second experimental animal model, the research team exposed mice to Ebola virus, which is one of the most virulent infectious agents for humans and other primates. The team chose mice for the model because it allowed them to study larger numbers of animals, in contrast to experiments with non-human primates, and test various drugs and formulations. The team used a range of CpG concentrations against challenge doses of

Ebola virus between 10 and 1000LD_{50} in a checkerboard titration and administered single doses to the mice at a variety of times from six days before infection to 24 hours after infection. Their results indicate that the mice showed limited protection depending on the CpG dose/virus dose and time.

The team also developed an inhalation challenge mouse model, which proved to be lethal following inhalation exposure with Ebola virus.

The research team expects to conclude the first phase of this basic biomedical research project by the end of 2006.

Impact

This project demonstrates the potential usefulness of CpG ODN to prevent infection and disease against dangerous pathogens.

CRTI 0027RD // Biological Dosimetry and Markers of Nuclear and Radiological Exposures: Markers of Psychological Stress

PROJECT LEAD:
Health Canada

FEDERAL PARTNERS:
DRDC Ottawa, Atomic Energy of Canada Limited

INDUSTRY PARTNERS:
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Objectives

The purpose of this project is to investigate novel techniques that could assist medical personnel in identifying irradiated individuals. Peripheral blood lymphocytes provide the ideal biological material for monitoring radiation exposure because these cells are most vulnerable and easily attainable. Saliva proteins may provide additional biomarkers of radiation exposure. The effects that other stressors may have on these radiation responsive endpoints will also be investigated. The results of this study will be presented and the final report will be issued upon completion of the project in December 2006.

Relevance

When overexposure to ionizing radiation occurs, it is essential to rapidly identify exposed individuals for immediate medical attention and long-term health risk surveillance. Existing cytogenetic methods have limited sensitivity, available expertise, and expedience of use. The development of new rapid diagnostics would enhance the capacity to identify irradiated individuals.

Medical professionals need tools that could be used to rapidly identify irradiated individuals in a mass-casualty scenario. To initiate medical intervention, these tools must be biological or physiological indicators of exposure. Physical dosimetry can provide guidance, but medical treatment strategies can only be initiated upon the identification of symptoms indicative of radiation exposure. The radiation exposure biomarkers that this project will provide will be a significant investment in the areas of both risk assessment and biotechnology development toward radiological emergency preparedness.

Recent Progress and Results

In addition to participating in the development of the *National Biological Dosimetry Response Plan* (NBDRP), DRDC Ottawa has made significant progress in the development of research projects aimed at providing first receivers with critical medical information. The scope of work on radiation exposure biomarkers has been expanded to examine not only the effects of radiation, but also how psychological stress in combination with radiation may affect these radiation-responsive markers. This information is critical for determining the specificity of the selected biomarkers.

To study the biomarker profile changes induced by stress, non-irradiated volunteers donated blood both during a stressful event and four weeks after the event. There is previous evidence to suggest that $CD4^+$ and $CD8^+$ T-cells, as representative subpopulations of the hematopoietic system, are particularly sensitive to ionizing radiation and that the immune system, containing these same cells, is also sensitive to stress. The research team will present data from analytical cytometry studies using personal cell analysis (PCA) to screen donor blood samples during and four weeks after a stressful event, and will compare the $CD4^+$ and $CD8^+$ T-cells counts and ratios. Investigations using three-dimensional cultures to simulate a living system have revealed a unique radiation-responsive biomarker profile in one cell type, but did not produce any significant results when performed on human blood irradiated ex vivo.

The researchers have shown that a simple saliva test may offer a way to identify psychological stress associated with a traumatic event. Results indicate that individuals who perceived higher levels of stress during a distressing event generally had changes in a number of salivary biomarkers, including salivary alpha-amylase, cortisol, Immunoglobulin A (IgA), and three different cytokines. These findings may also provide a way to distinguish psychological stress from the physical stress induced by radiation exposure since some of these biomarkers are common to both types of stress, but may not respond in the same manner. These differences may lead to agent identification specificity and the development of a personal, field-deployable biomonitoring tool prototype.

Impact

The information gained from analyzing stress samples will help differentiate between individuals that have been exposed to radiation and those who are undergoing stress. Also, the researchers intend to examine the synergistic effects, if any, of radiation exposure and psychological stress on these identified biomarkers. The added benefit of using PCA systems is that they provide a portable test platform requiring only a small (10 µL) blood sample, thus making them ideal as triage tools. The current availability and worldwide use of the PCA system by life science and clinical testing institutions make it ideal for immediate deployment. Furthermore, the development of a deployable saliva biomonitoring tool will provide a non-invasive, easy-to-use assay for the operational community. The identification of radiation-responsive markers has been completed and the development and validation of a saliva test field kit is expected soon.

CRTI 0029RD // Protecting First Responders Against Chemical and Biological Threats

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Objectives

The purpose of this project is to provide guidance to first responders on the selection and use of personal protective equipment (PPE) for CBRN response, and to develop CBRN PPE standards for application in Canada.

Guidance on response techniques, capabilities, and selection of existing equipment will be released as it becomes available. A new set of requirements will also be developed for a national standard, which will be released in 2007. The research team will consult with international standards bodies and rationalize the proposed standards where appropriate.

Relevance

The outcomes of this project are already being used to equip and train first responders. Advice produced by the project is also being used directly in support of PPE selection, design, and standardization, both within Canada and abroad.

Recent Progress and Results

This project involves a variety of activities, including scenario development and modelling of releases, development of evaluation methods and models for protective performance of respirators and clothing, and investigations into the dermal toxicity of selected chemical warfare agents and toxic industrial chemicals. Consultations with the responder community on response activities and protocols are also conducted.

The first version of the guidance document, *Selection and Use of Personal Protective Equipment for the Canadian First Responder to a CBRN Terrorism Event*, has been released in English (<http://www.rmc.ca/academic/chem/research/crti/reports/cpt0505/Selection_and_use_of_PPE_for_Can_FR_to_CBRN_terr_event_Oct_2005.pdf>). The French version will also be available by June 2006. The document includes the following information:

- The anatomy of a CBRN event, with information on scenarios, establishing response zones, and judging the nature and magnitude of the event;

- Information on responders and their roles;
- PPE recommendations, such as using the decision tree, selecting PPE based on event type, identifying deficiencies, taking an all-hazards approach to protection, and other important considerations; and
- Explanatory information such as assumptions and limitations; more detailed scenario and modelling information; a discussion on response zones; acceptable exposure levels; chemicals, biologicals; and radiologicals of concern; and realistic performance assessments.

Team members have also been developing and testing methods for realistic performance assessments on a variety of types of equipment already in use by the response community, as well as those under development. Work is ongoing to standardize methods across the international community. Fundamental research in areas relating to the dermal toxicity of pesticides has just been completed, while research and modelling to assess adequate respiratory protective performance by air-purifying respirators for responders in the support and protective action zones is ongoing. The project will be completed in January 2007.

Impact

The operational community has contributed to the development of the guidance document and investigations into the performance of existing and prototype PPE. Initial guidance has now been transferred to the responder community and a workshop is planned for summer 2006 to discuss the implementation of the guidance and areas where further work is needed. The recommendations of the standards project team and the technical outcomes of the project will be used to inform the development of national standards and to assist in the standardization and development of improved PPE.

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 Canada – Atlantic Environmental Radioactivity Unit

INDUSTRY PARTNER:
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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 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 70-second period in a constant stream of 200 ml per minute of helium carrier. The CO_2 must then be released to the ion source at a constant rate of approximately 5 µl STP per minute. This requires temporary storage of the CO_2/He mixture. Gas chromatograph-type column traps similar to those used in the elemental analyzer were initially tested, but they interfered with the proper operation of the analyzer. An open-trap system (containing no trapping medium) that can hold the bulk of the CO_2 at peak output has been developed and tested.

This system provided the first steady beam of negative carbon ions from CO_2 generated by the elemental analyzer. Improvements to this system have been designed so that a more homogeneous mixture of CO_2 and He can be fed to the ion source, by adding He at the CO_2 peak using a mass flow controller. Timing for the loading of the trap from the elemental analyzer and for

the operation of the mass flow controller is critical, so a programmable logic controller system is being developed. The system will also handle communications between the elemental analyzer, the ion source, and the AMS system master control software. Work is now underway to develop the hardware and software for this system.

With the successful operation of the transfer line, tests of the overall system operation, in manual mode, have begun. The first radiocarbon measurement using all components of the system was conducted in January 2006. These tests will be followed with an assessment of system C-14 memory (the rate at which the C-14 from one sample is removed from the system so that a subsequent sample can be accurately analyzed).

Health Canada and Fisheries and Oceans Canada personnel will identify and then collect the appropriate samples to characterize the RN event from a number of areas in Canada (e.g., near operating nuclear power plants). When the control software is ready, they will run tests on these samples, as well as on well-characterized samples for procedure validation. This project is expected to be completed in December 2006.

Impact

With the information gained from the above tests, procedure manuals will be written and simplified sampling protocols will be provided to first responders and others involved in sample collection for both event monitoring and area remediation. Seminars on this technique and, in particular, on the sample collection requirements will be provided to all personnel involved. The existence of this equipment and the knowledge of its use will provide Canada with the capability to respond expeditiously to events in which this radionuclide is dispersed in the environment, thus minimizing its impact.

CRTI 0064RD // New Technologies for Surveillance of Biowarfare Agents and Identification of Engineered Virulence Genes

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University of British Columbia

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Objectives

The purpose of this project is to adapt the researchers' Bacterial Comparative Genomic Hybridization (BCGH) technology, which couples the resolving power of two-dimensional (2-D) DNA electrophoresis with comparative genomic hybridization to rapidly identify engineered genes in modified biowarfare organisms. The process to identify an unknown virulence gene using BCGH involves comparing engineered biowarfare strains harbouring novel genes against a related lab reference strain. The researchers will then combine DNA fragments from the two strains, display them in two dimensions, blot them onto a membrane, and sequentially probe (hybridize) them with DNA from each individual strain. The engineered gene is identified as a novel spot or spots that can be excised from a parallel gel, cloned, and sequenced to reveal its identity.

Researchers from DRDC Suffield and the Public Health Agency of Canada's National Microbiology Laboratory (NML) are responsible for culturing restricted pathogens and Biological Safety Level 3 organisms. The DNA for these cultures will then be provided to the University of British Columbia (UBC).

The research team will use the adapted technology to profile *Bacillus anthracis*, *Yersinia pestis*, *Francisella tularensis*, *Burkholderia pseudomallei*, and the food-borne pathogens *Escherichia coli* O157, *Salmonella typhi*, *Shigella flexneri*, and *Yersinia enterocolitica*. This information can then be used to tailor therapy and develop surveillance strategies.

Relevance

The technology to genetically modify organisms such as *B. anthracis* and *Y. pestis* has existed for over a decade, making engineered biowarfare strains with increased or novel virulence properties a distinct threat. The rapid identification of engineered genes using BCGH will facilitate diagnosis, surveillance, vaccination, and therapeutic measures that can be targeted at the virulence gene or gene product to control disease outbreaks.

Recent Progress and Results

The researchers have determined the display parameters (e.g., fragmentation conditions, gel composition, temperature, time) for *B. anthracis, Y. pestis, F. tularensis, B. pseudomallei, E. coli* O157, *S. typhi, S. flexneri,* and *Y. enterocolitica*. They have successfully generated 2-D DNA displays for *F. tularensis* T65 (using restriction enzymes *AseI, DdeI, HindIII, HinfI, RsaI,* and *Sau*3A) and *Burkholderia pseudomallei* 230 (using restriction enzymes *AccI, ApoI, BanI, BsrI, DdeI, HincII, RsaI,* and *XhoI*). These displays are in addition to those already developed for *S. typhi, S. flexneri, E. coli* O157, *B. anthracis, Y. pestis,* and *Y. enterocolitica*.

The team continues to assess the sensitivity, quality assurance, and quality control of BCGH using a panel of spiked genes representing a spectrum of sequence composition. To validate the technology, they used BCGH to compare isolates of *Salmonella enterica* serovar Typhimurium, *S. flexneri*, and clinical isolates of *E. coli* O157, adding to previous and ongoing comparisons of pairs of *Y. pestis* and *B. anthracis* strains.

The researchers have also established an archive of displays at the NML and have submitted an abstract on the BCGH results that will be presented at the American Society for Microbiology's annual international Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC) in September 2006.

The researchers expect to complete the project in December 2006.

Impact

The final outputs of this project will include 2-D display analysis of all of the selected organisms and standardized protocol at NML and DRDC Suffield, including streamlining of protocols for routine use in diagnostic and forensic laboratories. The adapted BCGH technology will give the NML and DRDC Suffield the capability to rapidly identify virulence genes introduced in engineered biowarfare strains and mitigate the potential short- and longer-term consequences of a disease outbreak.

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 activities while minimizing the risk to all involved.

The aim of this project is to create an electronic dosimeter based on optically stimulated luminescence (OSL) suitable for such long-term monitoring applications. The project follows two separate but related tracks: Bubble Technology Industries (BTI) will design the dosimeter and associated electronics, and the University of Toronto (U of T) Electronic-Photonic Materials Group (EPMG) will conduct the research to adapt it to a chip-level design. The project will yield a field-ready prototype minidosimeter, using 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. This 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 significant accomplishment in this project was the production of a prototype minidosimeter based on the use of a tiny PMT rather than on the commercial Geiger-mode APD. The tiny PMT option offers a number of advantages, including low noise, lower power requirements, and lower cost, with higher efficiency because of its better-matched spectral response and a much larger sensitive area. A new design for the electronics board was implemented to make the minidosimeter design compatible with the mini-PMT, as well as the commercial APD and the custom APD being developed by the U of T partners. This minidosimeter formed the basis for a new CRTI Technology Acceleration (TA) project to develop a long dwell detection in transit (LDDT) dosimeter for cargo container monitoring (CRTI 05-0006TA). These dosimeters will be tested in cargo screening trials in the summer of 2006.

The U of T effort has been focused on the production and optimization of a custom avalanche photodiode. 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 to optimize the OSL-based dosimeter. A unique multilayer APD design, coupled with this precise control over the doping levels in the APD structure, led to this tunable APD. The custom APD also 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.

This project was originally slated to end in March 2006, but was extended until December to test the prototype minidosimeters during cargo screening trials later in 2006.

Impact

The major deliverables for the project are two suites of minidosimeters, one for the cargo trials and one for testing at the Health Canada environmental monitoring stations. A tested design for a custom avalanche photodiode will allow the minidosimeter to be evolved into a chip-level design, enabling miniaturization and mass production. Minidosimeter prototypes are already being evolved into detectors for cargo screening applications, and a chip-level dosimeter would have great application in personnel monitoring.

CRTI 0087RD // Therapeutic Antibodies to Ebola and Marburg Viruses

PROJECT LEAD:
Public Health Agency of Canada – National Microbiology Laboratory

FEDERAL PARTNER:
Canadian Food Inspection Agency – National Centre for Foreign Animal Disease

INDUSTRY PARTNER:
Cangene Corporation

OTHER PARTNER:
University of Alberta

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Objectives

The objective of this project was to develop a panel of monoclonal antibodies (mAbs) to the Ebola and Marburg viruses, which could be used as a post-exposure prophylaxis to prevent serious illness in those exposed to the viruses. A panel of antibodies recognizing different epitopes is necessary because these viruses have single-stranded ribonucleic acid (RNA) genomes, which allows them to mutate very rapidly and evade neutralization by single mAbs. As a short-term solution, the research team will use goats to make a polyclonal antiserum against both the Ebola and Marburg viruses.

Relevance

The Ebola and Marburg viruses, which are listed as Category A Biological Agents by the Centers for Disease Control and Prevention(CDC) in the United States, cause an acute hemorrhagic fever in humans with mortalities ranging from 23 to 90 percent. With neither therapeutic nor prophylactic treatments available for these filoviruses, they present a great risk to both military and civilian populations. Many experts in the field believe that therapeutic antibodies are the most promising strategy for the short-term treatment of people exposed to these viruses.

Recent Progress and Results

The research team used multiple techniques to develop antibodies, including naïve human phage display, immune non-human primate and mouse phage display, and traditional mouse hybridoma technology using novel antigens. They found that the naïve human phage display library was not effective for developing antibodies to Ebola. When they used the immune non-human primate phage display, they identified an antibody that recognized one of the glycoprotein forms of Ebola virus. Researchers at the University of Alberta successfully generated more than 50 reactive monoclonals using mouse hybridoma technology and Ebola virus-like particles (VLPs generated at the National Microbiology Laboratory [NML]). NML project participants used live, attenuated viruses and hybridoma technology to develop monoclonals and generated 9 mAbs to Ebola virus and more than 30 mAbs to Marburg virus. When the team tested the NML mAbs in vitro and in vivo, they found that the mAbs were capable of neutralizing Ebola infection and protected mice when given within 24 hours of infection.

Impact

The antibodies identified during this project will need to be further developed before a viable product is available for use in humans. The antibodies that have not been shown to have a protective effect in animal models will be screened for use as diagnostic and detection reagents.

CRTI 0091RD // The Development of Recombinant Monoclonal Antibodies for the Treatment and Detection of Bioterrorism Agents: Development of Neutralizing Monoclonal Antibodies to Anthrax Toxins

PROJECT LEAD:
Public Health Agency of Canada – National Microbiology Laboratory

FEDERAL PARTNER:
DRDC Suffield

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Objective

The purpose of this project is to develop recombinant monoclonal antibodies (mAbs) that can neutralize lethal *Bacillus anthracis* toxins.

Relevance

B. anthracis is a potential biowarfare agent. Recombinant mAbs could play a key role in the development of anthrax diagnostic tests and therapeutic strategies, such as vaccines, for first responders, first receivers, the operational community, and the public.

Recent Progress and Results

The team produced panels of high-affinity mAbs to recombinant protective antigen (rPA) and characterized the immunochemical and immunobiological properties. They determined the precise molecular region to which the antibodies bind (epitope specificity) for three potent neutralizing mAbs using overlapping synthetic pin-peptides spanning the complete amino acid sequence of the PA toxin. These mAbs recognize a novel linear epitope within domain 2 of rPA, corresponding to the inner region of the heptameric PA pore.

The researchers produced in vitro assays, which demonstrated that these mAbs effectively neutralize lethal toxin action against J774 and RAW macrophage cell lines. The team's in vivo studies illustrated that mAb F20G7-7 can passively protect animals from lethal intoxication. The successful development of these protective anti-anthrax toxin mAbs—the first developed in Canada—clearly demonstrates that this approach should be extended to other bioterrorist threats.

Impact

The development of recombinant mAbs against anthrax toxins has increased capacity in public health, veterinary, and defence laboratories across Canada, and led to the formation of the Canadian Monoclonal Antibody Resource Network (CANMab).

CRTI 0105TA // Mobile Real-Time Radiological Surveillance System

PROJECT LEAD:
McFadden Technologies Ltd.

FEDERAL PARTNERS:
Health Canada – Radiation Protection Bureau, Royal Canadian Mounted Police, Natural Resources Canada

INDUSTRY PARTNERS:
Mobile Detect Inc., Pixon LLC.

OTHER PARTNER:
Department of National Defence – Shirley's Bay

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Objectives

The purpose of this project was to develop a fully integrated radiological surveillance system that could provide sensitive, real-time detection of gamma radiation in Royal Canadian Mounted Police (RCMP) vehicles or other vehicles on routine patrol. The system's telecommunications system transmits data to a central server and database, and is capable of transforming large volumes of radiological data into meaningful graphic information. These data can be tailored to make them accessible to emergency management and response centres and lead field operations. The surveillance system characterizes the normal radiological environment of the area under 24-hour, seven-days-a-week (24/7) surveillance and uses novel data analysis algorithms to identify signatures of anomalous radiation sources with low false-negative and false-positive rates. The system supports person-carried and static sensors.

Health Canada's Radiation Protection Bureau acted as the technical authority to the project and was responsible for developing liaisons with the RCMP, Natural Resources Canada (NRCan), and the Department of National Defence (DND).

Relevance

The project has resulted in a practical radiological security system that is available to the first responder, first receiver, and operational communities. It provides the earliest possible detection and assessment of illicit radiation sources and practical incident management assets for first responder and community safety. The system information contributes significantly to a national or international common operating picture.

Recent Progress and Results

Mobile Detect Inc. developed a production-ready, mobile, real-time radiological surveillance system for field use in community and asset protection, and by first responders and emergency management. The system, which is in use in RCMP vehicles, has collected over seven million radiation measurements in Ottawa's National Capital Region (NCR).

The system has a graphical user interface with user options relevant to incident management and can be used to view real-time or historical radiation data overlaid on mapping or aerial images. The user 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 characterize the normal radiological environment in the area under surveillance. It generates alerts by comparing real-time radiation data with pre-defined alert criteria. System users define the alert criteria to achieve the optimal balance between the cost of false positives and the required system sensitivity. Users can adjust alert criteria to respond to a variety of radiological terror threat levels. Telecommunication between the remote sensors and the central server can be made via wide-area wireless networks, satellite, local-area wireless networks, or Ethernet.

Deployed radiation sensors are two-litre plastic scintillation detectors with automatic targeted spectroscopy (ATS) that are controlled by a mobile detection unit with an onboard computer that includes a global positioning system (GPS), telecommunications,

and power management. ATS exploits the available energy resolution to discriminate among expected terror agents and legitimate radiation sources.

Users can select the size of the sensors from a wide range of options with trade-offs in sensitivity, weight, volume, and ruggedness for applications in mobile, static, and covert operations. The system provides intelligent management and support of other radiation detectors (e.g., neutron, third party), as well as other chemical and biological sensors and will integrate their data with system radiation data.

Impact

The system provides autonomous, 24/7, cost-effective, and practical radiological surveillance and radiological threat agent identification, which significantly enhances radiological security and safety for communities, critical infrastructures, responders, and receivers. The availability of this counterterrorism tool will catalyze the development of a new concept of operations and standard operating procedures among cooperating incident response and management agencies.

The RCMP and Health Canada continue to use the surveillance system in the NCR. The system was used as the technological basis for the Ottawa International Airport Radiological Security System developed under a separately funded CRTI project (CRTI 03-0018TD), which is currently in operation. The technology is also being used in the intelligent traffic system of the city of Colorado Springs, Colorado.

