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

MEDECOR 2: Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects

Project Close-out Report for CRTI 07-0186RD

Hillary Boulay Greene

Defence R&D Canada – Ottawa

Technical Report
DRDC Ottawa TR 2012-127
July 2012

Canada

MEDECOR 2: Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects

Project Close-out Report for CRTI 07-0186RD

Hillary Boulay Greene
DRDC Ottawa

Defence R&D Canada – Ottawa

Technical Report
DRDC Ottawa TR 2012-127
July 2012

Principal Author

Original signed by Hillary Boulay Greene

Hillary Boulay Greene

Defence Scientist/ CARDS Section

Approved by

Original signed by Julie Tremblay-Lutter

Julie Tremblay-Lutter

Section Head/CARDS Section

Approved for release by

Original signed by Chris McMillan

Chris McMillan

DRP Chair & Chief Scientist/ DRDC Ottawa

This work was funded by the Chemical, Biological, Radiological and Nuclear and Explosives (CBRNe) Research and Technology Initiative (CRTI) under Project 07-0186RD.

In conducting the research described in this report, the investigators adhered to the 'Guide to the Care and Use of Experimental Animals, Vol. I, 2nd Ed.' published by the Canadian Council on Animal Care.

Abstract

The CBRNE Research and Technology Initiative (CRTI) funded the project CRTI 07-0186RD "Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects" to develop a field-deployable medical decorporation management tool that will provide treatment strategies for removal of internalized radionuclides by optimizing treatment gain and minimizing risk. The project progressed well, was on time and adhered to budget. At project completion, the final software tool was delivered meeting the specified performance criteria and objectives set at project conception. First responders and medical personnel now have at their disposal a fieldable guidance tool capable of providing the most current decorporation guidance for internalized radionuclides and recommending ideal risk reduction strategies based on treatment times and dose savings.

Résumé

L'Initiative de recherche et de technologie CBRNE (IRTC) a permis de financer le projet CRTI 07-0186RD « Optimisation de l'outil de décorporation médicale (MEDECOR) en ce qui a trait au temps et à l'utilisation, pour l'amélioration des effets biologiques ». Ce projet visait à mettre au point un outil de gestion de décorporation médicale déployable sur le terrain, qui fournirait des stratégies de traitement pour éliminer les radionucléides ayant pénétré dans le corps en optimisant les avantages et en réduisant les risques. Le projet a bien progressé, et l'on a respecté les échéances et les limites du budget. Au terme du projet, l'outil logiciel final a été livré conformément aux critères de performance indiqués et aux objectifs fixés à l'étape de la conception. Les premiers répondants et le personnel médical disposent maintenant d'un outil utilisable sur le terrain et capable de fournir les consignes les plus à jour sur l'élimination des radionucléides ayant pénétré dans le corps et de recommander des stratégies idéales pour éviter les risques, fondées sur la durée du traitement et les économies de doses.

This page intentionally left blank.

Executive summary

MEDECOR 2: Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects: Project Close-out Report for CRTI 07-0186RD

Hillary Boulay Greene; DRDC Ottawa TR 2012-127; Defence R&D Canada – Ottawa; July 2012.

Introduction: Project CRTI 07-0186RD "Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects aimed to develop a field-deployable medical decorporation software tool that would provide treatment strategies for the removal of internalized radionuclides by optimizing benefit and minimizing risk. The project was carried out in four phases: data harvesting and literature search, software design requirements, software development and model generation, and animal studies to validate tool outputs.

Results: The project team has developed easy-to-understand models and algorithms to quantify time-dependent decorporation efficacy, committed effective dose estimation, and risk reduction for both radionuclide elimination and therapeutic drug initiation and termination. The fully functional, optimized software tool was delivered at project completion.

In the course of the project, MEDECOR2 was field tested at a military exercise in the Czech Republic at the invitation of the project's international partner. The exercise involved training and demonstration of the software tool, which was then field-trialed by military personnel for its abilities to triage victims and determine appropriate treatment strategies following internal contamination scenarios. It was very well received and several useful recommendations were incorporated in the tool development.