CRTI 0120RD // Development of 2-D Molecular Imprinting Techniques

PROJECT LEAD:
National Research Council

FEDERAL PARTNER:
DRDC Suffield

OTHER PARTNER:
Memorial University of Newfoundland

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Objectives

The goal of this project is to develop molecularly imprinted arrays of chemically and spatially resolved functional groups onto well-defined substrate surfaces that can be used in chemical sensor applications and will be fully compatible with many existing high-sensitivity, multi-channel detection technologies.

Relevance

One of the many applications of this technology is to enhance the capabilities of first responders or military personnel to ascertain or rule out the presence of harmful chemical agents on- or off-site. Coupled with sensors for real-time chemical detection and identification, this technology has the potential to rapidly detect live agents.

In addition to its applications in the area of molecular recognition and rapid chemical detection, the technology also has potential applications in separation science and in the chemical, pharmaceutical, and biotechnological industries.

Recent Progress and Results

The research team carried out computational work on simulations for different molecular systems to estimate the interaction of binding energies, binding distance, and the active site groups between simulated molecular systems and different chemical agents. This also allowed the research team to determine which monomers and polymers would be the best candidates for the imprinting technology. Based on these modelling studies, the team proposed and successfully synthesized several series of multi-functional polymers and monomers for two-dimensional (2-D) molecular imprinting applications.

Among the approaches tested, the team found that a 2-D molecular imprinting technique using a monomer-polymerization approach was the most selective and reproducible. The process involved derivatizing the surface of a stamp with the molecular target of interest (theophylline), and then dipping it in a solution containing complementary monomers to form hydrogen-bonded molecular clusters around each target molecule via self-assembly. The stamp was then brought into contact with a surface containing a vinyl silane monomer, a crosslinking agent, and an initiator to perform a surface polymerization reaction and the transfer of the nanotemplated recognition cavities. After removing the stamp, a 2-D molecularly imprinted polymer (MIP) was formed on the substrate. The synthetic recognition cavities formed on the substrate were then used to rebind the target molecules and the resulting transferred 2-D MIPs were characterized by fluorescence microscopy, atomic force microscopy, x-ray photoelectron spectroscopy, and attenuated total reflectance Fourier-transform infrared spectroscopy (ATR-FTIR). The results clearly indicated that polymer lines are formed on the surface, are stable, and contain the recognition sites to rebind theophylline.

The most significant recent achievement was demonstrating the selective rebinding of theophylline by the MIP when compared to the binding of the chemically similar caffeine molecule. The team tested the selectivity through competitive rebinding experiments, using mixed theophylline/caffeine solutions of different ratios (theophylline/caffeine: 50/50; 30/70; 20/80). Then they measured the resulting samples using ATR-FTIR spectroscopy to determine the relative amount of theophylline and caffeine molecules that rebound to the MIP samples. Analysis of the infrared spectra proved that, although theophylline and caffeine signals were both present in the spectra, the intensity of the theophylline signal was much higher than that of caffeine.

To further demonstrate the selectivity of the MIP prepared using the monomer approach, the team used fluorophore-tagged theophylline (DapTh) in a series of fluorescence microscopy experiments. They prepared samples with MIP lines bearing the recognition cavities for theophylline and conducted rebinding experiments in theophylline (A-series) and caffeine (B-series) solutions. The samples were then immersed in the DapTh solution. It was anticipated that if the theophylline was absorbed initially, it would occupy the recognition sites and block the binding of DapTh, giving a low-fluorescence intensity. It was also anticipated that if the caffeine binding to the MIP was weak, the signal from the DapTh would be more intense as the DapTh would compete more effectively or find more vacant sites. The results showed that the A-series samples had much lower fluorescence contrast than the B-series samples in fluorescence microscopy after rebinding in the DapTh solution, proving that the MIP samples exhibit a higher affinity for theophylline than for the chemically similar caffeine molecule. The profile lines obtained from these samples give a quantitative measure of the selectivity.

Impact

This is the first successful example of combining soft lithography with molecular imprinting technology to generate high-resolution arrays of specific molecular recognition cavities on well-defined substrate surfaces. The knowledge generated in the form of publications and patents will allow the National Research Council and others to exploit the use of MIP technology in antiterrorism detection devices, separation sciences, and chemical, pharmaceutical, and biotechnological applications.

CRTI 0131TA // HI-6 Nerve Agent Antidote System

PROJECT LEAD:
DRDC Ottawa

FEDERAL PARTNERS:
Public Health Agency of Canada – Centre for Emergency Preparedness and Response, Public Safety and Emergency Preparedness Canada

INDUSTRY PARTNER:
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OTHER PARTNER:
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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 undertake preliminary formulation. Project partners will then conduct efficacy and toxicity pre-clinical studies for HI-6, atropine, and avizafone when jointly administered, and will complete a Phase 1 clinical trial.

Relevance

Since the early 1990s, defence personnel from several nations, including Canada, have relied upon an auto-injector containing the nerve-agent antidote oxime HI-6 to immediately treat chemical agent exposure. HI-6 was chosen primarily because it provides superior effectiveness against a broad range of nerve agents. However, deficiencies with the current system include the lack of a commercial supply source for Good Manufacturing Practice (GMP)-grade HI-6, a cumbersome system of multiple auto-injectors, and an incomplete data package to support a regulatory submission.

Through the NAA project, two of the three drug substances in the current protocol will be replaced; HI-6 dichloride (2Cl) will be replaced with HI-6 dimethanesulfonate (DMS) and diazepam will be replaced with avizafone. The substitution of HI-6 2Cl with HI-6 DMS is beneficial because HI-6 DMS has superior solubility characteristics. The use of avizafone in place of diazepam will allow one auto-injector to be used instead of the two that are presently required, with diazepam administered by separate auto-injector.

Changes to the auto-injector will also simplify its use and enable it to be easily activated while wearing protective clothing. The NAA project partners will address the critical supply situation pertaining to HI-6 by identifying at least one pharmaceutical source of supply for HI-6. Pre-clinical efficacy and toxicology data will be obtained that will enable a Phase 1 clinical trial to be conducted, thereby demonstrating the safety of the new NAA system. The completion of this data package will enable the first responder and operational communities to carry an auto-injector that contains the most superior oxime available for a broad range of nerve agents and includes the anti-convulsant within the auto-injector.

Recent Progress and Results

The project team completed a baseline project document that identifies and supports all tasks and deliverables of the original international project, as identified by the six nations who initially expressed interest in it. It includes a Gantt chart with planned start and finish dates.

Since the inception of the project, a trilateral Memorandum of Understanding (MOU) has been established between Canada, the United Kingdom (UK), and the Netherlands. The overall project lead has been passed to the UK, with Canada retaining responsibility for the delivery of HI-6 DMS. Project partners anticipate a follow-up MOU with additional partners.

The Canadian team has completed investigations to identify a new non-bis (chloromethyl) ether (BCME) route for HI-6 synthesis. Although successful on a small scale, the multiple routes investigated were not deemed to be scalable to the required quantities. The team has identified a method to convert HI-6 2Cl to the required HI-6 DMS salt on a small scale and does not anticipate

any problems with the conversion at large-scale volumes. In the absence of a suitable, industrially viable non-BCME process, the team modified the previously identified process for HI-6 2Cl and has successfully transferred the process to three companies as part of a down-selection process to identify a supplier suitable for scale-up and production batches. The team also recently purchased a small GMP-grade batch of the product for use in initial pre-clinical and possible clinical testing.

Due to a lack of information on the production development of avizafone, the project partners initiated proof-of-concept investigations into the production of the drug substance. They completed the first stage of the proof of concept with the production of a small quantity of avizafone and follow-up work is progressing. The new process has the potential to provide avizafone at a markedly reduced cost over the current method. The UK partner has also identified a source of supply for avizafone.

The project team held an auto-injector workshop with the MOU participants to identify all requirements and specifications of the three-in-one auto-injector. Representatives from three auto-injector manufacturers also made a presentation to the project team on what is currently available on the market. The team has prepared a specifications document that will be provided to interested auto-injector manufacturers to develop prototypes capable of delivering the three drug substances.

The project team presented the project plan to the Medicines and Health Care Products Regulatory Agency (MHRA) in the UK and obtained support for using the BCME process to manufacture HI-6 2Cl with subsequent conversion to the HI-6 DMS form.

The project team has identified DRDC Suffield as a cost-effective location for completing some of the pre-clinical studies. DRDC Suffield's laboratories, however, are not currently certified to Good Laboratory Practice (GLP) specifications, which is required for the completion of studies to contribute to licensing. In partnership with DRDC Suffield, the project partners have begun the work that is required to make the laboratories GLP-compliant.

Impact

The completion of the efficacy, toxicology, and Phase 1 clinical trial of the new NAA system should provide the necessary documentation for first responders and the operational community to seek approval for its use through Health Canada's Special Access Program, potentially as early as 2009. This approval will enable these communities to purchase an auto-injector that contains the best oxime available for a broad range of nerve agents and removes the need for two separate auto-injectors.

Having a facility such as DRDC Suffield certified to GLP specifications will benefit other government departments for future medical countermeasure studies.

CRTI 0133RD // New Technologies for the Rapid Assessment of Radioactive Contamination

PROJECT LEAD:
Health Canada – Radiation Protection Bureau

FEDERAL PARTNER:
National Research Council

INDUSTRY PARTNER:
MDS Sciex Inc.

OTHER PARTNER:
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Objectives

The purpose of this project was to develop automated online techniques, based on inductively coupled plasma mass spectrometry (ICP-MS) measurement after either chromatographic or thermal separation, to rapidly and sensitively determine significant radionuclides (Americium [Am], Strontium [Sr], Plutonium [Pu], Uranium [Ur] isotopes) that can pose a serious health threat after a radiological or nuclear (RN) terrorist attack.

Relevance

In an RN terrorist attack, the nature and quantities of radionuclides involved must be measured rapidly to assess the impacts and to minimize adverse health, economic, and environmental effects. Conventional methods (e.g., alpha-spectroscopy for actinides) cannot meet emergency response needs because they require a significant amount of time (days) for sample preparation and measuring. The rapid analytical techniques developed in this project will lead to better incident surveillance and monitoring, incident assessment, immediate consequence management, and criminal investigation.

Recent Progress and Results

The focus of the work in the last year builds on the team's previous achievements in the on-line application of gas phase chemistry to separate actinides prior to measurement by ICP-MS and flow – injection-based chromatographic separation methods. The team assessed radionuclides using ICP-MS with high performance liquid chromatography (HPLC) and electrothermal vaporization (ETV). The first approach, coupling HPLC to an ICP-MS, was developed and tested on

air particulate and urine samples. The technique produced low detection limits, fast sample turnaround (e.g., 80 samples per 24 hours for air particulate samples), multi-element capability (Pu, U, Am, Thorium), and good reproducibility. More importantly, the approach is independent of the type of ICP-MS, which was a significant limitation of the gas phase chemistry methodology. The HPLC-ICP-MS technique also improved the detection limits for actinides in urine by a factor of approximately four compared to flow – injection-based chromatographic separation methods. The researchers will submit a paper on the methods for actinides in air particulates to *The Journal of Analytical Chemistry* in the near future. The team also launched a method intercomparison to validate the method for urine samples by comparing performance characteristics for this method with those being used in other laboratories.

For the second approach, the team coupled ETV to an ICP-MS equipped with a reaction cell to measure Sr-90 in environmental samples. This methodology effectively removed isobaric interferences (such as Zirconium-90) and achieved a detection limit of 0.04 parts per thousand (ppt) with a precision better than 10 percent at a concentration of 4 ppt.

The research team also continued work on automating the system for actinide protocols. The system, which is now almost fully automated with the exception of the sample loading step, increases sample turnaround, improves measurement precision, and reduces human error.

Impact

The methods developed in this project will enhance Canada's capability to respond to RN threats by providing rapid and sensitive measurement solutions to field samples collected following an attack. These methods will be converted to standard protocols and transferred to federal and provincial laboratories through a National Nuclear Emergency Laboratory Network and Interoperability Technology Demonstration (TD) project (CRTI 05-0108 TD).

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:
GenOhm Sciences Inc. (formerly Infectio Diagnostic Inc.)

OTHER PARTNER:
Université Laval – Infectious Diseases Research Center

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Objectives

The purpose of this project is to collaborate on the design, development, and testing of rapid (less than one hour), fluorescence-based polymerase chain reaction (PCR) assays for the specific, ubiquitous, and sensitive detection and identification of *Yersinia pestis* and *Francisella tularensis*. Assays for these agents will be developed on the Smart Cycler™ platform by targeting unique DNA sequences in conserved chromosomal genes and pathogen-associated virulence genes. The assays will include a rapid sample processing procedure to prepare samples, internal controls to monitor PCR efficiency, and dried reagent formulations.

Relevance

The ability to identify *Y. pestis* and *F. tularensis* within an hour, rather than days or weeks, should improve immediate response and near-term consequence management capabilities of the operational community in the event of a bioterrorist attack. Rapid identification of biothreat agents should help crisis management authorities to make informed decisions regarding the hazard, which will help to ensure public confidence and reduce fear and panic during a crisis. Freeze-dried formulations should increase the shelf-life of the reagents, improve reproducibility, and reduce space and storage requirements.

Recent Progress and Results

Previous DNA-based assays developed in this project used standard PCR protocols coupled with agarose gel electrophoresis. Each gene target was amplified (amplicon) in a multiplex format (multiple gene targets per reaction) and distinguished by its size using gel electrophoresis and ethidium bromide. For the *Y. pestis* assay, the target genes are located on different genetic elements (i.e., plasmidic and chromosomal genes), while target genes for the *F. tularensis* assay are essential elements associated with either housekeeping functions or virulence. The gel-based assays were subsequently adapted to fluorescence-based amplicon detection using either SYBR Green I dye, where each amplicon is distinguished by analyzing the melting curves generated by the Smart Cycler™ instrument, or TaqMan-Minor Groove Binder (MGB) probe technology, where amplicon detection is performed in real time, thereby reducing analysis time significantly. Probe assays were proven to have similar detection sensitivities to the other formats with detection limits that range from 2 to 10 genome copies per PCR reaction for *F. tularensis* assays and 5 to 25 genome copies for *Y. pestis* assays. Internal controls were designed and tested for the probe assay format to verify the efficiency of each PCR reaction.

The research team also investigated rapid sample preparation methods of genetic material with various types of clinical and environmental specimens (i.e., blood, nasal swabs, and powders). Furthermore, GenOhm Sciences Inc. began developing and manufacturing dried reagents and assay protocols for live agent testing, based on their specification and qualification assessment of critical assay components. Live agent testing has started in the federal laboratories using PCR assays in wet-reagent format.

Over the next year, the project's partners will evaluate assays for both organisms in the federal laboratories in dry-reagent format using spiked clinical and environmental samples. The project is scheduled to be completed by 31 December 2006.

Impact

The final outcomes of the project will include rapid DNA-based diagnostic assays for *Y. pestis* and *F. tularensis* validated to industrial standards, with which two federal sites will have the capability to detect and identify the two bacterial biothreat agents in various clinical and environmental sample types. The project will also yield species-specific and strain-specific sequence data for future molecular research of these organisms.

CRTI 0196RD // Development of Rapid Field Tests and Training Programs for Veterinary First Responders to Address Agroterrorism with Animal Pathogens

PROJECT LEAD:
Canadian Food Inspection Agency

FEDERAL PARTNERS:
Public Health Agency of Canada, National Research Council

OTHER PARTNERS:
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Objectives

The main goal of this project was to develop rapid, highly sensitive diagnostic tests for use during emergency response to outbreaks of high-threat animal viruses, such as foot-and-mouth disease (FMD), hog cholera, avian influenza, and Nipah virus. The second objective was to identify and train veterinary first responders in the use of rapid tests developed under the project.

Relevance

Canada is currently free of FMD, hog cholera, avian influenza, and Nipah virus; however, the potential exists for them to be introduced intentionally or otherwise and be transmitted to livestock, wildlife, and in the case of the latter two viruses, humans. All of these diseases could severely affect trade and adversely affect animal or human health, and the environment. This project increases Canada's capability and capacity to detect signs of high-threat animal disease early and accurately in animals, to differentiate quickly between diseases that have similar signs, and to manage longer-term consequences through containment and eradication. It also harmonized linkages with laboratory networks in the United States.

Recent Progress and Results

Teams from five Canadian Food Inspection Agency (CFIA) laboratories continued to develop and evaluate platform technologies, including real-time reverse transcriptase polymerase chain reaction (RRT-PCR), DNA and protein microarrays, and several rapid antigen – antibody detection systems (RAADS).

The RAADS included a fluorescence polarization assay (FPA), an enzyme-linked immunoassay (ELISA), a lateral flow immunoassay, and colloidal gold immunoblotting.

The RAADS team developed and tested lateral flow assays for avian influenza, hog cholera, and FMD virus antigens, as well as an indirect enzyme-linked immunoassay ELISA, using specific peptides derived from non-structural antigen of FMD virus for antibody measurement. The team also developed the first multiplex immunoassay using the Liquichip® (Luminex) system that will measure several specific antibodies to non-structural proteins of FMD in cattle simultaneously and from a single serum sample. This immunoassay may be used as an alternative to current confirmatory tests for differentiating infection from vaccination after a positive or suspicious ELISA result. Two papers on the RAADS team's results have been published and they have submitted another manuscript for publication.

The Nipah virus team developed monoclonal antibodies (mAbs) and recombinant antigen for the virus and produced a prototype test. The results of their work on the development of the mAbs and the novel findings of Nipah virus pathogenesis observed during initial animal infection studies have been published.

The real-time polymerase chain reaction (RT-PCR) team made substantial progress in developing, validating, and transferring assays for FMD, hog cholera, and avian influenza. They targeted specific regions of FMD, hog cholera, and avian influenza genes for the development of oligonucleotide primers and hydrolysis probes. They determined estimates of diagnostic sensitivity and specificity (direct and relative) using serial specimens collected from experimentally infected animals. For the hog cholera assay, the team conducted beta-site testing and validation work on the virus collections at the Foreign Animal Disease Laboratory on Plum Island, New York, and the European Reference Laboratory for Health Canada in Hanover, Germany. To improve the avian influenza RT-PCR assay, the team continued to collaborate with the United States Department of Agriculture (USDA)'s Southeast Poultry Research Laboratory, in Athens, Gerogia. The team also established Canada's capability to detect Nipah and related viruses and antibody in infected or vaccinated animals at the CFIA laboratory in Winnipeg. Assays for virus detection include RRT-PCR and immunofluorescence.

The DNA and protein microarray team produced several significant results, including an FMD virus gene chip that consists of 110 common and serotype-specific probes derived from the FMD genome, an avian influenza virus genechip containing 502 probes for 15 hemagglutinin subtypes, and a gene chip and a suspension microarray for detecting and differentiating hog cholera and other pestiviruses. The team submitted manuscripts on the FMD gene chip and the hog cholera suspension array, and both have been accepted for publication.

They also developed a protein suspension microsphere immunoassay (MIA) to detect avian influenza virus antibodies, and a multiplex MIA containing two proteins to detect hog cholera antibodies. They submitted a manuscript on the avian influenza MIA, which is in journal review.

The training team developed and implemented a formal first responder network laboratory training course held at the CFIA in Winnipeg. The team also produced training binders and equipment, including an RRT-PCR portable testing unit, which are now available for future first responder network training. The RT-PCR team delivered training to nine CFIA employees from across Canada on the FMD, avian influenza, and hog cholera RT-PCR assays developed during this project.

Overall, the researchers had completed the majority of the work including animal studies, reagent development, and validation by the end of March 2006. With supplementary funding, the team will further develop a high-throughput multiplex ELISA for FMD in conjunction with Lawrence Livermore National Laboratory, and harmonize testing methods with the USDA Animal and Plant Health Inspection Service.

Impact

The project produced 16 individual tests, a training course for first responders, and trained analysts from laboratories across Canada. Some tests have already been used in real outbreak situations such as the RRT-PCR for avian influenza, which was used in British Columbia in 2004. This test will be used in 2006 for H5N1 virus surveillance in wild birds. Also, RRT-PCR tests for hog cholera and FMD developed under the project will be implemented in veterinary laboratories across Canada over the next few years under the Canadian Animal Health Surveillance Network (CRTI 04-0004RD).

CRTI 0203RD // Standoff Detection of Radiation

PROJECT LEAD:
DRDC Ottawa

FEDERAL PARTNERS:
Atomic Energy of Canada Limited, Health Canada

INDUSTRY PARTNER:
Bubble Technology Industries

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Objectives

The objective of this project is to construct a fieldable prototype standoff radiation detector. Conventional radiation detectors work on the principle of "direct" detection, whereby the radiation must actually enter the detector to be counted. This presents a significant drawback in that a radiation surveyor must enter a radiation field in order to detect it. To address this, the project team will construct a detector based on "indirect" detection, allowing the surveyor to detect a radiation field from a distance. This will allow surveyors to detect contaminated areas prior to entry and to characterize such areas to identify high and low dose rate areas, and will facilitate mission planning.

Relevance

In the immediate aftermath of a radiological attack, it will be necessary to delineate and quantify the contamination produced by the attack. The standoff detector introduces a novel way to perform this role in a manner in which the operator is not exposed to high levels of radiation or at risk of contamination. As the technology develops, it may also find applications in post-incident remediation, or in applications relevant to prevention, such as in nuclear safeguards verification or in security screening.

Recent Progress and Results

The project team completed a prototype detector in 2005, which met or exceeded all of its design specifications. It has been tested in numerous field trials at DRDC Ottawa, in which alpha, beta, and X-ray sources were imaged from distances as great as 500 metres. In June 2005, the project team participated in the United States (US) – Canada field trials held at Pacific Northwest National Laboratories in Richland, Washington, where the prototype detected an alpha-emitting source (Americium-241) at a distance of 1 250 metres. Given that conventional detection of alpha particles can only occur at distances of a few centimetres, this result represents a considerable leap forward in detection technology. The project team also demonstrated at these field trials that their capability significantly exceeded the capabilities of the other participating teams from the US. Most recently, the team tested the standoff detector during the four-day CRTI Radiological-Nuclear (RN) Laboratory Cluster Exercise Maritime Response in March 2006.