Animal studies were done to help validate the outputs of the tool and provide supportive data for the decorporation of strontium compounds. The large scale animal study examined the biosolubility and biodistribution of an inhaled radionuclide ($SrTiO_3$) followed by the efficacy of various decorporation agents.

Significance: The MEDECOR2 tool, in combination with casualty estimation models, will assist preparedness planners in determining the resources required for casualty management and establishing stockpiles. The tool is also intended for use during a response to a radiological-nuclear (RN) event where there is potential for internal contamination. It will provide a means by which first responders and receivers can manage casualties by assisting in the determination of persons who need immediate decorporation treatment to reduce dose, those who will not benefit and those who are not at risk.

Future plans: The tool, as delivered, is fully functional and ready for distribution to end-users. As more information becomes available through R&D and decorporation strategies evolve, there will be a need to update and revise the guidance in MEDECOR2. Discussions on how to handle distribution, version control and updating are ongoing with the industry partner SAIC Canada and RadSci Research.

Sommaire

MEDECOR 2: Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects: Project Close-out Report for CRTI 07-0186RD

Hillary Boulay Greene ; DRDC Ottawa TR 2012-127 ; R & D pour la défense Canada – Ottawa; juillet 2012.

Introduction : Le projet CRTI 07-0186RD « Optimisation de l'outil de décorporation médicale (MEDECOR) en ce qui a trait au temps et à l'utilisation, pour l'amélioration des effets biologiques » visait à mettre au point un outil logiciel de décorporation médicale déployable sur le terrain, qui fournirait des stratégies de traitement pour éliminer les radionucléides ayant pénétré dans le corps en optimisant les avantages et en réduisant les risques. Le projet a été réalisé en quatre étapes : collecte des données et recherche documentaire, détermination des exigences de conception du logiciel, développement du logiciel et création du modèle, et études sur les animaux pour valider les résultats de l'outil.

Résultats : L'équipe de projet a élaboré des modèles faciles à comprendre et des algorithmes pour quantifier l'efficacité de la décorporation en fonction du temps, l'estimation de la dose efficace engagée et la réduction du risque à la fois pour l'élimination des radionucléides et le dosage initial et final des médicaments. L'outil logiciel optimisé et entièrement opérationnel a été livré à la fin du projet.

Au cours du projet, MEDECOR2 a été soumis à des essais dans le cadre d'un exercice militaire en République tchèque, sur l'invitation du partenaire international du projet. L'exercice comprenait une formation et une démonstration de l'outil logiciel, suivies de sa mise à l'essai sur le terrain par des militaires afin d'évaluer ses capacités à trier les victimes et à déterminer les stratégies de traitement appropriées à la suite de différents scénarios de contamination interne. L'outil a été très bien reçu, et plusieurs recommandations utiles ont été intégrées dans sa mise au point.

Des études sur les animaux ont été effectuées afin de faciliter la validation des résultats de l'outil et de fournir des données pertinentes pour la décorporation de composés de strontium. L'étude à grande échelle sur les animaux a servi à examiner la biosolubilité et la biodistribution d'un radionucléide inhalé ($SrTiO_3$), puis l'efficacité de divers décorporants.

Importance : L'outil MEDECOR2, conjugué aux modèles d'estimation des victimes, aidera les planificateurs de l'état de préparation à déterminer les ressources nécessaires pour la prise en charge des victimes et l'établissement des stocks. Il doit également servir pendant une intervention en cas d'incident radionucléaire (RN) lorsqu'il y a possibilité de contamination interne. Il fournira aux premiers intervenants et au personnel médical de première ligne un moyen de prendre en charge les victimes en aidant à déterminer les personnes qui doivent recevoir immédiatement un traitement de décorporation pour réduire la dose, celles à qui le traitement ne sera pas utile et celles qui ne courent aucun risque.

Travaux futurs : L'outil livré est entièrement opérationnel et prêt à être distribué aux utilisateurs finals. À mesure que plus d'information sera disponible par le biais de la R&D et que les stratégies de décorporation évolueront, il faudra mettre à jour et réviser les consignes dans MEDECOR2. Des discussions sont en cours avec les partenaires industriels, SAIC Canada et RadSci Research, sur le traitement de la distribution, du contrôle des versions et de la mise à jour.

Table of contents

Abstract ……. i
Résumé …..... i
Executive summary iii
Sommaire iv
Table of contents vi
List of figures vii
List of tables viii
Acknowledgements ix
1 Introduction 1
2 Purpose 2
3 Methodology 3
4 Results 7
4.1 The Software Tool: MEDECOR2 7
4.1.1 Triage Module 7
4.1.2 Treatment Module 9
4.1.3 Continuing Care Module 10
4.1.4 Other features of the software 11
4.2 Field Testing of the MEDECOR2 Software Tool 12
4.3 End-user Testing 13
4.4 Animal Studies to Validate Sr-90 Model 14
4.4.1 Pilot Study 14
4.4.2 Main study 16
5 Transition and Exploitation 18
5.1 Follow-on Development 18
5.2 Transition to End Users 18
5.3 Intellectual Property Disposition 19
6 Conclusion 20
References 21
Annex A Project Team 22
Annex B Project Performance Summary 24
B.1 Technical Performance Summary 24
B.2 Schedule Performance Summary 24
B.3 Cost Performance Summary 26
Annex C Publications, Presentations, Patents 27

List of figures

Figure 1: MEDECOR2 Handheld device architecture 4
Figure 2: MEDECOR2 Device Emulator for PC Platform 5
Figure 3: Basic Concept Diagram for MEDECOR2 Software Tool 5
Figure 4: Clinical Assessments Menu page from MEDECOR2 software tool..... 7
Figure 5: Screen shot for MEDECOR2 Triage Assessment module..... 8
Figure 6: Screen shot of MEDECOR2 Treatment module..... 10
Figure 7: Screen shot of MEDECOR2 Continuing Care Assessment module..... 11
Figure 8: Physician assessment for treatment options using MEDECOR2..... 12
Figure 9: $SrTiO_3$ decorporation results from main animal study..... 17

List of tables

Table 1: Data from Sr-90 trial during field testing of MEDECOR2 in Czech military exercise .. 13

Table 2: Decorporation of $SrTiO_3$ results from pilot study 15

Table 3: Study cohorts for main animal study on decorporation of $SrTiO_3$ 16

Table 4: Project team and project review committee (PRC) members 22

Table 5: Major Project Milestones for CRTI 07-0186RD: original schedule vs actual completion dates..... 25

Table 6: Budget allocations and expenditures for CRTI 07-0186RD 26

Acknowledgements

This work was supported by Defence Research and Development Canada Centre for Security Science Chemical, Biological, Radiological/Nuclear, and Explosives Research and Technology Initiative (CRTI 07-0186RD) with project partners from Atomic Energy of Canada Limited (AECL), Department of National Defence's (DND) Directorate of Nuclear Safety (DN Safe), DND's CF Health Services (DHSO), Health Canada (HC), and SAIC Canada. The author would like to acknowledge the programmers and subcontractors at SAIC (RadSci Inc) for their significant efforts in the development of the software tool resulting from this project. International partners from the Armed Forces Radiobiology Research Institute in the US (AFRRI) and Purkyne Military Medical Academy (MilMed) in Czech Republic provided scientific input and opportunities for operational testing.

This page intentionally left blank.

1 Introduction

Following the events of September 2011, the terrorist threat of radionuclide dispersal via explosive or non-explosive energetic release is of great health concern. After the release of radioactive material from a radiological dispersal device (RDD), first responders and the public are at risk from internal contamination by aerosolized radionuclides. It is possible for radionuclides to enter the human body through inhalation, ingestion, skin and wound absorption. These internalized radionuclides are known to be of a significant health concern by releasing energies that are damaging to nearby cells and organs, thus having an impact on both immediate and long term health.