The project team has also been focused on the next steps for standoff detection technology. The team has identified several new research areas that show progress. Some of these would represent small variations on the existing system that could result in greatly enhanced capability. Some of the other approaches are completely

new directions that could result in complementary capabilities for the detection of ionizing radiation fields at a distance. The project team also began to apply for a patent on its current approach, and is liaising with potential clients and industrial partners with the intent of commercializing this technology.

Impact

The project's main deliverable, the detector, has been delivered and has undergone extensive field trials. As a Research and Technology Development (RD) project, the deliverable was never intended for direct hand-off to the operational community. However, the project team is already in discussion with potential clients and industrial partners to ensure that this technology is developed for operational applications, an essential component to the ultimate success of this project.

CRTI 02-0007TA // Medical Countermeasures Against Ricin

PROJECT LEAD:
DRDC Suffield

INDUSTRY PARTNERS:
Twinstrand Therapeutics Inc., Cangene Corporation

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Objectives

Ricin is a potent toxin found in castor beans. It is readily produced, has a history of use by terrorist groups, and is viewed as a significant future terrorist threat agent. There are currently no approved medical countermeasures against ricin poisoning. This project had three sequential objectives accomplished by three partners with unique and innovative capabilities. The first objective, fulfilled by Twinstrand Therapeutics Inc., was to develop a harmless toxoid to replace ricin in animal immunization or in monoclonal screening. The second objective, achieved by Cangene Corporation, was to produce high-titre anti-ricin antisera in goats under Good Manufacturing Practice (GMP) conditions, and anti-ricin monoclonal antibodies by phage display technology. The third objective, fulfilled by DRDC Suffield, was to test and evaluate the antibodies as therapies against ricin poisoning in a mouse model.

Relevance

First responders are at personal risk in areas contaminated with ricin, and their effectiveness is compromised by the lack of a medical countermeasure. A treatment against ricin poisoning would have enormous positive psychological benefits to first responders, improving their performance in situations involving ricin exposure.

Recent Progress and Results

This project has been successful in accomplishing its objectives, and in many instances it has exceeded expectations by providing novel insights and enhanced capabilities and contributing to potential new work.

Twinstrand Therapeutics Inc. created several toxoid candidates to replace ricin. Of these, the best (i.e., the most antigenically similar to ricin, harmless, and lacking toxicity) toxoid was produced in bulk (in gram amounts) under GMP conditions. The toxoid was used to immunize goats in this project, and could also be used as a vaccine candidate for protection against ricin or as an unrestricted antigen to develop detection assays or kits. Given the restriction against the use of ricin by the Organization for the Prohibition of Chemical Weapons (OPCW) and the Chemical Weapons Convention (CWC), the toxoid could also be used as a replacement of the toxin to develop detection assays. The toxoids have also developed an in vitro (cell culture) model for assessing ricin toxicity or neutralization.

Cangene Corporation produced high-quality, high-titre goat polyclonal anti-ricin antibody. Researchers also investigated the purification of these antibodies to facilitate the treatment of patients. Cangene developed human monoclonal antibodies in vitro, one that reacts specifically to the ricin A chain, the other to the ricin B chain. This marks the first time that effective human monoclonal antibodies against ricin have been developed.

At the start of this project, ricin was not available from any commercial sources. With the consent of regulatory agencies, DRDC Suffield produced a sufficient amount of ricin for current and future needs. Prior to this work, the scientific community assumed that medical countermeasures were ineffective following ricin poisoning. However, DRDC Suffield researchers determined that 60 percent of mice, given 5 LD50 of ricin, survived when antibody therapy was given up to 16 hours post-exposure.

The success of this project was due, in part, to the active participation in communications, including annual face-to-face meetings, monthly teleconferences, and ongoing weekly or daily e-mail or telephone conversations. The ability of the project partners to exceed the expectations of the project may be credited to their innovation, collaboration, and generosity in giving more than their required in-kind contribution.

Impact

This project was completed in February 2006. This new medical countermeasure (antibody therapy) will assist first responders in managing the effect of ricin, either on a group targeted by terrorists, or on themselves as they enter contaminated areas. The intervention of first responders with access to medical countermeasures could make the difference between unfortunate casualties and recovering patients.

CRTI 02-0024RD // Probabilistic Risk Assessment Tool for Radiological Dispersal Devices

PROJECT LEAD:
DRDC Ottawa

FEDERAL PARTNERS:
Canada Border Services Agency, Canadian Nuclear Safety Commission, Canadian Security Intelligence Service, Public Safety and Emergency Preparedness Canada

INDUSTRY PARTNER:
SAIC Canada

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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, different activity levels, and different 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 directly supports the CRTI investment priority to focus on the science and technology (S&T) dimensions of risk assessment. There is a scientific gap in the collective 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 then use these data to assess the scenarios for which they should plan. This information could also help security personnel determine possible weaknesses in Canada's defence against radiological terror, and thus direct their efforts at preventing RDD attacks.

Recent Progress and Results

In the last year, the project team developed a model that describes the construction of a generic RDD; this model is the framework on which the whole project rests. Second, the project team has developed the inputs to an RDD risk assessment database. This database feeds the feasibility assessment half of the risk calculation, and can be refined as the tool is used and its outputs are analyzed. Finally, the project team has 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 enabling the automated consequence assessment so critical to this project. Progress on these fronts was reported to the 2005 Midyear Meeting of the Health Physics Society.

All of these inputs have come to fruition in the completion of the beta version of the Probabilistic Risk Assessment (PRA) Tool. The PRA Tool permits rapid assessments

of feasibility, consequence, and risk for a wide array of possible RDD attack modalities. Furthermore, the highly configurable nature of the tool enables the user to perform sensitivity analyses on these risk assessments. These analyses are performed by modifying the feasibility estimates at all stages of the RDD construction and deployment process, the scenario-specific variables that affect how the consequences of a given class of RDD events are assessed, or the system variables that determine globally how consequences are assessed for all RDDs. Project partners plan to conduct user testing on this tool. The next nine months will see continuous improvement in the tool as the project comes to completion.

Impact

The just-released beta version of the tool has already been presented to project team members and others to considerable acclaim. Users are immediately impressed by the power of the software tool and the capabilities that it gives the user. These capabilities have never existed before, and represent a considerable step forward in RDD risk analysis. The project team expects that this tool will be adopted, at a minimum, by agencies with security mandates to enhance their understanding of the RDD threat, and to focus their attentions on the scenarios of greatest concern. The tool will require ongoing attention from the scientific community to ensure that the risk assessment database and the other inputs to the tool are as accurate as they can be.

CRTI 02-0035RD // Canadian Network for Public Health Intelligence

PROJECT LEAD:
Public Health Agency of Canada

OTHER PARTNERS:
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Objectives

The purpose of this project is to develop and implement the Canadian Network for Public Health Intelligence (CNPHI)—a secure, web-based resource to collect and process surveillance data, disseminate strategic intelligence, and coordinate response to biological threats.

The goals of the 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 boundaries 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

Many unique pockets of expertise relating to infectious diseases and data collection systems exist in Canada, but there is currently no national framework to integrate them in a timely manner. The CNPHI will facilitate the integration of relevant public health intelligence into a common national framework to support coordination among jurisdictions. The integration of surveillance, epidemiology, and laboratory information, maintained within an infrastructure that has the capacity to identify, communicate, and respond to biological events is the foundation to bioterrorism preparedness and effective public health management.

Recent Progress and Results

For the first year of this project, project partners focused on system design and development. It was only in the second year that the CNPHI really took shape. The CNPHI website was launched on October 1, 2004. The CNPHI currently provides public health resources to over 1 800 federal, provincial, territorial, and regional

public health professionals from coast to coast. All provinces and territories, and all regional health authorities in Canada participate in the CNPHI.

The CNPHI is divided into two main centres: the Canadian Integrated Outbreak Surveillance Centre (CIOSC) and the Response and Resource Management Centre.

The CIOSC includes Public Health Alerts and Notifications (PHA/N), the FluWatch system, and the National Enteric Surveillance Program (NESP). The PHA/N is a secure communication system that enables stakeholders to exchange comprehensive and timely information about communicable disease events through the distribution of "alerts" and "notifications." It is designed to complement existing communication networks and enables users to share information with colleagues nationwide, identify events of significance across the country, identify potential linkages to local occurrences, and guide appropriate public health response when necessary. FluWatch is an aggregate surveillance system designed to monitor influenza and influenza-like illness (ILI) and the resulting outbreaks within designated surveillance regions while respecting jurisdictional responsibilities. Key sites, including hospitals, schools, long-term care facilities, and workplaces participate as designated sentinel sites to monitor activity and report on a weekly basis to their respective surveillance region. FluWatch is currently being piloted in New Brunswick, Newfoundland and Labrador, and Nova Scotia. The NESP is an aggregate surveillance system designed to monitor enteric pathogens and automatically detect anomalies based on submitted data. This system provides an environment to facilitate online data collection from various jurisdictions; summary tables and reports are available on a weekly basis.

The Response and Resource Management Centre has two components: Intelligence Exchange Resources and Virtual Operations Resources. Intelligence Exchange Resources offer secure, web-based resources to assist stakeholders with structured and organized activity management. These tools include a collection of communication, coordination, and information management resources. Access to and use of these resources are based on registered membership in groups centered on a public health issue or topic. Virtual Operations Resources offer a collection of secure tools that facilitate information management for an operations centre environment. The wide range of communication tools, combined with an emergency contacts management application, assist in the day-to-day management of information for an operations centre.

Impact

The CNPHI is the only successful pan-Canadian public health surveillance, communication, and response information management resource. It facilitates efficient information exchange, enhances surveillance capacities, and provides much-needed response resources. The CNPHI is the only government project to be considered for integration into INFOWAY's Pan-Canadian Surveillance Solution.

CRTI 02-0041RD // Real-Time Determination of the Area of Influence of CBRN Releases

PROJECT LEAD:
Health Canada

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Health Canada, Environment Canada, Atomic Energy of Canada Limited

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Objectives

The goal of this project is to develop a CBRN modelling system that can provide first responders and decision makers with reliable, real-time forecasts of the timing, location, and amount of deposited CBRN material, including the effects of precipitation on the material, in the event of a terrorist attack.

The CBRN modelling system will be designed to address four key areas: forecasting the trajectory and concentration of CBRN material in the air; forecasting the location, duration, and intensity of precipitation; calculating the amount of airborne material deposited on the ground when it is raining or snowing; and calculating deposition in the absence of precipitation. To accomplish this, the researchers will integrate the atmospheric transportation and dispersion models (Modèle lagrangien courte distance [MLCD] and Modèle lagrangien de particules [MLDP]) currently used in Canada to handle emergency situations, into their model.

Relevance

CBRN material released into the atmosphere by terrorist activities will form an airborne plume that undergoes advection and dispersion by ambient wind and turbulence fields. The appropriate response to this situation requires 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 possible delay between releases and forecast.

The predictions will quickly identify the total area of the deposited material, as well as hotspots of high concentration that require immediate attention. 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 model predictions will be essential to rapidly assess and mitigate the effects, and 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

Through previous project tasks at McGill University, 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) have been studied. The project participants reviewed these studies to determine how best to merge the two precipitation forecasts to surpass the accuracy of the individual methods. Merged NWP/nowcast precipitation forecasting has now been implemented at McGill University, and is being transferred to Environment Canada to be included in the integrated model.

Following the development of a below-cloud wet scavenging scheme for rain in the last fiscal year, the project team developed a new below-cloud snow scavenging scheme for the project, which takes into account the mass-dimension relationship and settling

velocity of snow particles, the spectral collision efficiency between snow particles and aerosol particles, and the size distributions of aerosol particles and snow particles. They then implemented the scheme into the MLCD and MLDP atmospheric dispersion models. The team also implemented three in-cloud scavenging schemes into the MLCD and modified the MLCD to accept three-dimensional precipitation fields from NWP models.

To evaluate the incorporated wet scavenging scheme, the team used Atomic Energy of Canada Limited (AECL) data on the washout of tritiated water vapor (HTO) from airborne plumes. They conducted a variety of sensitivity tests to identify the major factors affecting the wet scavenging of HTO and the preliminary results of the evaluation are very good.

University project partners are in the process of developing dry deposition schemes for gases and aerosols. Upon completion, they will also be transferred to Environment Canada to be incorporated into the MLCD and the MLDP.

The integrated overall system will be completed by March 2007.

Impact

Important elements continue to be incorporated into the overall system for forecasting the transport and deposition of CBRN materials. Datasets of HTO washout collected in the past two years by AECL will continue to be used to evaluate the newly developed wet scavenging scheme for gases. Measurements of the wet deposition of Beryllium-07 by Health Canada will be used to evaluate the newly developed wet scavenging scheme for aerosols.

The system developed in this project will be linked to the Accident Reporting and Guidance Operational System (ARGOS) platform and run operationally at the Canadian Meteorological Centre's Environmental Emergency Response Division. As a primary end user, Health Canada will gain access to predictions through the ARGOS.

CRTI 02-0041TA // Deployable CBRN Monitoring Network

PROJECT LEAD:
Health Canada

FEDERAL PARTNERS:
Canadian Nuclear Safety Commission, Environment Canada

INDUSTRY PARTNERS:
Bubble Technology Industries, General Dynamics Canada

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Objectives

Terrorist-initiated and accidental events are unpredictable, both in terms of place and time. This project aims to fill a gap in Canada's emergency response capability by providing a sophisticated CBRN detection and monitoring network that can be quickly deployed wherever it is needed, and remotely operated from any location.

The network is intended to support any number and type of suitably interfaced sensors covering areas of any size. The sensors aim to deliver detailed quantitative data for use in event surveillance, emergency response, and long-term follow-up. The key to the design is flexibility in communications, data handling, and sensor design. The deliverables under the current contract are a portable suite of leading-edge CBRN sensors, one communications hub, and complete software for the sensors, hub, and remote data reception and control. The software architecture must be designed with maximum flexibility to augment and integrate the system with other response systems in the future.

Health Canada is the lead for this project. Bubble Technology Industries (BTI) is providing special radiation monitors, interfacing all sensors to a communications hub, and developing the software that controls the network and provides both raw data and critical information to the end user. General Dynamics Canada is providing the biological sensor. All federal partners are providing technical input into the development of the system, and will test the Deployable CBRN Monitoring Network upon its completion.

Relevance

The results of this project primarily address immediate reaction and near-term consequence management capabilities. Because of its flexibility of deployment and sophisticated data output, it also contributes to Canada's collective command, control, communications, coordination, and information capabilities for CBRN planning and response; improves operational capabilities for prevention, surveillance, and alert against CBRN events; and enhances longer-term consequence management capabilities.

Recent Progress and Results

The Deployable CBRN Monitoring Network has been designed to deploy one or many independently operating modules, each configured to meet the needs of the emergency scenario at hand. Each module comprises a communications hub and an associated suite of detectors. The hub provides the communication path between its sensor suite and a remotely located command centre. Each sensor has global positioning system (GPS) and on-board intelligence that presents location, analyzed data, and raw data on request, to the hub. The on-board GPS facilitates either static or mobile deployment of the sensors. Communication between the hub and its sensors is wireless, with a modality chosen to suit the spatial distribution of the sensor suite. In the current system, radio frequency transceivers are used to communicate data between each sensor and the hub. Communication between the hub and command centre can be provided through satellite, cellular, or landline connection; the

first embodiment of the system uses the cellular network for data transmission. Two-way communication and control between the command centre and the deployed modules is achieved using a custom, Internet-based software application developed by BTI. The software architecture and data formats are designed to be flexible to facilitate integration with existing or planned response systems.

The first embodiment of the Deployable CBRN Monitoring Network has been delivered to Health Canada for testing. The system includes four portable sensors and one communications hub. BTI has specially designed and built two portable radiation detectors: a high-rate gamma monitor and an alpha-beta-gamma air monitor. The gamma monitor uses advanced circuitry to allow spectral analysis in high-radiation environments, dose and dose-rate calculations, automatic isotope identification, and a wide dynamic energy range (up to 8 MeV). The gamma monitor has been tested with a wide range of sources to obtain resolution and energy calibration data and to very high rates with a 137Cs irradiator. The gamma monitor has been demonstrated to provide good quality spectra for gamma fields ranging from background levels to more than 100 mrem/h. The monitor quantifies higher fields with a Geiger-Mueller tube to ensure operation in even extreme radiation fields.

The compact portable air monitor provides spectral analysis of airborne alpha, beta, and gamma radiation and features automatic or remotely actuated filter advances. Testing has demonstrated that the air monitor provides very high-quality spectra and enables early identification of potentially hazardous air activity well before significant internal exposure has occurred. The chemical sensor is a suitably interfaced, commercial Bruker RAID-M ion mobility-based sensor that detects both chemical warfare agents and toxic industrial chemicals. The biological agent sensor is a portable 4WARN Sentry system supplied by General Dynamics Canada that detects the four standard biotoxin simulants.

Impact

As the lead federal agency, Health Canada is currently testing the Deployable CBRN Monitoring Network and providing feedback on the design and characterization of the sensor performance. The CRTI-funded portion of the project ended in March 2006. Upon completion of the project, Canada will be equipped with a unique, deployable sensor system that will enable early detection of and rapid response to CBRN emergencies. Additional sensors can be interfaced to the network to further augment the system's capabilities.

CRTI 02-0043TA // Accelerated Consequences Management Capabilities

PROJECT LEAD:
DRDC Suffield

FEDERAL PARTNER:
Environment Canada

INDUSTRIAL PARTNER:
Allen-Vanguard Corporation

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Objectives

This project aimed to accelerate development of the Universal Containment System (UCS), a containment, mitigation, and decontamination system used to absorb and contain blast and bomb or device fragments, neutralize chemical or biological substances, and remove radiological particles from surfaces. Allen-Vanguard Corporation, licensee for an aqueous family of decontaminants developed at DRDC Suffield (CASCAD®), markets the UCS to CBRN response teams. The UCS enables these teams to contain, mitigate, or decontaminate packages suspected of containing CBRN agents, enclosed areas contaminated by a chemical or biological warfare agent, or other locations contaminated as a result of a CBRN terrorist attack. The research team examined the environmental impact of using the UCS, its operating temperature range limits, equipment redesign, and its performance against a wide spectrum of agents on a variety of surfaces.

Relevance

The project team has developed a system with an improved decontamination and blast suppressant formulation and procedure, along with application equipment. The team documented proof of its effectiveness on a cross-section of civilian and military surfaces against a wide variety of chemical and biological warfare agents. Based on liquid-phase reactivity, vapour desorption data on various contaminated surfaces, product toxicity, an environmental impact study, and a live-agent field trial performed to certify the system, the team also developed a booklet for first responders. The booklet describes the utility and capability of the modified UCS, its associated equipment to address chemical and biological agents and mitigate blast effects, and how to use the system more effectively for immediate response and near real-time consequences.

Recent Progress and Results

Researchers determined the effectiveness of UCS foam in decontaminating surfaces contaminated with chemical warfare agents (mustard [HD] and soman [GD]) using scrubbing and non-scrubbing techniques to simulate emergency field decontamination methods. The team conducted gas chromatography (GC) analysis of selected chemical warfare agents desorbing into a flowing air sweep above a contaminated surface, and of residual agents in liquid extracts of the surfaces. These surfaces were representative of porous office materials (e.g., alkyd paint on dry wall, latex paint on drywall, varnished wood, ceiling tile, carpet, concrete, and asphalt) and non-porous office materials (e.g., chemical – agent-resistant coating on steel, alkyd paint on steel,

window glass, anodized aluminium, and vinyl tile). All surfaces were examined to assess the effectiveness of the UCS foam in decontaminating HD; only those surfaces that were effectively decontaminated were then examined with GD. Results were subjected to mathematical modelling to learn more about the desorption hazards. Some surfaces were readily decontaminated, while others were not amenable to successful decontamination, as the decontamination process proved too labour intensive for practical use in the field. The effectiveness of UCS foam for detoxifying anthrax spores was determined and documented in six reports: two reports on HD on porous and non-porous surfaces, two reports on GD on porous and non-porous surfaces, one desorption model, and two reports on anthrax.

The project team examined liquid-phase rates, stoichiometries, and products of reaction of original formulations and formulations modified with HD, tabun (GA), sarin (GB), GD, cyclohexyl sarin (GF), o-ethyl S-2-diisopropylaminoethyl methylphosphonothiolate (VX), o-isobutyl S-2-diethylaminoethyl methylphosphonothiolate (R33), and tricothecene (T2) toxin. To conduct their analysis, the team used a liquid chromatography–diode array detector/mass spectrometry detector (LC-DAD/MSD) and liquid chromatography-flame photometric detection (LC-FPD). Researchers determined the minimum volumetric ratios of decontaminant to agent required to achieve 99 percent effectiveness over a one-hour contact time, as well as ratios of decontaminant required to decontaminate surfaces contaminated with residual agent over a range of contact times. The team conducted a literature survey on potential products, and verified and quantified anticipated products for nerve agents by LC-DAD/MSD. Characterization of HD products will be completed using a newly developed liquid chromatography–mass spectrometry (LC-MS) methodology. Four reports were generated as well as a technical note on an attempted methodology for analyzing residual Lewisite in reaction mixtures. Two reports on products generated during reaction with nerve agents and their temporal behaviour will also be issued.

The project team determined the environmental impact on aquatic toxicity, ready biodegradability, and soil toxicity of UCS components and mixed formulations, including an inactive training solution, to assess the need for post-treatment or effluent containment. In three reports, it was demonstrated that the aquatic and soil toxicities were in the order expected from the level of active ingredient; an assessment of the need for remediation will be undertaken.

A report on UCS surfactant concentrate identified factors responsible for cold weather gelling. Several additives were proposed for lowering gelling temperatures, and one was selected to determine its impact on blast-suppressant and liquid-reactivity characteristics when incorporated into the concentrate. The team developed methodology to characterize the shelf life of UCS components, and identified and documented mechanisms of deterioration in two reports. These results, combined with other studies, led to changes to the concentrate compositions, formulation preparation methods, and application equipment for the UCS that significantly extend its usable pot life (results were documented in two reports). The team evaluated the modified system and formulation in a field trial. The field trial examined the decontamination of four civilian surfaces as well as the suppression of explosive ordnance and explosively disseminated HD. The trial demonstrated that blast and explosive agent dissemination mitigation capabilities were retained (results were documented in two reports).

Impact

Information from this project led to the design of an improved product and equipment for use in CBRN events. A modified formulation was developed with a longer pot or storage life and a lower gelling temperature. The environmental impact of the modified formulation has been quantified and reactivity against a variety of chemical and biological warfare agents has been demonstrated. Its effectiveness was verified on a cross-section of civilian surfaces contaminated with HD and GD, which were decontaminated in a realistic emergency response scenario. A new 4.5-gallon backpack, a 30-gallon dolly, and a large-scale, 250-gallon foam delivery system, all incorporating superior procedures for formulation preparation, were designed and manufactured. Blast-suppressant and decontamination characteristics were authenticated in a proof-of-concept field trial incorporating the modified formulation, preparation procedure, and equipment. The results of the project team's research efforts were summarized in a final overview report. An end-user booklet for first responders has been produced that provides an overview of response procedures, blast mitigation and decontamination options (small-scale to large-scale decontamination), and associated equipment; it also includes a database of test data obtained previously and during this project.

CRTI 02-0045RD // Forensic Optically Stimulated Luminescence

PROJECT LEAD:
DRDC Ottawa

FEDERAL PARTNERS:
Public Safety and Emergency Preparedness Canada, Royal Canadian Mounted Police

INDUSTRY PARTNER:
Bubble Technology Industries

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Objectives

The objective of this project is to apply the optically stimulated luminescence (OSL) approach to forensics to enable investigators to identify suspected former radiological-nuclear (RN) storage sites using a portable detector.

Relevance

Along with improving Canada's prevention, surveillance, and alert capabilities, this portable OSL detector will also address longer-term consequence management issues through retrospective OSL dosimetry of an RN-contaminated area. The OSL technique will provide 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

The technique has successfully measured stored radiation-induced charge in a variety of common building materials and household items. The project team has developed a laboratory prototype, characterized a variety of OSL-emitting materials, and constructed a field-portable prototype OSL reader. The team plans to complete an OSL materials database, conduct field and laboratory device testing, and write a user manual for the portable reader. Project partners who will be end users of the device will be involved in field tests.

During the past year of the project, the project team has focused on constructing the portable OSL field prototype. Various components of the detector were examined and compared to determine the most effective internal design. Clusters of seven low-power light-emitting diodes (LEDs) were compared to a single, super-power LED for sample stimulation. With the use of a parabolic reflector, the light collection efficiency proved to be nearly equivalent for both LED types, and due to the power requirements of the super-power

LEDs, the team decided to use LED clusters for stimulation. Testing of the LED clusters indicated excellent power density.

The team added a set of specially coated transmission filters to the design to reduce transmission in the 700 nm region. The electronic printed circuit board (PCB) was fabricated and tested, and the forensic optically stimulated luminescence (FOSL) software was integrated with the new hardware and tested. The mechanical design of the portable reader was conceptualized to fit all detector components, including the photomultiplier tube (PMT), filters, LEDs, electronic PCBs, the parabolic reflector, and the sample holder. Fabricated out of stainless steel, it was determined upon testing that the weight of the design needed to be reduced. A new mechanical design was then developed and fabricated out of aluminum with much better results. Hardware verification and testing was very promising.

The final field prototype is now complete and laboratory and field testing are underway. Some preliminary tests were performed at DRDC Ottawa using a 10 mCi Sr-90 source on a variety of materials for various exposure times. Radiation-dependant OSL signals were measured for all materials previously exhibiting this characteristic, measuring both small samples of the materials and directly reading the surface of the materials. Although field tests of the device held at the National CBRN Response Team Exercise Steele Response proved unsuccessful, tests conducted at the CRTI Exercise Maritime Response in March 2006 were successful.

The initial sample characterization and laboratory prototype were described in the journal *Applied Radiation and Isotopes* (63, 2005, pp 689-695). An abstract has been accepted for the upcoming Institute of Nuclear Materials Management (INMM) conference in July 2006.

Impact

The construction of a detector designed to measure former radioactive storage locations is a novel idea. This detector is both portable and sufficiently sensitive to measure radiation doses in common building materials outside of a laboratory setting. This device has potential applications in forensics and intelligence communities concerned with radiological terrorist scenarios, as well as to other specialty radiological responders and military CBRN teams. Personnel involved with ensuring radiological or nuclear compliance (such as the International Atomic Energy Agency [IAEA]) may also be interested in such a technology as a means to identify past storage locations of illicit material. This project will be complete in September 2006 and commercialization of the device will occur after that. The operational community, however, has been and will continue to be involved in the design and testing of the device, simplifying the technology transfer to these communities.

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, SAIC Exploranium

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Objectives

The aim of this project is to develop 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 will use the various software components and enhancements created within this project. This work will begin with the implementation of a gross dose–rate-based alarm. The systems will be enhanced to perform in situ, real-time isotope identification. Further development using full spectrum analysis in real time will extend the library of isotopes used to identify the isotopes and create more sensitive alarming capabilities. This will include using an advanced spectral analysis, Noise-Adjusted Single Value Deconvolution (NASVD), to greatly improve isotope identification in NaI spectra. Finally, these developments will be integrated with high-level decision-making algorithms that will minimize nuisance alarms, thus avoiding unnecessarily alerting response personnel. The final deliverable of the project will be a high-level, expert decision-making system with enhanced isotope identification capabilities 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 harbors, across borders, and out of nuclear facilities. Rapid, accurate characterizations of natural, medical, industrial, and special nuclear material will provide security personnel with 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

Software has been developed for mobile NaI detectors that identify a broader library of industrial isotopes and illicit material, as well as a user interface customized for security personnel. This new software has been deployed by the Canada Border Services Agency (CBSA) for a year and is currently being used at their pilot project monitoring ports to identify 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 them to alarm a central station. The software is currently being rolled out to upgrade the detector network.

Improved spectral analysis will also be implemented in both fixed and mobile networks based on NASVD. Two significant software products leading towards the final objective of full spectral identification have recently been developed. The first is an automatic data processing service that can evaluate and remove the natural background and perform a full spectral fitting on the residual spectrum. The second is a spectral library creation and testing browser tool that will speed up the development and testing of new libraries.

Incoming data are automatically separated from their background components and any residual spectrum is analyzed for library isotopes. Full spectral components from a predefined isotope library are matched to the residual spectrum, which produces air kerma dose rates for each isotope. The current library contains radon components, Ir192 (used for metallurgical testing) and the common byproducts from the nuclear generation process (Ar41, Xe133, and Xe135). By identifying and quantifying innocuous and nuclear contaminant isotopes, the software can define a set of preprogrammed responses not only for library isotopes but also for any isotopes outside the library's scope. The corresponding background reading for each record is stored to enable background verification. The results are currently being verified against data archived over the last six years.

The improved sensitivity with the new process has been demonstrated by finding small amounts of anthropogenic radiation in data that were previously considered free of such radiation. The effects of cross-isotope interference also have been significantly reduced. The new full spectral library is used to fit multiple spectral components to determine the air kerma for each isotope. The use of multiple components compensate for different spectral shapes. The new software is simpler, more accurate, and sufficiently reliable to make advanced decisions for the purpose of alarm verification.

A new software browser has been created to view, select, and analyze archived data. This tool provides a visual aid to accelerate the development of new libraries and the verification of results from archived data. The tool displays how the library was used to fit a selected spectrum, displays what the resulting fit looks like, and can extract any residual spectrum that can then be used to create additional spectral library components.

Impact

This project will create a comprehensive expert alert system. It will process and evaluate continuous isotopic and radiation field measurements that alarm with high sensitivity and low false alarm rates. It will provide event classification and efficient information distribution to assist laboratory clusters in managing radionuclide incidents.

Automated, high-sensitivity, full spectral analysis (NASVD) will be used to monitor RN incidents as well as interdiction of illicit materials. This will be done by using a full spectral component fitting that will be implemented in a variety of detectors by the end of the project. This project will be completed by March 31, 2007.

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:
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Objectives

The purpose of this project is to develop three tools to prepare against and respond to intentional incursions of highly contagious diseases, such as foot-and-mouth disease (FMD), avian influenza, and classical swine fever. The first tool will be a computer simulation model for policy development called the North American Animal Disease Spread Model (NAADSM). The model will be collaboratively developed and programmed by the Canadian Food Inspection Agency (CFIA), the United States Department of Agriculture (USDA), the Ontario Ministry of Agriculture and Food (OMAF), Colorado State University (CSU), and the University of Guelph. Environment Canada researchers will take the lead in the development of the second tool, an atmospheric dispersion model for real-time plume predictions. The CFIA will oversee the development of the third tool, an emergency management system that will help responders track outbreaks and enable decision makers and epidemiologists to evaluate the progress of control measures.

Relevance

When dealing with the incursion of a foreign animal disease, whether it is intentionally or accidentally introduced, the speed at which decisions are made is critical to mitigating the impacts of the outbreak. The models developed in this project will help researchers understand the potential consequences of such incursions and the impact of various control options before an actual outbreak occurs. The emergency management system will help responders handle the volume of data that would be generated by such outbreaks.

Recent Progress and Results

The project team released the first official version of the NAADSM on April 1, 2005. Since then, the version has undergone significant testing and validation to ensure that the model works as it was intended. A group of government epidemiologists from Australia, New Zealand, Canada, and the United States is now comparing the North American model with models

from Australia and New Zealand. Preliminary results indicate that the three models produce similar predictions. The model is currently ongoing sensitivity analysis to determine which input parameters are the most sensitive.

The project team is conducting research to characterize the contact structure among livestock operations in Ontario so that this structure can be better represented in the NAADSM. The team has also started to collect data to define the NAADSM parameters for avian influenza, and expect preliminary results by July 2006. They are also looking at the number of vaccine doses that would be required to control FMD in North America, and expect results in 2007. Finally, the team plans to create a bank of FMD outbreak scenarios for Ontario by 2007. This bank will provide trigger points for various control options to control FMD and will serve as a template for the rest of Canada.

The team plans to complete the project in December 2008.

Impact

By June 2007, the team will have simulated various FMD outbreak scenarios and tested control options, and the results will be available for policy makers to use. The atmospheric dispersion model will also be ready to use in an operational response against FMD, which can be transported long distances by wind. The team will also identify areas at risk of airborne FMD transmission. They expect that various modules of the emergency management system will be in operation as of March 2008, and the final system will be fully operational in December 2008.

CRTI 02-0067RD // Restoration of Facilities and Areas After a CBRN Attack

PROJECT LEAD:
Environment Canada

FEDERAL PARTNERS:
DRDC Ottawa, DRDC Suffield, Public Health Agency of Canada

INDUSTRY PARTNERS:
Allen-Vanguard Corporation, SAIC Canada, VLN Technologies, Hytec Hydrocarbon Reclamation Ltd.

OTHER PARTNERS:
United States Environmental Protection Agency

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Objectives

The goal of the project is to gather and compile information on and then test and validate all known procedures for restoring the exteriors and interiors of affected buildings following a CBRN attack, including the air inside the building and contaminated surfaces. The restoration includes pickup, neutralization, decontamination, removal, and final destruction and disposal of the contaminant, and cleaning and neutralizing material and contaminated detritus resulting from the incident. The goal is to be achieved through fulfillment of the following specific objectives:

- Research and test new methods for restoring areas and facilities after a CBRN attack;
- Collect known methods of restoration and evaluate those concepts;
- Prepare manuals of procedures for the restoration of buildings and other areas;
- Develop new ideas for the restoration of areas;
- Evaluate and test all ideas for the restoration of facilities on a lab scale; and
- Develop procedures for contaminant pickup, neutralization, encapsulation, concentration or separation, and final disposal.

Relevance

The results of this project have contributed to Canada's collective knowledge and capability to address the longer-term consequence management dimensions of a CBRN event, specifically through improved technologies for decontamination, containment, and disposal of

CBRN – contaminated materials. It is anticipated that various project activities will contribute to the development of several other capabilities, including techniques for identifying and prioritizing the decontamination and restoration needs of buildings, facilities, or geographical areas, and techniques and equipment to identify, quantify, and mitigate the spread of CBRN agents into the environment.

Recent Progress and Results

The project was completed in March 2006. The project team conducted a comprehensive search and critical analysis of all available data on restoration and decontamination technologies, methods, and available equipment. Technologies were categorized and evaluated according to their nature, effectiveness to target agents, commercial availability, waste generation potential, and other factors. The team conducted an analysis of technology gaps and associated research needs. The resulting literature search was published in February 2005 (*Review of Decontamination and Restoration Technologies for Chemical, Biological, and Radiological/Nuclear Counter-Terrorism*, Environment Canada, Report Series No. EE-176, 187 pp, Ottawa, Ontario, 2005).

Based on results of the above analysis, the project team identified strategic directions for the subsequent laboratory research. Area-specific project teams conducted research in all three areas of decontamination: chemical, biological, and radiological. For each area, researchers identified target agents or groups of agents and selected promising decontamination technologies for evaluation and optimization.

Environment Canada, Allen-Vanguard Corporation (AVC), DRDC Suffield, and SAIC Canada researched chemical decontamination technologies, focusing on organophosphorus agents, including pesticides, and other surrogate chemical weapon agents. Peroxyacids and other oxidants were used in most decontamination trials. The team developed a method to conduct a comparative evaluation of different decontamination formulations.

The Public Health Agency of Canada and AVC researched biological decontamination technologies, focusing on decontamination with foam and the use of vaporized hydrogen peroxide. In both cases, contaminated surfaces were effectively disinfected.

DRDC Ottawa, Environment Canada, SAIC Canada, VLN Technologies, and Hytec Hydrocarbon Reclamation Ltd. researched radiological decontamination technologies using a variety of physical and chemical methods. The group focused on porous surfaces that are particularly difficult to decontaminate.

At the end of the lab research phase, the teams produced detailed reports that will soon be published in Environment Canada's Environmental Emergencies (EE) Series. A users' manual has been developed for building decontamination, including CBRN cleanup.

Impact

The study generated very valuable analytical and research data on the effectiveness of methods for building decontamination and waste handling. Results of the work have been published and made available to stakeholders. In addition to the reports, results of the study have been submitted for publication to research journals and presented at a number of national and international conferences and symposia.

New research partnerships were also developed in the course of this project, including collaborative research with the University of Ottawa and the Wehrwissenschaftliches Institut für Schutztechnologien (WIS) in Germany.

This study evolved into two new CRTI-supported projects whose concepts and approaches are based on its findings: CRTI 04-0018RD, "Development of Standards for Chemical and Biological Decontamination of Buildings and Structures Affected by Terrorism," and CRTI 04-0019TD, "Field Demonstration of Advanced CBRN Decontamination Technologies".

CRTI 02-0069RD // Molecular Epidemiology of Biothreat Agents

PROJECT LEAD:
Public Health Agency of Canada – National Microbiology Laboratory

FEDERAL PARTNER:
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Objectives

The objective of this project is to establish a national molecular typing capability for *Bacillus anthracis*, *Francisella tularensis*, and *Yersinia pestis*.

Relevance

The molecular genetic techniques developed in this project will provide the operational community with a national capability to conduct DNA signature identification of the human pathogens *B. anthracis*, *F. tularensis*, and *Y. pestis* at the strain level. 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.

Multi-locus variable-number tandem repeat analysis (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. Multi-locus sequence typing (MLST) will be developed to characterize genetic loci of bacteria that evolve at a slower but steady rate and can be used to subtype the organism into a larger clonal group. Single nucleotide polymorphisms (SNPs) provide useful targets as genetic markers for molecular, population, and evolutionary studies, especially in clonal bacterial species, and are amenable to high throughput analysis.

Recent Progress and Results

Since the project's implementation in September 2003, the research team has procured the necessary equipment, reagents, and strain DNA from which to develop, test, and standardize molecular typing schemes. The team has also developed an MLVA molecular typing scheme and used it for typing strains in the national collections. Current and future work on this project includes development of an MLST scheme; MLST typing of strains in the national collections; investigations into alternative molecular typing methods, for example, single nucleotide polymorphism (SNP) genotyping; and establishing the capability for electronic data exchange.

The project team has routinely applied MLVA of *B. anthracis* using eight loci for the last two years of the project. Over the last six months, the number of loci used to type *B. anthracis* by MLVA has been expanded to 15 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 recently developed a molecular typing method called single-nucleotide repeat (SNR) analysis that can be used to differentiate *B. anthracis* isolates that have the same MLVA type (J. Clin. Microbiol. 2006, 44, 777-782). Single-nucleotide repeats are variable-number tandem repeats that display very high mutation rates. In an outbreak situation, SNRs allow for the differentiation of isolates with extremely low levels of genetic diversity. In this study, SNR loci were selected

in silico, and the loci with the highest diversity were used to design and test locus-specific primers against a number of *B. anthracis* strains with the same MLVA genotype. SNR markers were identified that allowed strains with the same MLVA genotype to be differentiated from each other. 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. The project team hopes to exploit this technique using other biothreat agents as well.

MLST of *Y. pestis* and *F. tularensis* has proved to offer very limited resolving power at the biovar or subspecies level. The project team has evaluated the usefulness of single nucleotide polymorphism (SNP) genotyping for *B. anthracis* and *Y. pestis* and has implemented it in their labs. SNP typing of *B. anthracis* with 14 loci using Taqman® Real Time PCR shows great promise as the SNP markers appear to be very stable. SNP typing of *Y. pestis* is being developed using SNAP shot technology. Currently, all of the genotyping data are stored in BioNumerics databases. The team is in the process of creating a secure access link for exchange of data between the National Microbiology Laboratory (NML) and DRDC Suffield using a BioNumerics server that will be located and maintained at the NML. Procedures have been written according to ISO17025 standards and will be included in the second scope of accreditation at the NML. The 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 are already being used to track naturally occurring outbreaks of *B. anthracis* and *F. tularensis* in animal populations in Canada by the national labs (DRDC Suffield and the NML). Other potential users within the operational community that would benefit from the methods developed in this project, for example, provincial public health labs, are encouraged to implement these technologies. The completion date for this project is March 2007.

CRTI 02-0080RD // Psychosocial Risk Assessment and Management (RAM) Tools to Enhance Response to CBRN Attacks and Threats in Canada

PROJECT LEAD:
University of Ottawa – Institute of Population Health

FEDERAL PARTNERS:
Public Health Agency of Canada, Canadian Food Inspection Agency

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Objectives

This project aims to provide an integrated framework for managing the psychosocial aspects of CBRN risks with specific guidelines for psychosocial risk assessment, psychosocial risk communication, and psychosocial interventions, from the warning and threat pre-event phases to the reconstruction and recovery phases. It will give way to practical, bilingual, field-based training tools to enhance the capability of key responders in Canada to mitigate the psychosocial impacts of CBRN threats and attacks.

This project is led by the Institute of Population Health of the University of Ottawa in partnership with the Public Health Agency of Canada and the Canadian Food Inspection Agency.

The project has two key objectives. First, the project team aims to develop a Canadian CBRN psychosocial risk management framework that articulates risk assessment with public perception and psychosocial dimensions to strengthen the capacity to rapidly launch effective response strategies to CBRN threats and attacks. Secondly, the team aims to develop a set of risk assessment and management (RAM) tools and training including strategies, decision trees, and guidelines.

The psychosocial modules will include evidence-based literature reviews and survey results that assess the perceptions of CBRN risks and psychosocial impacts of CBRN terrorism on the general public and first responders. The work will focus on various classes of agents, vectors, and target populations, for both threats and actual attacks.

Relevance

Canada is facing the heightened need to improve its preparedness to cope with the short-term, mid-term, and long-term consequences of CBRN threats or attacks. Research indicates that the behavioural and psychological impacts of CBRN terrorism may well be the most widespread, long-lasting, and costly consequences of such an event. As the response to a CBRN terrorist event depends on the agent and how it is used, there is an emerging realization that the response can be conducted by an array of non-traditional first responders, including local public health authorities, frontline health care providers, food inspectors, and lay responders. Adequate training for all key responders on psychosocial considerations is crucial to managing the acute and long-term effects of CBRN terrorism.

Recent Progress and Results

Based on an interdisciplinary literature review and synthesis of Canadian data gathered from responder communities and from the public, the research team formalized a *Psychosocial RAM Framework*, which was published in *Biosecurity and Bioterrorism* (2005, vol 3, no 4, pp. 316-330). Following publication of the framework, the project team conducted cross-country consultations on the needs for psychosocial training and the preferred, most efficient formats. The team established new collaborations in various provinces, such as with the British Columbia Justice Institute and the Sûreté du Québec, and at various levels, from international to municipal partnerships. The team consolidated its links with the European Union through an official project expansion involving the Netherlands, France, the United Kingdom, Spain, and Sweden. Collaborations were also established in the United States with the Department of Homeland Security (DHS), the Department of Defense (DOD), and the Centers for Disease Control and Prevention (CDC).

The team further developed its web tool, Psychosocial Risk Assessment and Management (P-RAM), as well as an accompanying prototype of a psychosocial risk manager tool, PRiMer. The project expanded its database with the systematic coding of all retrieved empirical published papers on psychosocial CBRN and an extensive psychosocial analysis of 10 case studies of CBRN – related events. This analysis documents the existing psychosocial evidence according to the *Psychosocial RAM Framework*. The team is currently developing the curricula for four modules that should be tested in the coming year. They are also building a portfolio of scenarios focused on the psychosocial impacts of CBRN terrorism.

Requests for information and uptakes of knowledge transfer about psychosocial issues related to CBRN terrorism and other risks of national significance have created a ripple effect, heightening interest among various agencies and departments in psychosocial issues and mobilizing a web of new partners to address issues of public confidence and trust, and social considerations. The analysis of psychosocial impacts has been extended to other threats, such as the flu pandemic. These opportunities to apply and further refine the model are used to embed the *Psychosocial RAM Framework* in the planning and in the best practices of all-hazard preparedness and response activities.

Impact

The project will enable agencies and responders to integrate psychosocial considerations that have an empirical evidence basis into their planning and response activities. It will allow them to articulate the psychosocial aspects associated with the bio-environmental specificities of CBRN hazards. It will offer them a portfolio of tools, from case studies to scenarios, to address issues of public confidence, trust, compliance, and community resilience. Taking into account psychosocial factors will improve the effectiveness of first responders, result in more accurate and realistic forecasting, and enhance the health and well-being of Canadians.