From a health physics perspective, it is important to know the magnitude of the intake to perform dosimetric assessments and from a medical perspective, removal of radionuclides leading to dose aversion (hence risk reduction) is of high importance. However, the efficacy of medical decorporation strategies is extremely dependant upon the time of treatment delivery after intake. The "golden hour", or more realistically 3-4 hours, is imperative when attempting to increase removal of radionuclides from extracellular fluids prior to cellular incorporation. However, the benefits from early treatment are not fully understood and could benefit from the development of health physics models capable of accounting for radionuclide-specific dispersion within and excretion from the body.

To assist medical first response personnel in making timely decisions regarding appropriate treatment delivery modes, it would be desirable to have a software tool which compiles existing radionuclide decorporation therapy data and allows the end user to perform triage leading to appropriate decorporation treatment strategies.

This work follows on from previous work which developed the original MEDECOR software tool to assist physicians, nurses and other medical first responders in determining appropriate decorporation treatment strategies following internal contamination. The MEDECOR tool was originally designed for use in a Palm OS PDA environment and was subsequently expanded to a Windows Mobile environment and Windows PC platform.

At the onset of the project, no prediction tools existed that would provide medical personnel with guidance on accrued health risks versus benefits of treatment. The aim of this project was therefore to enhance the existing MEDECOR tool by providing decorporation guidance while taking into consideration the health risks of exposure versus the risks and benefits of treatment in a time-dependent manner.

2 Purpose

The overall aim of the project was to develop a field-deployable medical decorporation management tool that would provide treatment strategies for removal of internalized radionuclides by maximizing gain and minimizing risk. The tool would ideally recommend risk reduction strategies based on treatment times and dose savings.

At the time of project inception, the objectives of MEDECOR2 were closely aligned to several CRTI priority areas under Emergency Casualty Management and Treatment. How the project intended to address each priority area is described below:

1. **Develop deployable treatment and casualty management capabilities**.

   MEDECOR2 will provide a synthesis of complex relationships between multivariate data into a simple-to-use tool that may be installed on a personal digital assistant (PDA) and/or laptop computer (both favoured by first responders who require portable guidance platforms). There is currently no tool available to medical first responders capable of providing guidance on treatment times and risk reduction strategies for radiological casualties.

2. **Develop mass casualty management during a CBRNE event through the development of tools for risk assessment of treated and untreated casualties**

   MEDECOR2 will provide rapid assistance to the medical personnel and aid them in the development of treatment strategies leading to best possible health outcome to the patients based upon a timely risk reduction strategy. The minimally or non-exposed member of the public will be appropriately risk-assessed and thus decrease the long-term demands on the medical reassurances.

3. **Compare risks from treatment versus risk from exposure**

   MEDECOR2 will be one of the only radiological/nuclear tools in its class capable of providing guidance with respect to treatment strategies based on comparative risk of treatment and risk of exposure.

4. **Demonstrate bi-national interoperability in response to a cross-border CBRNE event.**

   The development of the previous version of the tool (MEDECOR) was guided by Dr. W.F. Blakely (US Armed Forces Radiobiology Research Institute) to ensure bi-national interoperability with the US tools currently in use by the first-responder community (BAT and FRAT). The MEDECOR tool was also successfully tested at a NATO exercise for international interoperability. MEDECOR2 will maintain these same standards.

3 Methodology

In order to effectively optimize the MEDECOR tool for time of use and improved bioeffects two major goals were undertaken for the project: (1) to derive risk reduction models for the top ten high-risk radionuclides and (2) to validate the developed models for strontium (Sr-90) in an animal model.

The approach for meeting these goals was to break down the project into several phases, each one being somewhat dependent on the previous. The objective of the first phase was to acquire the highest quality data about decorporation efficacy for various therapeutic treatments for the "ten high-risk radioisotopes". This included data harvesting and sorting of the following identified (but not limited to) parameters: time-dependant efficacy of treatment(s), synergistic treatment efficacy between competing therapies, physiological implications to efficacy, therapy risk, committed effective dose delivered, relationship between animal and human models and risk reduction. Special emphasis was placed on obtaining data related to biokinetics, bioassay and decorporation of strontium compounds as this was the radioisotope of choice for validation of the tool. This first phase also included the re-evaluation of ten "high-risk" radioisotopes and definition of detailed outcomes. This was an important first step for which the data were readily available.