CRTI 02-0093TA // Advanced Polymer Research for Application to Personal Protective Equipment

PROJECT LEAD:
AirBoss

FEDERAL PARTNERS:
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Objectives

The objective of this project was to develop a new multi-purpose polymer formulation for personal protective equipment (PPE) that offers the greatest level of CBRN protection and resistance to flame, oils, and other harmful substances.

Relevance

In CBRN incidents, first responders often do not have the time to analyze the type of agents in use before donning their PPE. Therefore, they rely on complete and satisfactory protection for a limited period of time. Current PPE, however, only provides a certain amount of protection. For example, PPE used by firefighters provides no protection against CBRN agents, and the equipment now being used in the fight against CBRN agents provides no protection against flame or oils.

This project addressed this need by creating a new multi-purpose polymer that can be used to manufacture protective boots, gloves, and gas masks and that offers the best protection to a wide range of harmful substances.

Recent Progress and Results

This project was divided into five stages. During the first stage, the researchers tested the resistance of PPE products currently on the market to a wide range of chemicals, including chemical warfare agents such as distilled mustard (HD) and sarin (GB).

In stage two, the team identified the physical and chemical performance factors they were looking to achieve with the new formulation. These included resistance to toxic industrial compounds (TICs), oils, ozone, accelerated aging, flame, static, and cold, as well as several other physical characteristics such as tension, elongation, resistance to abrasion, and material hardness.

AirBoss's chemists then developed more than 100 different polymer compounds and tested them at the laboratory at DRDC Suffield to determine the most promising formulations. The researchers conducted additional validation tests to find the best potential compound to develop.

The project team conducted the fifth and final stage of the project in 2005–2006, which involved using the new compound called CRTI-116 to produce PPE. They found that in addition to meeting all of the criteria

established in stage two, CRTI-166 performed better than most of the products tested in stage one. For example, no other product provided flame resistance. They did, however, find the CRTI-116 must be adapted or modified to suit the target application. For example, in gas masks, the compound performs better than its competition, but when assembling the masks, the team noted that the compound was too rigid to provide an adequate seal. It will also have to be adapted to be flexible enough for use in gloves and highly resistant to abrasion for use in boots.

The project team also evaluated various surface treatments that could be used to improve certain properties of CRTI-116. For example, they found a plasma treatment that increased resistance to oil and in certain cases, improved resistance to TICs, though it had no effect on gas resistance. Another surface treatment, with hydrogenated nitrile butadiene rubber (HNBR), showed some resistance to TICs, depending on the TICs involved. There are hundreds of TICs in existence, and the validation work for all of them still remains to be done. This surface treatment also improved resistance to gas when application and cooking parameters were controlled. Also, based on the results for gas resistance after aging, once the product has been stabilized according to a controlled time, temperature, and cooking method, the HNBR treatment can produce a reasonable performance. Overall, the researchers concluded that surface treatments could have a considerable impact in terms of improving the performance of equipment used to protect against TICs.

Impact

The project has resulted in a new polymer that has proven superior in hazardous substance protection to the majority of PPE products currently on the market. The CRTI-116 gas mask, gloves, and boots prototypes developed during in the last stage of the project will require some modifications before being ready to deployed in the field. However, the researchers are confident that CRTI-116, especially with the addition of a surface treatment, can be used to produce PPE for first responders that provides the maximum CBRN protection and resistance to flame, oils, and other harmful substances.

CRTI 02-0091TA // Clostridium botulinum Type A Genomic DNA Microarray

PROJECT LEAD:
Health Canada

FEDERAL PARTNER:
National Research Council

INDUSTRY PARTNER:
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Objectives

The objective of this project is to address forensic needs by developing subtyping methods based on comparative genomics and cell surface glycans.

Relevance

This project will assist the operational community to respond to CBRN terrorism by providing molecular typing based on genomic differences between strains of *Clostridium botulinum*, and by determining the variability in cell surface glycans. Flagellin genes have been identified as potential typing targets, based on the sequence variability of flagellins of *C. botulinum* strains. A polymerase chain reaction (PCR)-based flagellin typing scheme for *C. botulinum* based on DNA sequences of variable regions of the flagellin gene is much more discriminatory than the currently used neurotoxin typing scheme. Typing based on flagellin sequence could enable the operational community to rapidly identify strains of *C. botulinum* of the same neurotoxin serotype.

Recent Progress and Results

Researchers examined the phenotypic and genotypic diversity of flagellar filaments from *C. botulinum* Group I and Group II strains belonging to serotypes A, B, E, and F. Transmission electron microscopy indicated variability in the degree of flagellation, ranging from no flagella on some strains to extensive flagellation on other strains. Analysis of isolated flagella by sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE), followed by mass spectrometry peptide identification of putative flagellin proteins, showed that Group I strains typically produced one or more flagellins of approximately 30 kDa. Group II type B and F strains produced multiple flagellins ranging in apparent molecular weight from approximately 30 to 40 kDa. Type E strains produced a major flagellin with an apparent molecular weight of approximately 50 to 53 kDa, in addition to flagellins of approximately 30 kDa. Despite extensive diversity in apparent molecular weight, the amino and carboxyl terminal sequences of all *C. botulinum* flagellin proteins examined were highly conserved and matched the sequence of two tandem and highly homologous open

reading frames identified amongst five putative flagellins within the Hall A genome sequence. Given the structural components of *C. botulinum* flagella and the high homology between the tandem copies, these open reading frames were designated as flaA1 and flaA2.

The variable middle portions of these flagellin genes from 75 strains of both Group I and Group II *C. botulinum* were sequenced. Strains clustered into Group I and Group II, suggesting that the divergence observed in the flagellin protein profile is also present at the DNA sequence level. Sequences clustered into several flagellin classes within each group and did not correlate to the neurotoxin serotype, suggesting that flagellar gene typing could enhance the current strain identification system based on the seven neurotoxin serotypes. In addition, a second flagellin gene was identified that, while possessing the same conserved regions as flaA1/A2, contained a much larger variable region. Mass spectrometry confirmed that this larger open reading frame corresponded to the Group II type E-specific flagellin. As a second structural component of *C. botulinum* flagella, this open reading frame was designated flaB.

Impact

This work will be used as a tool for rapid forensic identification to the strain level for *C. botulinum*, and marks a significant improvement over more time-consuming or less discriminatory methods currently used. The tool will be available by the end of the project for use by the Botulism Reference Service for Canada, or other interested laboratories. It will be accessible to any operational laboratory capable of PCR amplification and with access to DNA sequencing of PCR products.

More detailed determination of the glycan structure on *C. botulinum* flagellin will validate the use of glycosylation genes in the genome for the development of PCR-based typing encompassing flagellin and glycan biosynthetic genes. The microarray will be used to determine whether the expression of glycan biosynthetic genes change with environmental shock or growth conditions. This has potential forensic applications if the glycan structure is determined by the growth conditions of *C. botulinum*. This project is scheduled to be completed by March 2007.

CRTI 02-0093RD // Advanced Emergency Response System for CBRN Hazard Prediction and Assessment for the Urban Environment

PROJECT LEAD:
Environment Canada – Canadian Meteorological Centre

FEDERAL PARTNERS:
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Objectives

The objective of this project is to develop and validate a prototype state-of-the-science, multi-scale, multi-physics modelling system to predict the transport and dispersion of CBRN materials into the urban environment and beyond.

This undertaking consists of five major components. First, the project team will develop a "building aware" and "virtual building" model (urbanSTREAM) to predict urban flow on a microscale. Once the model is developed, the team will include a subgrid-scale urban parameterization in a meso-Á scale numerical weather prediction model (GEM-LAM). Next, researchers will couple the urban microscale flow model (urbanSTREAM) with the "urbanized" GEM-LAM. The team will then develop a Lagrangian Stochastic (LS) model (urbanLS) to predict urban dispersion. Finally, researchers will validate the fully coupled multi-scale modelling system for urban flow and dispersion prediction in a real cityscape.

In the context of the Public Security Technical Progarm (PSTP), a sixth component was added to the project involving collaboration with United States scientists to use full-scale urban field experiments obtained in Oklahoma City, Oklahoma and Montréal, Quebec to validate CBRN model prediction capabilities for the urban complex. Under this component, researchers will also investigate methodologies to determine the emission source distribution (source reconstruction) from the limited information provided by a finite and noisy set of concentration measurements by a network of CBRN sensors. A prototype of the modelling system will be in place at Environment Canada's Canadian Meteorological Centre (CMC) in March 2007.

Relevance

The prototype modelling system will serve as a high-precision predictive tool to plan scenarios; predict injuries, casualties, and contamination resulting from a CBRN incident in the urban environment; and to conduct forensics and post-release analysis. As such, the modelling system can provide a strong technical and scientific foundation to support Canada's more broadly based effort to advance counterterrorism planning and operational response capabilities. The modelling system can provide critical information to emergency managers

for planning and emergency response at special events (e.g., G8 summit, winter Olympics, etc.). Finally, the modelling system will contribute to other CRTI projects such as those related to development of the Accident Reporting and Guidance Operational System (ARGOS) or the Canadian Health Integrated Response Platform (CHIRP).

Recent Progress and Results

The urban microscale flow model (urbanSTREAM) introduces a number of state-of-the-art numerical techniques, such as complex geometry, adaptive mesh refinement, a non-oscillatory advection scheme, a multi-block approach with domain decomposition, and virtual buildings. These techniques have enabled the project team to realistically predict high-resolution urban flows in a real cityscape. The team has tested a parallelized version of urbanSTREAM on a number of different Beowulf clusters, and will transfer the code to the CMC's massively parallel IBM computer system. The fully three-dimensional (3-D) field of wind and turbulence statistics provided by urbanSTREAM is used to "drive" the Lagrangian Stochastic model (urbanLS) for urban dispersion prediction. To date, the project team has tested the performance of urbanSTREAM and urbanLS against flow and dispersion in obstacle arrays measured in a water channel. Validation of model predictions against the full-scale Joint Urban 2003 (JU2003) field experiments in Oklahoma City, Oklahoma has begun.

The effects of the complex urban surface on the subgrid scales of the meso-Á scale global environmental multiscale limited area model (GEM-LAM) have been included through a Town Energy Budget (TEB) parameterization scheme. The TEB scheme has now been included into the physics package of the GEM and Mesoscale Compressible Community (MC2) models. The team has developed a general and innovative methodology to use satellite-derived data to provide a semi-automated urban land-use classification for a number of North American cities. Urban land use and classification data have been obtained for Oklahoma City, Oklahoma; Montréal, Quebec; and Vancouver, British Columbia. A 3-D turbulence kinetic energy (TKE) model has been implemented in MC2 (and will be also implemented in GEM) to better represent turbulence at the smaller scales. Two field campaigns were successfully conducted in Montréal in 2005 and 2006 (Montréal Urban Snow Experiment [MUSE]) to document the evolution of surface characteristics and energy budgets in a dense urban area under winter conditions. Work to evaluate the performance of the TEB scheme under these conditions has begun. Finally, work has begun on the coupling of urbanSTREAM with the "urbanized" GEM-LAM, whereby the latter model will provide the lateral boundary conditions for the former model (downscaling of the information). Validation of the coupled models using data from JU2003 has begun.

Through supplemental PSTP funding, a partnership with scientists at Lawrence Livermore National Laboratory (LLNL) will be initiated to undertake collaborative work in two areas: validation of each country's respective modelling systems using data sets from full-scale field urban field experiments (e.g., JU2003 and MUSE), and research into the development of a methodology for inverse source determination.

Impact

Once validated, this modelling system will enable decision makers and first responders to accurately predict a CBRN agent's movement and fate in the complex urban environment. It will form a fundamental basis on which they act to mitigate the effects of a particular CBRN incident in a real city. The modelling system will contribute to the development of an automated and integrated response system. Furthermore, it will be applied to specific high-profile events such as development of CBRN counterterrorism measures for the 2010 winter Olympics in the Vancouver–Whistler region. The modelling system has the potential to serve as a nationwide general problem-solving tool and resource for first responders involved in addressing CBRN incidents.

CRTI 03-0005RD // Sensor Technology for the Rapid Identification of Pathogens Used as Bioweapons

PROJECT LEAD:
National Research Council Canada – Industrial Materials Institute

FEDERAL PARTNERS:
National Research Council Canada – Steacie Institute for Molecular Sciences, Public Health Agency of Canada, DRDC Suffield

INDUSTRY PARTNER:
Becton, Dickinson and Company

OTHER PARTNERS:
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Objectives

The scope of this three-year project includes development of a novel technology that will lead to a rapid and sensitive detection system capable of identifying biological pathogens such as anthrax and plague used as bioweapons. The technology is based on luminescent polymeric transducers, which use certain polymers as transducers to detect and identify biological agents. The key goal of the project's researchers is to construct a functional prototype that can directly identify, in just one hour, fewer than 10^3 *Bacillus anthracis* cells and spores, either from a pure culture or from spiked test samples. Following its construction, the research team will move to the Public Health Agency of Canada's Level 3 laboratory in the third year of the project, to simultaneously detect multiple biological warfare agents by diffusing magnetic particles with different functionalities through the DNA sample and then trapping them. The result will be the confinement of a number of different DNA targets, a capacity that could be expanded in the future.

Relevance

A revolution in the field of bioagent detection will occur when low-cost portable devices that can quickly detect and identify nucleic acids—without the time-consuming process of prior amplification—become available. This

project aims to develop such a sensitive, rapid, and compact technology. Once implemented in a portable device, this novel and simple polymeric technology could enable first responders and public health providers to rapidly detect and identify potential bioweapons on-site and in real time. It should also improve the capability of medical triage procedures and tools for the detection and classification of medical events, as well as contribute to the efficient diagnosis of infectious diseases and genetic disorders.

Recent Progress and Results

The project team has already made important progress in establishing proof of concept that its polymeric transducer can be used to rapidly detect *B. anthracis*. To date, 300 copies of target DNA have been detected from a gene sequence isolated from *B. anthracis* in approximately 10 minutes. Detection was done directly in solution without prior polymerase chain reaction (PCR) amplification. Since that time, researchers have developed an even more efficient detection process, detecting in just a few minutes fewer than 30 copies in solution through tests on synthetic DNA oligonucleotides (oligos). The project team's next steps are to use the new detection process to detect DNA from *B. anthracis* on a solid surface, which requires isolating and detecting suitable DNA fragments from the bacterium that causes anthrax. The team has managed to obtain fragments of different lengths following testing of several methods to purify and fragment *B. anthracis*. Based on an analysis of these fragments, the team has selected the fragments most suitable for detection.

Progress has remained steady throughout the past year. Researchers have fabricated a second generation of electromagnetic "traps" based on a mixed architecture of ring and micropost that has increased trapping power tremendously. These electromagnetic traps are to be implemented in a microfluidic structure in the coming year. This year also saw the team select optimal capture and detection probes for *B. anthracis* according to plan. Their work on magnetic probes is ongoing and already a provisional patent has been filed on a new architecture of a fluorescent probe that could increase the sensitivity of detection even further. A focus on developing cationic transducers has led project researchers to synthesize many different polymer structures to improve detection efficiency and test these with the probes isolated from *B. anthracis*. Improvements on polymer structure are still ongoing. Developments in all areas of the project work are converging towards the project's end in September 2007 when the team will provide a demonstration of the technology under real conditions.

Impact

The impact of this revolutionary technology is enormous: not only will it provide military and civilian personnel with the fastest response time to biological threats, but it will give Canadian biotechnology companies a significant competitive edge over existing 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:
University of Ottawa – Institute of Population Health

FEDERAL PARTNERS:
Health Canada – Bureau of Women's Health and Gender Analysis, Department of National Defence

OTHER PARTNERS:
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 the literature for information about the support available for health care workers as first responders. They will ask 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. 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.

Researchers will use a variety of methodologies to achieve their objectives, including secondary data analysis, survey development and administration, gap analysis and development of a risk management framework using focus groups and policy analysis, and a policy forum for information dissemination and consultation with policy makers.

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. Their health and safety is critical during such events, as is their willingness to continue working during a large-scale outbreak. The population depends on the capacity and willingness of knowledgeable caregivers to provide health services and control infection.

The 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. It will highlight the need for gender-sensitive policy making since disasters affect men and women differently, and it will provide decision makers with insight into critical issues facing frontline health care workers, and the potential impact of large-scale bioevent disasters on Canada's response capacity.

Recent Progress and Results

Results from a series of five focus groups held in the Ontario cities of Ottawa and Toronto, as well as Vancouver, British Columbia and Halifax, Nova Scotia, suggest that the concerns of frontline nurses are similar from coast to coast. Nurses report feeling unprepared, unsupported, and torn between loyalties to their profession and to their families, who may fall ill because of exposure to many different sources of infection brought home by the working nurse. The need for education and training emerged as a dominant theme in these discussions, particularly as a proactive step toward preparedness.

It is clear from the findings of this study that health care workers are concerned about their roles as first responders in infectious disease outbreaks. They want their voices to be heard and reflected in proactive policies and procedures that will enhance Canada's collective ability to combat a large-scale outbreak, and protect them and their families as they participate in emergency response.

The next step for project researchers is to complete the survey data collection and prepare a report on the survey component in the fall of 2006. Throughout the next year, they will conduct a gender-based analysis of the survey results, the results of the focus group, and the updated literature review.

Impact

Researchers are disseminating knowledge gained through their project work on an ongoing basis. Plans are in place to provide all 100 focus group participants with a summary of the results from the project. 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 Health Canada Office of Nursing Policy. The final component of the project includes a workshop for policy makers that will be held in 2007. The final project report is targeted for March 2008.

CRTI 03-0013TD // Early CBRN Attack Detection by Computerized Medical Record Surveillance

PROJECT LEAD:
National Research Council – Institute for Marine Biosciences

FEDERAL PARTNERS:
National Research Council – Institute for Information Technology, Public Health Agency of Canada

INDUSTRY PARTNER:
AMITA Corporation

OTHER PARTNERS:
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Objectives

Through the collection and analysis of statistical data on health trends, syndromic surveillance systems are designed to detect the occurrence of abnormal diseases through time- and geography-dependent indicator variables. Such variables may include school absenteeism, over-the-counter drug sales of specific drugs (e.g., anti-diarrhea agents), and the number of patients presenting to emergency rooms with symptoms and physical signs typical of a specific disease. These surveillance systems can be used to alert first responders that a natural disease outbreak or terrorist attack may be in progress, and to track the progress of the outbreak after it has been detected.

This project will build on the Real-Time Outbreak Detection and Surveillance (RODS) 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. An outline of the steps needed to integrate the ECADS system with existing and planned surveillance systems in Canada and the United States will follow, along with development of a road map for implementing syndromic surveillance in Canada.

Relevance

The sooner public health officials know about a bioterrorist event, the more decisively they can intervene to stem its spread. The capacity of the ECADS system to detect bioterrorist events earlier than would be possible with traditional disease surveillance systems will address several of the highest risk scenarios identified by CRTI. In the absence of a terrorist attack, syndromic surveillance

systems will also provide public health officials with the ability to detect and manage naturally occurring disease outbreaks.

Recent Progress and Results

The ECADS system was successfully demonstrated with retrospective data from Walkerton, Ontario, in relation to the *Escherichia coli* contamination of the municipal water supply that occurred in 2000 and resulted in six deaths and widespread illness. The outbreak provided a model for what might happen following a bioterrorism attack using an enterotoxic agent.

The project team accessed 396 698 emergency room records, 392 699 of them electronically and 3 999 manually. Analysis of the data showed that surveillance of the chief complaints of patients presenting to area emergency rooms would have provided important information regarding the *E. coli* outbreak, and might have advanced its detection by as much as several days. Had the ECADS system been used, the outbreak could have been detected at least two days before public health officials issued the first alert, and possibly as early as four days before they released the boil-water advisory. This indicates that routine syndromic surveillance of emergency room data may provide information that can help in the detection, characterization, and management of outbreaks of naturally occurring or terrorist-induced infectious diseases.

Based on their experience with the Walkerton retrospective data, the project team is adding text-mining algorithms to increase the specificity and sensitivity of the ECADS system. The team has also held two scientific exercises and meetings to demonstrate the system and to share information and ideas with leading scientists from other syndromic surveillance projects.

In December 2005, the team successfully installed the ECADS system in the Grey Bruce Public Health Unit in Owen Sound, Ontario. Staff from the AMITA Corporation monitor and maintain the system daily via remote services and report that they have not yet encountered any technical difficulties. Since installation of the ECADS system, the Grey Bruce Public Health Unit has issued two alerts to area emergency departments based on data collected and analyzed by the ECADS system. The gastrointestinal alert detected through the system was confirmed by Health Canada's over-the-counter sales surveillance system.

With completion of a draft *Roadmap* and a *Privacy Impact Assessment*, the team also made progress on its goal of providing direction for implementing syndromic surveillance in Canada.

Impact

By the end of the project, researchers will have produced a software system able to process medical data in real time and generate alerts for public health or antiterrorism first responders. Such alerts will ensure that first responders are better informed and better prepared for naturally occurring or terrorist-induced diseases. The researchers will also have developed a road map that describes the steps and processes that must be taken to integrate the ECADS system within Canadian systems, taking into account technical and other issues such as privacy assessments. The road map is targeted to first responders, municipal, provincial, and federal public health and safety communities, and the military.

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:
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OTHER PARTNER:
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Objectives

The isotropic nature of conventional radiation detectors makes it difficult to remediate areas contaminated with radiological materials rapidly when fragments of the material are strewn over the area and lie close to one another. 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 aims to address these issues by incorporating directionality into a portable gamma ray spectrometer.

The project team will develop two detectors. The first detector will be developed for use in high-level radiation fields to localize the source of radiation and rapidly remediate radioactive material spread over an area. The second, highly sensitive detector will be developed for use in low-level radiation fields (i.e., outside a hot zone) to detect, localize, and identify lower radiation activity or shielded sources. Researchers will seek input from first responders into the design and testing of the device to ensure the detectors meet their needs.

Relevance

Current detectors have several shortcomings in identifying a single source of radiation in the presence of multiple sources. The use of the directional gamma ray probe (DGRP) will greatly improve response capability to CBRN terrorist events by enabling responders to locate, identify, and determine the activity level of radiation sources more rapidly and accurately. Several groups of responders have already contributed to the development of the proposed devices. Following completion of the project, the DGRP will initially augment the responder community's suite of radiation detection devices, but with time, project researchers expect it will replace current hand-held spectroscopic units that do not offer the invaluable directional information.