The second phase of the project was focused on model generation. The objective was to develop models and algorithms that would be used to quantify time dependent decorporation efficacy, committed effective dose estimation and risk reduction due to both radionuclide elimination and therapeutic drug initiation and termination. Essentially the approach was to optimize the data and explore different computational algorithms to provide outputs determined in Phase 1. The ideal model would synthesize the complex data and compute easy-to-understand results appropriate for decision making in the field.

The third phase was to be focused on the development of the medical management tool itself. As mentioned previously, the revised tool is a natural extension of the MEDECOR, which has already been proven useful to first responders. The tool was to be designed for ease of use in the field, satisfying the need for early medical management yet maintaining expert user ability to assist in clinical settings, training and exercise functions. This phase was handled exclusively by SAIC Canada and Dr. Ed Waller, however project team inputs for evaluation of tool were also essential. A complete description of the software requirements and software design documentation can be found in reference [1].

The second goal of the project and what also represented the final phase (but occurred concurrently with the third phase) was to conduct animal studies. The objective of the animal work was to validate the MEDECOR2 outputs for the strontium model. It was anticipated that these studies would validate the model for existing data and the computational tool predictions as well as provide supportive data and new information where it was lacking or limited. This phase was conducted exclusively at AECL's Chalk River Laboratories according to approved animal ethics protocols, however input from all project partners was imperative for designing the experimental requirements and final plan. As with any research and development project, there was uncertainty and risk associated with the results from the animal study and whether they would validate the developed model for strontium. Mitigation strategies were put in place so that the development of the software tool was in no way dependent on the results of the animal work.

The two were conducted on parallel paths and would converge near project completion with the integration of the animal data into the computational code if warranted.

To begin the first phase of the project, an extensive literature review and data harvesting exercise took place to acquire the highest quality and most recent data on various decorporation strategies and their efficacy for high risk radioisotopes. It was quickly realized that although there were abundant studies on decorporation treatments, the data on associated risk and benefits of time-dependant administration was severely limited. There are still a lot of gaps in this field of research and many questions to be answered by future work. Despite the lack of specific data we were looking for, there were still ample biokinetic models, bioassay data and other studies on which to develop the health physics models for the revised MEDECOR tool.

During the initial phase of the project, work also began on establishing the requirements for the software tool. This not only included "what" the tool should contain but "how" the tool should be designed. From the programming perspective, it was determined that the software should be designed in such a way that model parameters can be easily adjusted since new data will be added at various stages. It was also determined that MEDECOR2 should consider the broadest target reasonable for distribution of the tool. With this is mind, the development environment should meet the most basic hardware requirements for a mobile device (i.e. handheld) plus the optional targeting of the PC platform. The development environment for MEDECOR2 was the platform independent application framework Microsoft.Net and could be run using the Microsoft Windows Mobile operating system on the handheld device (Figure 1) or using a Windows operating system on a PC. The PC version of the application is essentially a PC-based device emulator in that it uses almost the entire code-base for the mobile edition. The user sees the application exactly as it would be presented on a handheld device (Figure 2). Further details can be found in the MEDECOR2 Software Design Document [1].

Figure 1: MEDECOR2 Handheld device architecture

Figure 2: MEDECOR2 Device Emulator for PC Platform

The primary purpose of the MEDECOR2 tool is to aid medical personnel and first responders in making a treatment assessment that balances the risks associated with a particular decorporation treatment regime with the risk of no treatment (i.e. the risk from the committed effective dose) following internal contamination by radionuclides. From the software tool content perspective, it was determined that the tool should use health physics calculations and decorporation algorithms to define decorporation models that are in turn used to determine treatment assessments. The decorporation models are used to determine the outputs of the tool based on the user's inputs [2]. A basic concept diagram for the MEDECOR2 Tool is shown in Figure 3 below.