Recent Progress and Results

Over the past year, the project team has focused on constructing and refining the high-level radiation field DGRP, and built and tested three detection systems. The directional sensor, which consists of four Geiger-Muller tubes positioned in quadrants separated by lead shielding, localized a radiological source to within ± 7.5 degrees of the horizontal, in agreement with Monte Carlo calculations. The spectroscopic sensor is made up of a lanthanum bromide crystal coupled to a tiny photomultiplier tube (PMT). Testing of the sensor demonstrated the excellent energy resolution of the scintillation crystal, enabling sources in high-level radiation fields to be identified. Researchers also constructed, tested, and then redesigned the auto-calibration system to improve its functionality. Team members presented these aspects of the detector design at the Institute of Electrical and Electronics Engineers (IEEE) 2006 Nuclear Science Symposium.

The project team completed development of the software, incorporating input from the responder groups that resulted in improvements to the user interface display and control. The team also designed a membrane switch that replaced the initially proposed joystick for device control. The researchers then optimized the size and orientation of these subsystems, as well as the improved electronic printed circuit boards, batteries, and on-board global positioning system (GPS), and mounted them all in a custom-designed, moulded plastic enclosure. The team is currently testing the final prototype in laboratory and operational environments and expects it to be complete in early fall 2006.

At the same time, team researchers have been designing and constructing the sensitive DGRP. This involves construction of the detector assembly, which now uses four sodium iodide scintillation crystals coupled to individual PMTs to provide both directional and spectroscopic information. Other work has included redesigning the electronic printed circuit boards, which are now being laid out, and designing a new casing for the detector to accommodate the different sensor shape and size. Although the design of this detector is quite different than that of a high-level radiation field device, there are similarities in the way data are displayed and controlled. The team is aiming to complete the final prototype in late summer 2006 and follow it up with device testing in the laboratory and aboard a United States Coast Guard vessel. Although testing is still a few months away, the researchers are already developing scenarios for the operational field trials.

Impact

While both the low- and high-level radiation field detectors indicate the direction of the radioactive source—a feature not available in any commercially available detector—the development of a sensitive, hand-held spectroscopic detector that incorporates directionality represents a breakthrough in radiation detection technology in high-level radiation fields. With it, responders can identify isotopes in the high-level fields. Moreover, 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 reducing the radiation dose to which they 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. Responder testing is planned for the remainder of the project.

CRTI 03-0018RD // Experimental Characterization of Risk for Radiological Dispersal Devices

PROJECT LEAD:
DRDC Ottawa

FEDERAL PARTNERS:
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OTHER PARTNERS:
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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 overstate their impact greatly. 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.

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 have been 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 is characterizing the explosive dispersal of radiological material at DRDC Valcartier using non-radioactive ceramic simulants provided by the University of British Columbia. The explosives range at the DRDC Valcartier facility enables the researchers to perform these experiments in closed and open environments. The team began indoor testing in September 2005, completing three full weeks of testing by March 2006. The team determined the amount and the particle size distribution of the RDD-generated aerosols through the indoor tests. To complement the source terms established through the indoor tests, the team began a series of outdoor tests in October 2005 that are still ongoing.

For the outdoor tests, the team is using benign tracer materials that were characterized in the indoor explosive testing to simulate the release of radioactive materials in real atmospheric conditions. The team is then tracking the generated plume with a light detection and ranging (LIDAR) system. Project team members from the Royal Military College of Canada and Environment Canada are using the measurements of the plume evolution to validate atmospheric dispersal models.

The team is characterizing the non-explosive dispersal of radiological material at the University of Ontario Institute of Technology (UOIT). These tests involve the characterization of spray mechanisms for liquid and powdered sources, as well as methods for mechanical and chemical source preparation. The team is determining particle-size distribution using a laser-based particle sizer, cascade impactors, and other aerosol samplers. Researchers began powder spray testing in the summer of 2005 and were still conducting the tests by March 2006. In addition to the experimental work, the researchers are conducting spray-nozzle modelling using computational fluid dynamic models to predict nozzle properties.

Team members from Health Canada, Carleton University, and Acadia University are assessing the health effects of RDD-generated aerosols. Researchers are conducting a chemical analysis of air samples taken during the indoor explosive tests to characterize the aerosol generated. The type of sample taken will determine either the fraction of the original source that is aerosolized or the particle-size distribution. The team will use other analyses to determine the morphology of aerosol particles to gain insight into the physical mechanism involved in the generation of the aerosol, and enable them to develop predictive models that can be used to generalize the results of these experiments for 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, which will enable 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:
McFadden Technologies Ltd.

FEDERAL PARTNERS:
Health Canada – Radiation Protection Bureau,
Ottawa International Airport Authority, Transport Canada

INDUSTRY PARTNER:
Mobile Detect Inc.

OTHER PARTNER:
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Objectives

The purpose of this project was to deploy a fully integrated radiological surveillance system to the Ottawa International Airport (OIA). The system provides sensitive, real-time detection of gamma radiation with sensors deployed in covert static and mobile locations and uses telecommunications systems to transmit data to a central server and database. The system transforms radiological data into meaningful graphic information integrated with the airport security and emergency response systems and operations. It characterizes the normal radiological environment of the approach, public, passenger, baggage, airport operations, tarmac, staff, and air crew areas of the airport 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.

Health Canada's Radiation Protection Bureau (RPB) acts as technical authority for the project. The RPB has developed liaisons with the OIA and the Ottawa Police Service, Transport Canada, and the Department of National Defence (DND).

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 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 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). These essential human system developments are the result of cooperation among the airport operations and security teams and other members of the project team. The system has collected over six million radiation measurements in the OIA to date.

The system has a graphical user interface with user options relevant to incident management and can be used to view real-time or historical radiation data overlaid on mapping or aerial images. The user 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 characterize the normal radiological environment in the area under surveillance. It generates alerts by comparing real-time radiation data with pre-defined alert criteria. System users define the alert criteria to achieve the optimal balance between the cost of false positives and the required system sensitivity. Users can adjust alert criteria to respond to a variety of radiological terror threat levels. Telecommunication between the remote sensors and the central server can be made via wide-area wireless networks, satellite, local-area wireless networks, or Ethernet.

Deployed radiation sensors are two-litre plastic scintillation detectors with automatic targeted spectroscopy (ATS) that are controlled by a mobile detection unit with an onboard computer that includes a global positioning system (GPS), telecommunications, and power management. ATS exploits the available energy resolution to discriminate among expected terror agents and legitimate radiation sources.

Users can select the size of the sensors from a wide range of options with trade-offs in sensitivity, weight, volume, and ruggedness for applications in mobile, static, and covert operations. The system provides intelligent management and support of other radiation detectors (e.g., neutron, third party), as well as other chemical and biological sensors and will integrate their data with system radiation data.

Impact

The system provides autonomous, 24/7, cost-effective, and practical radiological surveillance and radiological threat agent identification, which significantly enhances 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 concept of operations and standard operating procedures among cooperating incident response and management agencies.

It is anticipated that other airports in Canada and abroad will soon adopt the system. 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

OTHER PARTNER:
Winnipeg Regional Health Authority

INDUSTRY PARTNER:
IBM

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Objectives

In this project, IBM will partner with the Public Health Agency of Canada's Canadian Network for Public Health Intelligence (CNPHI) and the Winnipeg Regional Health Authority (WRHA) to deliver a comprehensive, cost-effective, real-time biosurveillance and response readiness network for the city of Winnipeg, Manitoba. IBM's Healthcare Collaborative Network (HCN) will be combined with the CNPHI to provide an interconnected, Internet-based network that will enable the secure transmission and dissemination of key health-related data and intelligence important for bioterrorism event detection and response. For this project, the network will focus on the occurrence of unusual clusters of gastrointestinal and respiratory syndromes.

Relevance

In the event of an intentional CBRN event in Canada, regional health authorities will play a key role in frontline surveillance and response. Unusual clusters of disease will most likely to be identified at the community level, and regional health authorities will be responsible for providing and delivering effective response measures. Currently, health information in existing regional health infrastructures is captured throughout many "points of care," and the ability to move and consolidate the information for analysis is primitive. Delays in detection, and to a lesser extent the speed at which characterization proceeds, make it clear that existing systems cannot detect outbreaks of disease with the timeliness needed for an optimal response to many bioterrorist events.

This project, which builds on and leverages the complementary CNPHI and HCN technologies, will increase capacity for real-time detection and assessment of a CBRN event in a large urban centre. It will provide an opportunity to implement strategies to reduce exposure and limit disease, and to mobilize frontline response personnel and deliver resources where they are needed.

Recent Progress and Results

This project is now 19 months into a 24–month project plan. The technology infrastructure for the real-time biosurveillance system has been successfully implemented and a team has been established to support the infrastructure and user community.

The project partners identified three real-time data sources to contribute to the project: emergency room data from all Winnipeg acute care facilities; phone calls into a 24-hour, seven-days-a-week (24/7) health help line; and the over-the-counter sales of pharmaceutical drugs from a major retailer in the city. These data sources were connected and more than one year's historical data from the WRHA and pharmaceutical retailer has been transferred over the technology infrastructure. The data transfer from the WRHA and the pharmaceutical retailer demonstrated the stability and scalability of the technology infrastructure. The project partners then added three more over-the-counter national pharmaceutical retailers to the network. They also implemented the second version of the Canadian Early Warning System (CEWS), a web-based syndromic surveillance analysis engine. CEWS V2 now supports 10 analytical algorithms and seamlessly integrates with the CNPHI for role-based access.

With the implementation phases successfully completed, the project is currently in the analysis and evaluation phase. This phase is broken down into four studies: a retrospective data review, a confirmation study, a prospective data review, and a simulation study.

The project will be completed by September 2006.

Impact

This project has already generated significant interest from many jurisdictions throughout Canada. Over the next several months, efforts will be made to demonstrate the system to public health stakeholders across the country. It is anticipated that the technologies developed in this project will be implemented by many jurisdictions to address current gaps in CBRN and public health surveillance.

CRTI 03-0021TD (1) // Assay Development and Production Team for the Identification of Bioterrorism Agents: Development of New Antitoxin Antibodies and Reagents

PROJECT LEAD:
Public Health Agency of Canada

FEDERAL PARTNERS:
DRDC Suffield, Canadian Food Inspection Agency – National Centre for Foreign Animal Disease

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Objectives

This project has led to the formation of a team of scientists dedicated to developing immunodiagnostic reagents able to identify human, animal, and zoonotic biothreat agents that can be validated, produced, and distributed to first responders in the event of a biothreat event. One of the specific goals of the project team is to produce reagents and assays useful for detecting and identifying the bacterial biothreat toxins produced by *Clostridium botulinum* serotypes A, B, and E, which are responsible for the majority of naturally occurring human intoxications. The team will develop a panel of specific anti-clostridial neurotoxin reagents, which will enable them to develop assays to detect, diagnose, and potentially neutralize or block the deadly toxins. The project team will also test the reagents they produce for their ability to neutralize toxin action.

Relevance

The *C. botulinum* neurotoxins (BoNT) are among the most toxigenic bacterial compounds known to humans and are high on the consolidated threat list of select agents and toxins. Although natural intoxication can occur, the deliberate release of clostridial neurotoxins could cause extensive disease and death in the population. Frontline responders and the Canadian public health care system as a whole need high-quality immunoreagents to detect, limit, and provide treatment

during such a biothreat event. Since current antitoxin therapies use convalescent sera to neutralize toxins, the development of reagents that can neutralize toxin may lead to new CRTI projects on therapeutic antibody development.

Recent Progress and Results

The project team has developed high-quality monoclonal antibodies (mAbs) specific for heavy chains of BoNT for diagnostic and therapeutic research and development. This work involves characterizing mAbs to BoNT serotypes A, B, and E, which is ongoing. Efforts to develop mAbs against BoNT serotypes A have been successful and include an evaluation of their reactivity to the natural holotoxin complex. The team has also produced recombinant neurotoxin heavy chains and synthetic peptides for use as immunogens. Team researchers have already demonstrated the sero-reactivity of mice using the recombinant heavy chains as antigen.

The team has also developed a high-throughput screening assay using fluorometric microvolume assay technology (FMAT) to enable the screening of anti-botulinum hybridoma clones. Because the assay uses much less antigen and increases screening capacity, end users will be able to screen larger numbers of clones when antigen is limited, and provide surge capacity. The throughput methodology may also be used to analyze and identify site-specific mAbs, epitope binding, and cross-reactivity, as well as to develop serodiagnostic assays for public health. These findings can be applied to and even accelerate the development of mAbs to specific targets without arraying devices.

Impact

Project researchers are using the anti-BoNT mAbs and high-throughput assays developed during the project to develop assays for detecting and identifying pathogenic organisms, or their components, that pose a threat as bioterrorism agents. Development and production of these reagents and assays will ensure that Canada has a ready supply of high-quality products in emergencies when international borders may shut down and reagents become limited. The use of such high-quality reagents for detecting infectious agents rapidly will also improve the protection of frontline responders and Canadian citizens. It is anticipated that all of these benefits will contribute to public confidence in the ability of the Canadian public health care system to respond to infectious disease outbreaks or biothreat events.

CRTI 03-0021TD (2) // Assay Development and Production Team for the Identification of Bioterrorism Agents: Development of New Reagents and Antibodies Related to Bacterial Bioterror Agents

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

This project has led to the formation of a team of scientists dedicated to developing immunodiagnostic reagents able to identify human, animal, and zoonotic biothreat agents that can be validated, produced, and distributed to first responders in the event of a biothreat event. A specific goal of this project is to produce immunoreagents and assays that can be used to detect and identify the bacterial biothreat agents *Bacillus anthracis*, *Yersinia pestis*, and *Francisella tularensis*. Upon the discovery of a candidate diagnostic reagent, such as a protein, peptide, or monoclonal antibody (mAb), project team researchers will develop it into a viable assay that can be validated according to accepted international standards. Once the validation is complete, the assay can be adopted by first responders, including frontline provincial and territorial laboratories, reference laboratories, and response networks.

Relevance

The availability of diagnostic assays during a biothreat emergency is critical. The intentional release of biothreat agents would have a severe impact on human health, the public health system, and the economy. With the capacity to detect and identify biothreat agents quickly, first responders will be able to contain and respond more

easily and rapidly, mitigating the overall impact of the biothreat event. The core team formed in this project will ensure that relevant diagnostic assays are produced and available in Canada during an emergency, without the need to depend on foreign suppliers.

Recent Progress and Results

Over the past year, new staff and expertise were added to the core team at the National Microbiology Laboratory (NML), and staff from DRDC Suffield were cross-trained in the NML hybridoma facility. The team is already at work developing new mAbs specific for *F. tularensis* and *Y. pestis*, and has identified several candidate proteins in *F. tularensis* as potential immunogens for generating suitable diagnostic mAbs. In preparation for expressing and purifying these proteins, the team successfully amplified the genes encoding the proteins into a suitable bacterial plasmid vector with polymerase chain reaction (PCR) for cloning. The team has also obtained bacterial plasmids expressing the Fraction 1 (F1) and V antigens from *Y. pestis* from an American collaborator. Since protein expression and purification, the team has been using the proteins as immunogens for mAb production, enabling them to complete the initial characterization of several mAbs specific to numerous *F. tularensis* and *Y. pestis* antigens.

The core project team has fully characterized and incorporated into the project, diagnostic mAbs for *B. anthracis* toxins that were developed in a separately funded CRTI project. The project researchers have since distributed these mAbs to international collaborators, and are currently assessing them for development into diagnostic assays. Building on this other CRTI project has enabled the mAb section of the NML to establish a pipeline for distributing reagents through the Canadian Public Health Laboratory Network (CPHLN), including several related to influenza.

The project team has tested and assessed high-throughput screening assays using the ABI 8200 Cell Analyzer. A hollow fibre system enabled the team to produce batches of mAbs, which, following testing and characterization of the end products, led to the determination that the team had obtained satisfactory mAb reagents. Use of the ABI 8200 and the hollow fibre systems, coupled with the recently increased capacity for medium-scale growth of hybridoma cultures, has led to a significant increase in the capacity to produce mAbs in the mAb section of the NML. This increased capacity will allow researchers to develop new mAbs more efficiently, and to produce batch quantities of existing mAbs for immunodiagnostic assay production and distribution.

The team is involved in ongoing discussions with the Canada, United Kingdom, United States (CAUKUS) Detection and Diagnostics Reagents Working Group (CBRN Memorandum of Understanding on Biodefence) and the United States Critical Reagents Program (CRP) on the potential for collaborating to develop antibodies and assays.

Impact

The core project team expects that the reagents and assays they develop will detect and identify pathogenic organisms that pose a threat as biothreat agents, improving the ability of first responders to provide rapid and effective treatment to affected citizens and protect themselves. This improved ability to respond to a biothreat event will also contribute to public confidence in the effectiveness of Canada's response efforts. Moreover, developing and producing these assays in Canada will ensure that first responder laboratories have a ready supply of high-quality reagents and that they will not have to turn to foreign sources for supplies when time is critical. The team expects the project to be completed in the winter of 2007.

CRTI 03-0021TD (3) // Assay Development and Production Team for the Identification of Bioterrorism Agents: Rational Use of Crystal Structure Information for Site-Specific Monoclonal Antibody Development to Clostridial Neurotoxins

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

This project has led to the formation of a team of scientists dedicated to developing immunodiagnostic reagents able to identify human, animal, and zoonotic biothreat agents that can be validated, produced, and distributed to first responders in the event of a biothreat event. A specific goal of this project is to develop diagnostic monoclonal antibodies (mAbs) to bacterial toxins produced by well-established or newly emergent pathogenic microbes. These antibodies will be used to develop useful diagnostic assays and for advancing therapeutic research.

Relevance

The *Clostridium botulinum* neurotoxins (BoNT) are among the most potent toxins and are classified as biothreat agents. In March 2006, one of the world's worst outbreaks of botulism occurred in Thailand when villagers ate bamboo shoots contaminated with a neurotoxin produced by the bacteria *C. botulinum*. The outbreak highlighted the importance of developing simple methods to detect and identify toxins directly from food sources to assist in treatment. This is especially so since botulism, for example, is frequently misdiagnosed and samples must be obtained before antitoxin treatment can begin.

Recent Progress and Results

The project team has determined the crystal structure of several BoNT serotypes using known structural data to guide the development of antibodies in a rational fashion. The DeepView application (<www.expasy.org/spdbv>) used to simultaneously analyze several proteins and the high-resolution crystal structure images of BoNT Type B enabled the team to select regions of the neurotoxin as supposed immunological epitopes. Researchers selected 10 epitopes from the whole BoNT Type B molecule based on apparent surface exposure and commercially generated peptides used to immunize mice. They then immunized sets of mice with a different peptide targeted to the cell-binding domain of BoNT Type B. All three peptides generated a homologous anti-peptide antibody response. Trial bleeds taken from the mice immunized with specific peptides revealed that two of the three peptides are immunogenic for the recombinant HC-50B protein. When researchers compared the local secondary structure they discovered that the peptide epitope 179 is looped into a major lasso structure and fixed at both ends by the three-dimensional structure of the toxin. These data demonstrate that rational design of site-specific mAbs is useful for developing serodiagnostic assays for public health.

Impact

New and re-emerging infectious threats emphasize the need for quality immunoreagents and the need to maintain expertise in mAb development. This project will lead to the development of new diagnostics, as well as enhance fundamental knowledge of antibody development technology. These insights may be translated into useful diagnostic tools and practical therapeutics and vaccines for an effective response to bioterrorism.

CRTI 03-0023TD // Portable and Collapsible Chemical and Biological Isolators

PROJECT LEAD:
Public Safety and Emergency Preparedness Canada

FEDERAL PARTNERS:
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INDUSTRY PARTNER:
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Objectives

In the case of a major CBRN incident, emergency response agencies are mandated to assist with the real-time, on-site analysis of suspect materials. Procedures for handling these materials involve opening the container or package, performing preliminary tests on its contents, sampling the contents, packaging any samples, and resealing the container—all without accidentally releasing the suspect materials or endangering the health and safety of responders and the public at large. While existing equipment can safely contain either chemical or biological materials, there is nothing available that will safely contain both materials and that is small enough or light enough to allow for rapid deployment.

As a result, the objective of this project was to develop two affordable, portable isolation devices that would meet biological containment requirements for Risk Group IV pathogens, as defined by the Public Health Agency of Canada (PHAC). These devices would enable first responders to safely handle all suspect materials, including all known chemical warfare agents. The aim was to make one of the devices a rapidly deployable, lightweight isolator to allow for on-site collection, containment, and processing of suspect materials. The other device was intended to be a larger portable isolator.

Relevance

The isolators developed in this project will be adopted and demonstrated by the operational members of the project team, including personnel from the PHAC and the Royal Canadian Military Police (RCMP). These units were designed to ensure that, when produced in commercial quantities, they would be affordable and available to a wide community of first responders and investigative agencies from all levels of government. While the isolator units will be of great use in criminal and forensic investigations, the project team anticipates that they will also be of use wherever there is a need to contain, handle, and analyze potentially hazardous materials.

Recent Progress and Results

The project took two years to complete. In the first year, the project team identified suitable materials, designed the engineering of the isolator modules, and constructed the prototypes. Operational responders from the RCMP's CBRN Response Team, the PHAC's Emergency and Bioterrorism Response Division within the Office of Laboratory Security, and Public Safety and Emergency Preparedness Canada provided specifications for the units.

Once the project team constructed the prototype units, they tested them at DRDC Suffield using simulants for biological containment and live chemical warfare agents for chemical containment. The Office of Laboratory Security, at the PHAC, evaluated and approved the biocontainment capability of the prototypes.

In the last year of the project, the team constructed four additional sets of isolators to be tested and then delivered to first responders. The first responders evaluated and demonstrated the capability of isolators in actual field-use conditions. The PHAC and the RCMP project partners demonstrated the use of the isolators during a major multinational capabilities exercise (CAPEX).

Impact

The portable isolators developed, tested, and demonstrated in this project will fill a gap in the operational capabilities of first responders and other end users. They will have a significant impact on the ability of investigators to handle toxic materials and CBRN agents in both pre- and post-deployment forensic processing events. The isolator units are essential for safely and rapidly processing materials and evidence, and will ensure that the materials are handled according to the proper triage process. Samples collected will meet the acceptance criteria of receiving laboratories where the necessary confirmatory analyses will be performed. Use of these units will also reduce the quantities and, potentially, distances for transporting samples. These factors will facilitate forensic investigations since sample transportation is a significant impediment to investigations.

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 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 detector, developed by Bubble Technology Industries (BTI), which provides immediate detection and measurement of neutrons emitted from RN materials.

Scalability, in both the size of the detector and the network architecture, is a key element in the design of the Defender Nuclear Detection Web. By varying the detector size, a full spectrum of applications can be covered, ranging from a pocket detector for continuous surveillance by authorities and a handheld detector for personal and vehicle inspections to a fixed-installation detector for border checkpoints or rapid cargo container monitoring. The detector's interface, which enables the user to network through an open-architecture protocol, will enable the network to support other types of detectors with the appropriate communications protocol.

BTI is responsible for instrumenting the Defender detectors to provide an automatic readout of the 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, DRDC Ottawa, Transport Canada, the Canadian Police Research Centre, and Raytheon Integrated Defense Systems are participating in the project by providing user input and conducting field testing of the Defender Nuclear Detection Web across a wide cross-section of applications.

Relevance

Many radiation detection systems currently deployed for counterterrorism applications are limited by their ability to detect only gamma radiation. Both the International Atomic Energy Agency (IAEA) and the United States (US) Department of Homeland Security (DHS) have recommended neutron detection capabilities to assist in intercepting illicit RN materials. However, it has been historically difficult to provide widespread neutron detection capabilities due to the high cost and technical complexity of many neutron detection systems.

The nuclear detection web will address these limitations. It will provide an unparalleled, low-cost neutron detection system with the sensitivity and broad coverage to successfully detect illicit RN materials before they can be assembled into a weapon. Its flexible and readily tailored network will improve the communication of critical data between local and federal authorities and among federal agencies. It also supports 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

The project partners have made significant technological progress on the nuclear detection web over the past year. BTI participants developed and implemented a novel method of automatically reading the neutron level sensed by the Defender detector. They successfully interfaced the instrumented detector to a commercial cell phone, which provides power, GPS information, multi-modal user alarms, and wireless transmission of the sensor data

to the command centre. They also developed a custom software application that runs on the cell phone platform and performs the data analysis required to determine when a neutron alarm is triggered. Xwave researchers developed and implemented a flexible data management network application that collects and archives sensor data, overlays the sensor data onto maps and satellite images, and presents the data to the user in multiple formats and levels of detail.

The project's federal partners are currently field testing the Defender Nuclear Detection Web. Feedback from these trials is being used to guide the next stage of development. The project is expected to be completed in March 2007.

The Defender technology is presently being adapted for use in cargo-monitoring trials with the Canada–US Cargo Security Project.

Impact

In addition to the technological advancement of a unique, highly sensitive neutron detector, this project will result in the development of a flexible, scalable data management network. All five federal agencies participating in the project will retain the instrumented Defender detectors for ongoing use. 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.

CRTI 04-0004RD // Canadian Animal Health Surveillance Network

PROJECT LEAD:
Canadian Food Inspection Agency

FEDERAL PARTNER:
Public Health Agency of Canada

INDUSTRY PARTNER:
TDV Global Incorporated

OTHER PARTNERS:
Government of Nova Scotia, Government of Alberta, University of Prince Edward Island, University of Guelph, University of Montréal, Government of Quebec, Government of New Brunswick, Government of British Columbia, Government of Manitoba, Government of Newfoundland and Labrador, Canadian Cooperative Wildlife Health Centre, Saskatchewan Agriculture and Food, Prairie Diagnostic Services, Saskatoon

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Objectives

The Canadian Animal Health Surveillance Network (CAHSN) aims to improve the capacity of the federal–provincial laboratory network system to detect, in real time, emerging animal disease threats that could have a zoonotic potential, and provide a rapid response to minimize the human health and economic consequences to the country. This will be achieved by establishing a formal network of federal, provincial, and university animal health diagnostic laboratories directly linked to the Canadian Public Health Laboratory Network (CAHLN) that will combine surveillance intelligence received from many sources across Canada. 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 targeted surveillance data, process the data, and disseminate the intelligence for rapid exchange of information and decision making. The Canadian network will also establish a link to the Animal Health Laboratory Network in the United States.

Relevance

It is impossible to prevent the introduction of all agroterrorist agents into Canada. The most effective defence against bioterrorist events threatening livestock production and potentially affecting the human population is 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 that could threaten Canadian domestic food production and export markets, such as highly pathogenic avian influenza (HPAI), foot-and-mouth disease (FMD), classical swine fever (CSF), and Newcastle disease (ND). 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.

The CAHSN project directly addresses the risks identified in the Agri-Food Consolidated Risk Assessment Workshop (held in September 2004) by contributing to the development of background information and databases on animal disease incidence; improving intelligence, surveillance, and internal communications; and

developing networks of experts and expertise. This project also contributes to efforts to increase laboratory and surge capacity, enhance the applications of simulation exercises, and develop a cadre of trained technical staff to respond to an increased diagnostic load. The outcomes of the project directly address the gaps identified in surveillance and analysis, laboratory capacity, and national and international networking. Testing the system directly supports CRTI's investment priority related to early warning systems. It also indirectly addresses CRTI's aim to reduce false-positive rates in CBRN surveillance. The project further contributes to CRTI's priorities related to animal health biosecurity, laboratory cluster management, surveillance and alert, and outbreak investigations by first responders.

Recent Progress and Results

This project is now 6 months into its 36 month project plan. The project was launched in October 2005 with an interactive workshop for the national partners and other stakeholders of the CAHSN. The workshop provided participants with an opportunity to examine the essential elements and core functions of an early warning surveillance system for new, emerging foreign animal diseases in Canada, and to learn about other international surveillance models.

Development of the system is the main thrust of the first year. The collaboration of federal and provincial laboratories and the need to share data will be addressed with a Memorandum of Understanding (MOU). A draft MOU is currently pending circulation to partner laboratories for review. Extensive consultations with the project partner laboratories have been undertaken for them to contribute to the diagnosis of major foreign animal diseases that could be used as bioterrorist agents. Until now, the diagnosis of foreign animal diseases had been the mandate and responsibility of Canadian Food Inspection Agency (CFIA) laboratories. Although this will remain the case, expanding the diagnostic capabilities of provincial and university laboratories to assist in the surveillance for foreign animal diseases will enhance the response to an outbreak. Comprehensive surveys, site visits, and extensive evaluations of the provincial diagnostic laboratories have been conducted to establish a baseline of their respective needs with respect to equipment and training requirements, quality assurance, and biosecurity capacity and protocol issues. The two-week training program on foreign animal disease has been developed in which two laboratory technologists will participate from each lab. Training will commence in May 2006.

The CNPHI has been concentrating its efforts on the CAHSN system design and development, assisted by the results of a comprehensive survey conducted on the partner laboratories' information mangement systems. Developing the architecture for the CAHSN website has been their major focus. Web-based collaboration centres are under construction and will provide secure communication network centres for stakeholder working groups. An Alert Module, one of the main centres on the CAHSN website, will provide a secure communication system for timely exchanges in the event of a foreign animal disease outbreak.

The Surveillance team has been working to develop the surveillance database so that the data can be harmonized to facilitate collating and analysis by epidemiological algorithms within the CNPHI smart engine architecture for the CAHSN. The provincial laboratory in Manitoba has been identified as the lead site for deployment of the CNPHI smart engine and roll-out for bovine spongiform encephalopathy (BSE) as the initial surveillance application.

Impact

Effective zoonotic disease surveillance and response requires integration of human and animal health intelligence. Avian influenza, BSE, West Nile virus, and tularemia are just a few examples of zoonotic diseases that require integrated and coordinated public and animal health surveillance and response activities. It is estimated that 60 percent of all new diseases and nearly all bioterrorism related risks are zoonotic in nature.

In this project, CAHSN and CNPHI epidemiologists and information technology personnel will lead the development and implementation of an internationally unique, integrated zoonotic surveillance and response framework. The primary deterrent to interjurisdictional and interdepartmental intelligence sharing and integration relates to confidentiality and differing mandates. In this project, pre-defined protocols and algorithms will determine when animal and human surveillance intelligence will be shared, and with whom. Similarly, protocols will be developed to allow for exchange of intelligence during the response to a zoonotic event, allowing for joint modelling of disease spread, scenario planning, and decision making.

The 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. This solution set will both integrate existing systems and develop new components. The implementation of a comprehensive animal health information management solution set is internationally unique and will establish Canada as a leader in animal (and human) health information management.

Links between the Public Health Laboratory Network and the United States Animal Health Laboratory Network will be established in the third year of the project. This project will be completed by September 2008.

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 PARTNERS:
SAIC Canada, Lawrence Livermore National Laboratory, US Environmental Protection Agency, Russian Research Institute of Hygiene, Toxicology, and Occupational Pathology

OTHER PARTNERS:
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Objectives

The goal of the project is to develop cleanup targets and standards for decontaminating buildings and construction materials after a chemical or biological attack using data generated from exposure experiments. The focus of this work is to develop a generic approach to decontamination, and to determine 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 use as agents of chemical or biological terrorism will be developed by first establishing the relationship between the magnitude of exposure and the expected acute and chronic health effects (dose-response). Researchers will then assess real and potential exposure risks by identifying individuals at risk of exposure and considering all routes of exposure (i.e., contact, inhalation, ingestion). Finally, the team will characterize the risk to determine the potential for toxicity or infectivity.

Relevance

Decontamination of facilities following acts of biological or chemical terrorism is designed to mitigate hazards to the extent that the facilties can be recommissioned, usually to their former use. However, no suitable standards exist for determining levels safe for reoccupancy. For non-carcinogens, researchers will use no-observed-adverse-effect levels (NOAELs), lowest-observed-adverse-effect levels (LOAELs), reference doses (RfDs), and tolerable daily intake (TDI) factors; for carcinogens, they will use cancer-slope factors (CSFs). These and other pertinent laboratory data, mainly from animal exposure models, will be used to establish cleanup standards and to help determine whether the levels necessary for rehabitation are practically attainable; the likely cost of decontamination to acceptable levels, and whether the cost is justifiable; and if the location is rehabitable, whether restrictions for types of use need to be in place with respect to expected inhabitants and associated toxicological or pathogenic risks.

Recent Progress and Results

The initial phase of the project began with an extensive review of existing minimum toxic effect levels for chemical agents and minimum infective dosages for live biological agents from data generated from animal exposure models and from human exposure incidents. Target agents will be chosen to reflect the likelihood of use in a terrorist event, the logistic difficulties of laboratory manipulation, and gaps in data that were previously generated. A number of chemical agents, including nerve agents, pesticides, pharmaceuticals, toxins of biological origin, and several other known or suspected chemical agents of terrorism, as well as others that pose a significant risk of use as a chemical weapon, are currently being investigated for their inclusion in this study. The Russian Research Institute of Hygiene, Toxicology, and Occupational Pathology (RIHTOP) will develop toxicology profiles using newly generated and existing laboratory data. Additionally, several viruses and a number of bacteria are being considered to determine their ability to satisfy the criteria for inclusion, especially their likelihood of being used as a terrorist weapon, their feasibility for laboratory study, and, to a lesser extent, their known or assumed pathogenicity and virulence, or other factors that affect social anxiety. Infectivity profiles for live agents will be generated using existing data and data generated using animal models at the Public Health Agency of Canada (PHAC) National Microbiology Laboratory (NML) and University of Ottawa Centre for Research and Environmental Microbiology (CREM) laboratories.

Impact

Cleanup standards will be established for those chemical and biological agents most likely to be used in an intentional release. A broad range of personnel will use these standards, from first responders to top-level decision makers. Special emphasis will be placed on using standards and associated models for post-remediation clearance of facilities, and for determining the potential use of facilities following a contamination event. Consequently, standards will be made available in condensed format for use in emergency response scenarios, but will 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, SAIC Canada

OTHER PARTNER:
US 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, which are scheduled to take place between August and September 2006, will be conducted on the premises of the Counter Terrorism Technology Center (CTTC) at DRDC Suffield. Three test structures, one for each group of agents, will be erected and finished with construction materials that are common in houses and office buildings. Simulants for weapon agents will be disseminated to contaminate the surfaces. The interiors of the structures will be used in chemical and biological trials, while the exteriors will be used in radiological trials. The structures will then be decontaminated using commercially available technologies. The project team will analyze concentrations of the agent simulants on surfaces and in the air before, during, and after the decontamination, and evaluate the performance of the technologies for different surface materials. The team will also calculate the associated costs and material and labour requirements. The data gathered will be used to develop manuals and guidelines for decontamination teams.

Relevance

The scope of the study directly addresses longer-term consequence management issues, specifically CRTI's priority to improve technologies for decontamination, containment, and disposal of CBRN contaminated materials. Various tasks of the project are anticipated to contribute to the development of several other capabilities. These include developing a concept of operations (CONOPS) for the federal field team response to events and the way forward for inclusion of CRTI's laboratory clusters and field teams into federal and provincial emergency response plans. The project also supports CRTI's priorities to develop test protocols to evaluate CBRN detectors, including performance and specification standards and operational guidelines, and to develop novel techniques, including instrumentation, that offer measurable advantages over existing technologies in CBRN detection, identification, and characterization.

Recent Progress and Results

Work on this project began in the summer of 2005. The project team focused on selecting and optimizing field test systems and parameters, within the original project concept, and preparing for upcoming field trials. At the outset of the project, the team assigned roles and responsibilities among team members. They developed a detailed field trial plan, analytical plan, health and safety plan, and other pertinent documents, and estimated labour and material requirements and identified suppliers. The team assessed requirements for agent dissemination, decontamination, and analytical equipment, as well as for personal protective equipment and safety training. Once these requirements were assessed, the project team designed and fabricated the test structures, and selected surface materials, air filtration and ventilation systems, and waste collection systems. Finally, the team conducted laboratory tests to optimize surrogate agent dissemination, and verified and optimized sampling and analytical methods.

Each of the test structures for the chemical and biological decontamination, in which interior surfaces are to be decontaminated, are designed to have three sections. Each section will be approximately 3 m long by 1.2 m wide by 2.4 m high, and will have its own combination of surface materials. Materials will include ceramic tiles, drywall, wood paneling, painted steel, vinyl flooring, and gypsum ceiling tiles.

Surrogate agents were selected to resemble physicochemical properties of target weapon agents, including their resistance to decontamination, while minimizing associated health and safety hazards. Diethyl malonate (DEM) was selected as a surrogate chemical agent due to its persistence, ability to be decontaminated, and detection by military chemical monitoring equipment. *Bacillus atropheus* was chosen as a surrogate biological agent. Thallium compounds will be used in radiological decontamination trials.

Chemical decontamination will be accomplished using the Surface Decontaminating Formulation (SDF) developed by DRDC under the CRTI project "Accelerated Consequences Management Capabilities" (CRTI 02-0043TA). The team will use vaporized hydrogen peroxide in the biological trial. A combination of mechanical and chemical methods will be used in the radiological trial.

The team will take and analyze samples of both the indoor and outdoor air during the trials. Samples of surface materials (coupons) will also be collected and sent for analyses in chemical and biological laboratories at Environment Canada and the Public Health Agency of Canada (PHAC).

Impact

This project will generate valuable field data on the efficiency of advanced full-scale decontamination technologies on different building surface materials. Concepts of operations will be developed for CBRN decontamination of buildings and structures. The effectiveness of relevant analytical instruments and methods will be optimized and verified. Associated costs, including labour, material, and equipment, will be calculated. Information resulting from this project will be used to develop manuals and set up domestic and international 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 Electron Corporation (formerly Ionalytics Corporation) – Scientific Instruments Division

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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. Appropriate response requires rapid and selective identification of the agent or agents that have been deployed. The goal of this project is to develop such a technology based on high-field asymmetric waveform ion mobility spectrometry (FAIMS) mass spectrometry (MS).

Relevance

Sensor-based, field-deployable technologies serve as early warning systems, but due to their inherently low selectivity, they cannot conclusively identify chemical agents. Conclusive identification of the chemical or biological agent requires chromatography/MS-based methods, which are slow due to the extensive sample preparation required and the low throughput of the setup. FAIMS-based technology would provide quick, quasi real-time separation of the relevant industrial chemicals, chemical warfare agents, their decomposition products, and selected mid-spectrum agents. Due to its inherent selectivity, this technology may also reduce the amount of sample preparation required, providing savings in time and cost.

Recent Progress and Results

The first phase of the project, to be completed by the National Research Council (NRC) in November 2006 in collaboration with DRDC Suffield, will focus on chemical warfare agents. The NRC is charged with the majority of the technical work involved in developing the methods, while the Canadian Food Inspection Agency (CFIA) is providing methods, samples, and training in the handling and disposal of chemical warfare agents. Thermo Electron Corporation (formerly Ionalytics Corporation) will develop a matrix-assisted laser desorption ionisation (MALDI) interface and provide technical assistance with the FAIMS technology.

Experimental work has focused on developing a FAIMS-based method for the separation and identification of chemical warfare hydrolysis products and simulants. Development of a FAIMS-based method involves the optimization of various voltages, gas compositions, and heater settings to selectively transmit ions through the FAIMS device and into the mass spectrometer for detection. The species considered included the hydrolysis products methylphosphonic acid (MPA), ethylphosphonic acid (EPA), thiodiglycol (TDG), ethyl methylphosphonic acid (EMPA), isopropyl methylphosphonic acid, pinacolyl methylphosphonic acid, and the chemical warfare simulants triethyl phosphate acid (TEP) and tributyl phosphate (TBP).

Each component was determined to have a unique FAIMS parameter, the compensation voltage, at a generic set of FAIMS conditions. This was done first in high-performance liquid chromatography (HPLC)-grade solvents to minimize interferences from real-world samples in the initial development stage. Once the optimization experiments were complete and there was clear evidence that the species could be separated in the FAIMS device, spikes of individual components or mixtures were prepared in real-world matrices, like bottled water.

The results indicate that most species could be identified unequivocably (although TDG was somewhat challenging), even in the presence of a real-world matrix (bottled water). This was determined by injecting the sample into a stream of mobile phase. Results were available in two minutes. The conventional electrospray ionization mass spectrometry (ESI-MS) was also evaluated with the same samples. It took researchers up to 45 minutes to separate the hydrolysis products/simulants. The use of undiluted matrix resulted in the erosion of signal intensity with time (machine was getting dirty and not responding as efficiently). Thus, the FAIMS device provided excellent selectivity for detection, resulted in time savings because less sample cleanup was necessary, and reduced instrument downtime by keeping the mass spectrometer cleaner through selective transmission of ions. These results were obtained for only these types of compounds and only in bottled water, which is a relatively clean matrix.

The project team intends to investigate other food matrices (i.e., vegetable oil and cornmeal) to determine how a food matrix will affect the selectivity of the FAIMS device. If the FAIMS method operates well with these matrices, then work will begin with chemical warfare agents in solvent, in bottled water, in vegetable oil, and in cornmeal.

The deliverables for phase 1 of the project include development of a FAIMS separation protocol (April 2006), followed by an evaluation of the protocol compared to conventional methods (November 2006), and peer review and transfer to DND end users (November 2006).

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. Rapid analytical techniques have very broad applicability. They are critical for monitoring toxic chemicals that are difficult to analyze or require time-consuming sample preparation, and for quickly assessing and identifying contaminated first responders or other victims so that they can be rapidly treated. They are also critical for assessing contaminated foods, water supplies, and other commercial products, supporting criminal investigations and prosecution, and reassuring the public.

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 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 n/γ discrimination, and adequate environmental stability. In preparation for this project, a thorough assessment of existing sensor technologies and advances in technological development was performed and an alternative approach to producing a viable END was conceived. The objective of this three-year project is therefore to successfully develop an END that meets all of the above specifications. The project will begin with the conceptual design with input from all project partners, followed by the construction and testing of a laboratory prototype, and the fabrication and thorough testing of the final field prototype.

Relevance

Neutron-emitting radioactive sources, specifically PuBe and AmBe, which are commonly used in oil-well logging and density gauges, are employed globally and often with limited security precautions. The threat from deliberate explosion of even a small number of such sources, for instance, via a terrorist weapon such as a radiological dispersal device (RDD), could cripple a large urban infrastructure by contaminating many square kilometres 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 once they enter the body. In such a scenario, any readily available commercial electronic personal dosimeter (EPD) of the type deployed with first responders will measure only the gamma ray dose, and will therefore register only a small fraction (perhaps as low as 10%) of the total effective dose from external radiation. This project addresses CRTI's investment priority to develop science and technology in support of equipping and training first responders.

Recent Progress and Results

The project is in the first of four phases: the conceptual design phase. The project charter was approved and contracts were in place by September 2005. The project team has met to discuss details and design specifications for the END.

Three major challenges were identified in the design meeting. The first was developing a good electronic design to minimize power consumption by the neutron sensor, which supports the analogue and digital electronics, as well as the microcomputer used for data analysis and display. The photomultiplier tube (PMT) requires the most power of all of the components of the design, since its normal operating mode wastes current (and thus power) to achieve adequate voltage levels. To mediate this, a new way of operating the PMT was developed using a Cockroft-Walton voltage multiplier. This method reduces the power consumption enormously (by more than an order of magnitude). A prototype device has been successfully built and tested.

The second identified challenge was to develop a neutron sensor capable of detecting neutrons with adequate detection sensitivity over a wide energy range and without γ interference (i.e., with good n/γ separation properties). The initial design should be adequate to address this challenge, and various simulations are being run to ensure it is.

The last challenge was to design an appealing and user-friendly interface for the dosimeter. This challenge has not yet been addressed, as it will likely only become important once the project team meets the first two challenges.

The project team expects to complete the project in June 2008 with the delivery of two field prototype ENDs.

Impact

Many first responders currently wear alarming EPDs. The alarm of these dosimeters is often the first indication first responders receive of the presence of gamma-emitting radioactive material. The END to be developed for this project will provide responder communities with the ability to detect the presence of neutron sources and monitor their exposure to them, ultimately improving their response capability. The inclusion of end users in the project team will enable transition and ensure that the resulting product meets their needs.

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

INDUSTRY PARTNER:
SAIC Canada

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Objectives

Following a radiological-nuclear (RN) terrorist event, on-site evidence recovery and analysis will likely be complicated by widespread radiological contamination. This project has three main objectives. First, researchers are aiming to establish protocols for forensic identification specialists to achieve attribution despite an RN-contaminated site. Second, the team will develop and test nuclear forensic laboratory analysis methods to further their attribution capabilities. Finally, the team will create links between expert responders (such as Canada's Federal Nuclear Expert Response Team) and forensic identification specialists, thus paving the way for information sharing in the field. These objectives are being addressed through two field exercises and two laboratory inter-comparisons involving all project partners in the response, in the discussion and implementation of lessons learned, or both. The project is also considering nuclear forensic programs in the United States (US) and in the United Kingdom (UK).

Relevance

This project addresses several of CRTI's investment priorities. It supports the development of criminal investigation capabilities, the development of science and technology in support of equipping and training first responders, and the improvement of collective command, control, communications, coordination, and information (C4I) capabilities for CBRN planning and response. Specifically, the project will develop 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. Nuclear forensic lab analysis will also be improved to ensure that analysis of an unknown sample will yield information for attribution, while being admissible in a court of law. Ultimately, this work will improve 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

Two workshops were held at the beginning of the project to compare Canada's nuclear forensic program with those of the US and the UK. The project team discussed the collection, transport, and analysis of contaminated evidence, the admissibility of scientific results in court, responder training, and RN laboratory analysis. Several areas of collaboration were identified as a result of these meetings and are currently ongoing.

The first of the laboratory inter-comparison exercises was held in the fall of 2005. SAIC Canada prepared multiple sets of soil and swipe samples containing a specified amount of "unknown" radionuclide. These

samples were sent to radiological laboratories at the Canadian Nuclear Safety Commission (CNSC), Health Canada, and DRDC Ottawa for analysis. Labs reported their results back to SAIC Canada at 24-hour, one-week, and one-month intervals. Final results were compiled into a report by SAIC Canada, which compared overall results by each laboratory and highlighted some analysis discrepancies. The laboratories are now working on standardizing analysis procedures to achieve a more consistent (and correct) results. Plans for the second exercise, scheduled for fall 2006, include expanding participation to include more laboratories in the analysis.

The first of two field exercises was held in January 2006 with the participation of the Ottawa Police Service, the Royal Canadian Mounted Police (RCMP), the CNSC, and DRDC Ottawa. A contaminated crime scene was created with a variety of traditional forensic evidence, including counterfeit currency, bomb-making materials, and handguns, and the municipal police forensic team and two radiological experts processed the site. Several issues were highlighted that were not fully addressed in this exercise, including dealing with contaminated evidence and transporting contaminated material. These issues will be addressed before the next exercise. Procedural issues resulting from the exercise are being captured in a report for forensic investigators. The team plans to incorporate the field and laboratory exercises into one large-scale exercise for fall 2006, in the hopes of testing the transportation of contaminated evidence procedures, and traditional forensic analysis on contaminated items.

Impact

All knowledge products and capabilities developed from this project will be incorporated into end user systems. Protocols for forensic identification specialists will be incorporated into the RN portion of the CBRN First Responder Training Program (FRTP) and will be adopted by the RCMP and federal expert response teams. Collaboration with the US Federal Bureau of Investigations (FBI) and UK New Scotland Yard will enable the project team to compare international techniques and ensure interoperability. Prioritized laboratory techniques are being tested and implemented by the laboratory network. Project completion is scheduled in March 2007. Ultimately, since this project is largely focused on procedural issues, implementation costs for end users will be negligible.

CRTI 04-0045RD // Development of Collections, DNA Reference 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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Objectives

This three-year project has three primary objectives. First, the project team aims to obtain samples of critical fungal plant pathogens that could be used as bioterrorism agents against Canadian crops, forests, or the food supply. Second, the team will create multi-gene DNA sequence databases to develop molecular diagnostics for these agents. Finally, the team will complete on-line databases documenting the occurrence of plant pathogens in Canada.

Agriculture and Agri-Food Canada (AAFC) will maintain the repository for cultures and specimens through the Canadian Collection of Fungal Cultures and the Canadian National Mycological Herbarium. The Canadian Food Inspection Agency (CFIA) project participants will secure importation permits and address any biosecurity issues with these cultures. Researchers from AAFC and the Canadian Forestry Service (CFS) at Natural Resources Canada will develop the DNA databases. CFS participants will also design and undertake preliminary testing of the molecular assays, while the CFIA team will validate the final assays. The AAFC team will develop the pest–host database from historical records and publications.

Relevance

The economic and societal impacts of a bioterrorist attack on the food production system or the environment would be catastrophic. Accidental introductions of exotic pathogens have caused quarantine crises on major crops and the disappearance of entire ecosystems. Allegations of deliberate use of plant pathogens by some governments to destroy crops raise the risk of such an attack in Canada.

This project will address the urgent need to better understand and document the plant pathogens that normally occur in Canada, including many close relatives of the high-risk pathogens, and will contribute to the development of tools for recognizing suspicious outbreaks and confirming their non-Canadian origin. CFIA staff are first responders for quarantine outbreaks or bioterrorism attacks on agricultural systems, and are active participants in the project. Vigilance and monitoring by Canada are critical for maintaining trade of agriculture and forest products with partners who are putting in place new plant biosecurity measures.

Recent Progress and Results

The AAFC team has already compiled comprehensive collections of some of the fungal genera including species of interest, though others present a challenge, especially those that do not grow in culture. They have established type and exemplar cultures for most *Phytopthora* species and obtained a standardized set of *Fusarium* species cultures from the United States, as well as additional DNA samples of critical species from a historical collection in Germany. With the assistance of CFIA personnel, the AAFC researchers also obtained samples of soybean rust, which does not grow in culture, and used them to test the assays developed in the United States for this disease.

The AAFC team developed single-gene diagnostic assays for two of the fungal groups (i.e., potato wart and Fusarium head blight), which are now undergoing validation. The team is currently developing bioinformatics tools to facilitate the storage and analysis of DNA sequences. They have purchased a powerful server and once the databases are populated, they will use software developed for another AAFC project to quickly detect species-specific molecular markers. CFS researchers have adapted software (GenomesCOMP V1.0 2005) that enables them to scan entire genomes to determine the volatility of individual genes and applied it to *Phytophthora ramorum*. They have developed nucleotide polymorphisms for 13 genes and identified 84 polymorphisms through sequencing. Currently, CFS is genotyping these polymorphisms in using real-time polymerase chaise reaction (RT-PCR).

Lastly, the AAFC team has standardized data documenting approximately 90,000 Canadian records of host/pest/location/reference information and imported them into an Access database. These records will be updated in the future.

The researchers expect the project will be completed by September 2008.

Impact

This project will generate multi-gene DNA sequence databases for the development of molecular assays to be used by first responders to respond to an introduction of high-risk plant pathogens in Canada. These same molecular assays will be suitable for developing automated, high-throughput assays for monitoring plant pathogens. The pest–host database will be the 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 known to have occurred in Canada, the DNA sequence database will include information that will assist in determining the geographic origin of plant pathogens or matching different strains involved in suspicious outbreaks.

CRTI 04-0047TD // CBRN Incident Database

PROJECT LEAD:
Royal Canadian Mounted Police –
Explosives Disposal and Technology Section

FEDERAL PARTNERS:
Canadian Security Intelligence Service, Canadian Food Inspection Agency, DRDC Ottawa – Radiological Analysis and Defence Group, Canadian Nuclear Safety Commission, Natural Resources Canada

INDUSTRY PARTNER:
AMITA Corporation

OTHER PARTNERS:
Carleton University – Human Oriented Technology Lab, Singapore Armed Forces – Chemical, Biological, Radiological and Explosive Defence Group, Australian Federal Police Bomb Data Centre

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Objectives

The purpose of this project is to design and demonstrate a state-of-the-art, bilingual CBRN and explosive incident database (CID) that will capture data on CBRN incidents against infrastructure, people, and agri-food targets. The CID will be built as a commercial, off-the-shelf CBRN incident system that will be accessible to municipal, provincial, national, and international law enforcement and regulatory agencies.

Led by the Royal Canadian Mounted Police (RCMP), the project will involve collaboration from the Canadian Security Intelligence Service (CSIS), the Canadian Food Inspection Agency (CFIA), DRDC Ottawa, the Canadian Nuclear Safety Commission (CNSC), Natural Resources Canada, AMITA Corporation, and Carleton University's Human Oriented Technology Lab. The project's international partners include the Chemical, Biological, Radiological and Explosive Defence (CBRE) Group of Singapore's Armed Forces and the Australian Federal Police Bomb Data Centre.

Relevance

In the event of a real or suspected CBRN event, Canada's emergency response capability greatly depends on the speed, detail, and accuracy of data received by first responders. Having an incident database that is accessible to law enforcement and regulatory agencies will not only dramatically improve the effectiveness of Canada's response, it will also facilitate incident preparedness and prevention by sharing vital information on threats, precursors, and dissemination.

Recent Progress and Results

The project is proceeding ahead of schedule. Based on the technical knowledge acquired from the RCMP's 10 years of experience in explosive incidents and their existing incident database, experienced systems analysis and field experts have defined the functional scope and prepared detailed requirements of the CID. They have also documented the system architecture, which addresses the RCMP's requirements. Key users have been involved in the project through the user work group that has representation from police agencies across Canada.

The next stage in the project will focus on software engineering. Specialists will support the team in designing the user interface to ensure the system is effective in assisting bomb technicians during stressful situations and also for general purpose training and information collection. Researchers from Carleton University's Human Oriented Technology Lab will assist in the interface design to ensure the CID is easy to use and requires little to no training.

Once the design of the CID is complete, it will be built as a robust and production-grade system that will provide information to users through a secure, web-based network. A select group of users will assist in testing the system to ensure it meets the project requirements as planned.

A four-month live technology demonstration will conclude the project. The project team will incorporate feedback from the demonstration into the CID and then deploy it onto the RCMP network. The CID will be made available to users and police forces at more than approximately 500 locations across Canada.

The researchers expect to complete the project by July 2007.

Impact

The final CID will enable users to track information such as hazardous device-making materials, incident details, and dissemination methods, and make incident linkages in a matter of minutes and hours through real-time, 24-hour, seven-days-a-week (24/7) incident submission.

First responders such as police, fire, hazardous materials (HAZMAT), and emergency medical services personnel, as well as regulatory agencies, government legislators, and incident commanders, will use components of or the entire CID to assist them in analyzing incident information and spotting trends. The RCMP will also offer the CID to police forces and military organizations in other countries.

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 – Foreign Animal Disease Laboratory, Agriculture and Agri-Food Canada

OTHER PARTNERS:
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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. The methods developed in this project will be efficient at destroying viruses and degrading carcasses to earth-like material. Methods will also be developed to detect and identify volatile organic compounds contained in off-gases produced during composting. An assessment will then be made of the key chemical categories and specific compounds in the gases released. Studies on the gases released and on the breakdown of animal DNA will aim to determine whether this information could be

used to predict the overall safety of the compost for disposal on land. Standards will also be developed to determine virus survival under defined composting conditions.

Relevance

Foreign animal virus diseases, such as avian influenza and foot-and-mouth disease, are known to spread rapidly and can be economically devastating to a country. Current stamping out policies for managing outbreaks of disease in major livestock-producing countries have included hauling the contaminated animal carcasses away from the site of the outbreak and having them burned or buried. These practices can spread disease and are environmentally undesirable. Furthermore, the manure from infected animals can be a major source of virus and there has not been a plan in place to ensure the destruction of viruses in manure and other potentially contaminated organic matter before it is disposed of in the environment.

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

To develop suitable methods for monitoring the survival of avian influenza virus and Newcastle disease virus during composting, the Canadian Food Inspection Agency (CFIA) project team collected a variety of compost end products and inoculated them with known amounts of avian influenza and Newcastle disease virus. Using these samples, the team developed methods for releasing, separating, and concentrating the virus from the compost and for detecting the virus by conventional egg inoculation methods, as well as by real-time reverse transcription polymerase chain reaction (RT-PCR). The team found that the removal of organic matter, such as humic acids derived from compost, was critical for RT- PCR, whereas the egg inoculation procedures used to isolate the virus seemed to tolerate these substances and low levels of bacteria and fungi.

The Alberta project team constructed a field-type biocontainment structure at the Agriculture and Agri Food Canada (AAFC) Research Centre Farm in Lethbridge, Alberta. They also collected manure, animal tissue, and compost samples to determine whether measuring the degradation of selected animal genes can be used to predict the destruction of the viruses. The procedures yielded extracted DNA with a molecular size of approximately 20 kilobase pairs (kbp). There were inhibitors in the extracted compost DNA, and studies to date to purify extracts showed that the limit of detection of bovine DNA in 4 nanograms (ng) of compost DNA was 0.1 ng. At this level of sensitivity, the bovine growth hormone gene was not detected in mature compost suggesting total decomposition of the animal tissue.

Project partners at Iowa State University developed sampling methods and analyses to monitor the emissions of specific volatile organic compounds emitted from simulated compost. Results from their laboratory trials suggest that emissions of volatile fatty acids (i.e., acetic, propanoic, isovaleric, valeric and hexanoic acids) and esters (i.e., butanoic acid ethyl, propyl, 2-methylpropyl, butyl, 3-methylbutyl and hexanoic acid ethyl esters) are the best indicators of plant material decay, while selected sulfur- (i.e., carbon disulfide, dimethyl disulfide, trisulfide dimethyl, methyl mercaptan, and 1,4 dimethyl tetrasulfide) and nitrogen-containing compounds (i.e., indole and skatole) are clear indicators of decaying animal material under both aerobic and anaerobic conditions. The team also found that the volatile fatty acid emissions from corn silage composting were lower in concentration under aerobic conditions than under anaerobic conditions, while ketone emissions were lower in concentration under anaerobic conditions. The team believes that the emissions of these compounds (volatile fatty acids, esters, ketones, alcohols, and nitrogen-containing compounds) will decrease at the end of the field composting and will be an indicator of the stabilized compost material.

The project will be completed by March 31, 2009.

Impact

The knowledge and technology that is being cooperatively developed between Canada and the United States through this project will yield information that can be used to assist other countries to more effectively eradicate highly contagious, viral animal diseases. A reduction in the incidence of these diseases abroad will thereby reduce the likelihood of their entry into North America. Furthermore, the methods developed in this project will give Canada the capability to limit the spread of such diseases in the face of introductions through bioterrorism.

CRTI 04-0082TA // Radio Frequency- and Electronic Countermeasures-Compatible CB Blast Protective Helmet

PROJECT LEAD:
Royal Canadian Mounted Police

FEDERAL PARTNER:
DRDC Suffield

INDUSTRY PARTNERS:
Med-Eng Systems, EMC Consulting, Dunn Engineering

OTHER PARTNER:
Royal Military College of Canada

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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, is to design, develop, and evaluate a new radio frequency (RF)- and electronic countermeasures (ECM)-compatible chemical or biological (CB) blast protective helmet. Researchers will use 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 will have two unique, interchangeable visors suited for improvised explosive device disposal (IEDD) involving CB agents, and conventional explosive ordinance disposal (EOD)/IEDD threats. The helmet will be subjected to man-in-simulant 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 will be conducted at the RCMP Technical and Protective Operations Facility (TPOF), while blast performance will be 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

Although the project as a whole is on schedule, some milestones have been slightly delayed due to test schedules. Fortunately, these delays have not significantly affected the design and development of the helmet.

The researchers tested the CB blast protective helmet against very stringent standards (i.e., MIL-STD 461E and Def Stan 59-41) to determine its compatibility with ECM-jamming devices. Live man-in-simulant 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.

The RCMP Explosive Disposal and Technology Section expects to receive a final advance prototype of the RF- and ECM-compatible CB blast protective helmet during the summer of 2006, after which they will receive training on its use from Med-Eng researchers.

Impact

During this project's development, Med-Eng researchers identified new opportunities to extend the helmet's capabilities. For example, they are now exploring the possibility of reducing the helmet's weight to increase user comfort. Med-Eng researchers intend to apply the knowledge and expertise gained during this project to develop effective multi-threat protective equipment for the military sector, focusing particularly on head-borne systems, which remain one of the biggest challenges in military and tactical modernization program initiatives.

CRTI 04-0127RD // Canadian Health Integrated Response Platform

PROJECT LEAD:
Health Canada – Radiation Protection Bureau

FEDERAL PARTNERS:
Public Health Agency of Canada, Environment Canada – Canadian Meteorological Centre

INDUSTRY PARTNER:
Prolog Development Center

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Objectives

The purpose of this project is to develop the Canadian Health Integrated Response Platform (CHIRP). The CHIRP will integrate the functionalities of the Canadian Network for Public Health Intelligence (CNPHI) and the Accident Reporting and Guidance Operational System (ARGOS) to enhance the Canadian capacity for CBRN event detection, response, and preparedness throughout the radiological-nuclear (RN) and public health communities.

Relevance

Based on the leverage and interoperability of two successful CRTI-funded initiatives, the CHIRP will streamline and optimize the capabilities of the federal government to face a biological or RN threat.

Among the benefits that the CHIRP will provide are enhanced biological and RN surveillance and alerting capability and enhanced communications between first responders and decision makers in the RN and public health communities. The CHIRP will also improve operational preparedness and sustainability, and improve consequence management through better and faster coordination, communication, and decision making among CRTI laboratory clusters and cluster participants.

Recent Progress and Results

The CHIRP project charter was signed in January and funds for year one were transferred in mid-February. Health Canada project participants are currently collaborating with Public Works and Government Services Canada (PWGSC) to finalize the contract with the Prolog Development Center. Planned work on the project is expected to start in June 2006.

The existing ARGOS and Environmental Monitoring and Assessment Program (EMAP) will provide the Geographic Information System (GIS) platform. This platform will enable the spatical display of surveillance and event data. Leveraging this technology addresses a major challenge in establishing an effective radiological and biosurveillance system: the lack of an interconnected, electronic information infrastructure within the healthcare industry. Leveraging the CNPHI will provide the CHIRP with a large network of public health professionals and scientists, and the ability to integrate this network into a larger, comprehensive biosurveillance and response readiness framework.

The integrated platform builds and leverages the results of previously funded CRTI projects, the secure infostructure at the Public Health Agency of Canada's National Microbiology Laboratory (NML) and Health Canada's Radiation Protection Bureau and the Emergency Operations Centres at the NML and RPB.

The project is scheduled to be completed in late 2009.

Impact

The CHIRP will increase Canada's capacity to respond to a biological or RN event. It will lead to faster and more efficient detection, notification, coordination, consequence management, and decision making. The capacity is being developed by the mandated coordinating and operational communities and will gradually be adopted into their operations throughout the project as new modules are developed. Development of this integrated approach may also evolve into a comprehensive platform across the CRTI laboratory clusters and promote collaboration with international partners.

DGNS Technical Assessment Team – A Deployable Asset

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Objectives

Director General Nuclear Safety (DGNS), which is part of the Assistant Deputy Minister (Infrastructure and Environment) organization of the Department of National Defence (DND), is the regulatory authority for nuclear activities in DND and the Canadian Forces (CF). DGNS issues policies and guidance regarding ionizing radiation safety, authorizes use of equipment containing nuclear substances or generating ionizing radiation, and verifies compliance with all applicable regulatory requirements.

DGNS also serves as a departmental centre of expertise by providing specialized technical assistance to various DND and CF organizations. To verify compliance and provide specialized assistance in a tangible manner, DGNS, within its Directorate of Nuclear Studies and Analysis (DNSA), established a Technical Assessment Team (TAT). The TAT has a significant capability for characterizing radiation fields and contamination through quantitative, isotope-specific surveys and sample analyses. The TAT could also provide a useful function in later stages of emergencies and recovery stages.

The aim of this presentation is to describe the field capabilities of the DGNS TAT and demonstrate these capabilities with examples of field deployment.

Relevance

The primary objectives of establishing a TAT are related to the DGNS mandate to provide a tangible experimental and analytical capability to independently examine and validate compliance, provide assistance, or obtain data for quality assurance purposes.

Personnel assigned to the TAT have a high level of education in radiation science and broad experience. The TAT has a capability to measure alpha, beta, gamma, and neutron fields and isotopic composition. The fleet of equipment includes survey instruments and a suite of deployable gamma spectroscopic equipment, including sodium iodide (NaI) and high-purity Germanium (HPGe) detectors. The equipment and the team's scientific knowledge enable the TAT to develop in-depth understanding of complex situations. The equipment is compatible with that of other organizations such as DRDC Ottawa and the CRTI mobile nuclear laboratories.

The skills and equipment of the TAT are fully applicable to radiological emergencies. Furthermore, as one of the federal field teams, the TAT participates in CRTI exercises. Therefore, understanding TAT capabilities and its possible role in emergency response is of interest to the whole CRTI community.

Recent Progress and Results

To date, the TAT has been deployed to various locations within Canada. The TAT has verified the compliance of decommissioning activities, assisted DND and CF units in characterizing radiological situations whose complexity was beyond the capabilities or equipment of local personnel, and verified contractor performance.

The TAT investigated the low-level legacy of uranium contamination in the 1960s and 1970s at DRDC Valcartier. Low-level depleted uranium (DU) is difficult to detect using dose-rate or contamination meters, since it has a low radiological signature and is masked by natural radiation. High-resolution gamma spectrometry can be used to estimate relative ratios of uranium isotopes to distinguish between natural or depleted uranium. The TAT used a high-efficiency (60 percent), mechanically cooled, HPGe system to measure contamination and found that the contamination was fixed and appeared to be close to the present regulatory limits. The TAT also performed air quality measurement and additional contamination analysis of samples.

The TAT was also involved in characterizing low-level waste at an inactive DND waste site. The waste, which was disposed of from 1960 to1980, was not well documented, but due to the nature of the DND and CF activities, most of the isotopes present were estimated to have a relatively short half-life. To assess the current state of the site, the TAT conducted a scoping waste excavation and characterization in March 2005. The team characterized selected samples of waste to establish a technical basis for developing a long-range plan for the site. The waste characterization was done in two stages: the TAT used a dose-rate meter to identify active waste (often having very low activity), and then used NaI or HPGe spectrometers to identify the isotopic composition.

The TAT also participated in two CRTI-organized exercises, Exercise Follow On in February 2005 and Exercise Maritime Response in March 2006.

Impact

The TAT has significant capability for characterizing radiation fields and contamination by quantitative, isotope specific surveys and possesses the necessary expertise to quickly understand complex situations.