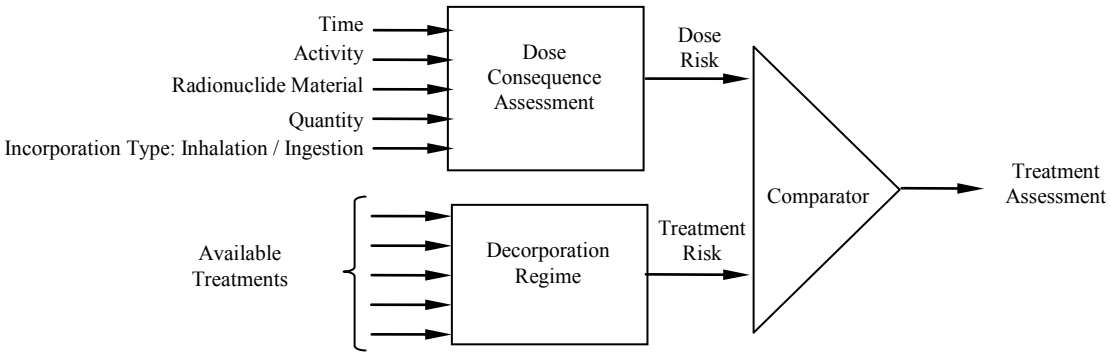

Figure 3: Basic Concept Diagram for MEDECOR2 Software Tool

During the design and development of the software tool, it was envisaged that the revised guidance tool, MEDECOR2, would have multiple triage modules/algorithms (whereas the original tool had only one risk assessment module) and also include options for advanced users under Treatment and Continuing Care. Each of these will be described in greater detail in the results section under The Software Tool: MEDECOR2.

The animal study portion of the project was an important component for validating the health physics models being used in the MEDECOR2 software tool. It was determined during the project initiation phase that animal work would be used to enhance the strontium-90 (Sr-90) data set and possibly validate the developed models. Animal models would provide an opportunity to explore a research area where published data were seriously lacking. The project team met early in the project to define the objectives of the animal work and carefully design the experiments so that animal ethics approval could be sought in sufficient time to conduct the studies within the timeframe of the project. It was decided that the animal work would be conducted in a two phase manner where a preliminary study with fewer animals would be conducted first to ensure all experimental details were worked out before proceeding to the large animal experiment. Results of the work are provided in the following section.

The final phase of the project focused on the delivery of the final version of the MEDECOR2 software tool and its end-user testing. An interim version of the revised MEDECOR tool was field-tested during a military medical CBRN response exercise in the Czech Republic in September 2010 [3]. This exercise was highly successful and provided valuable insight into the operational utility of the software tool. Feedback was provided following the exercise and because of when the exercise was conducted the developers were able to make the suggested amendments and improvements to the tool for the final version. Project partners provided end-user feedback on the tool and recommendations for future field-testing and exploitation opportunities were made. Following this, project close-out activities were carried out.

4 Results

4.1 The Software Tool: MEDECOR2

MEDECOR2 in its concept was to be a natural extension of the original MEDECOR tool developed in collaboration with RadSci Research and DRDC Ottawa. This new version was designed to improve functionality by improving the triage models, revising the treatment strategies to be consistent with current decorporation strategies as well as including a module to assess risk as a function of continuing care. Each of these is described further below. We wanted the guidance tool be user friendly and able to provide easy-to-understand results appropriate for decision making in the field. Screen shots of the user menu for the guidance tool are shown in Figure 4 to illustrate the user-friendly design of the software.

Figure 4: Clinical Assessments Menu page from MEDECOR2 software tool

4.1.1 Triage Module

The triage module is intended for use primarily by first responders in the field, although it may be useful to personnel at first receiver stations co-located with medical units.

The purpose of the triage module (Figure 5) is to determine which exposed persons are in need of immediate attention, and which are deemed to be at little risk from the exposure.

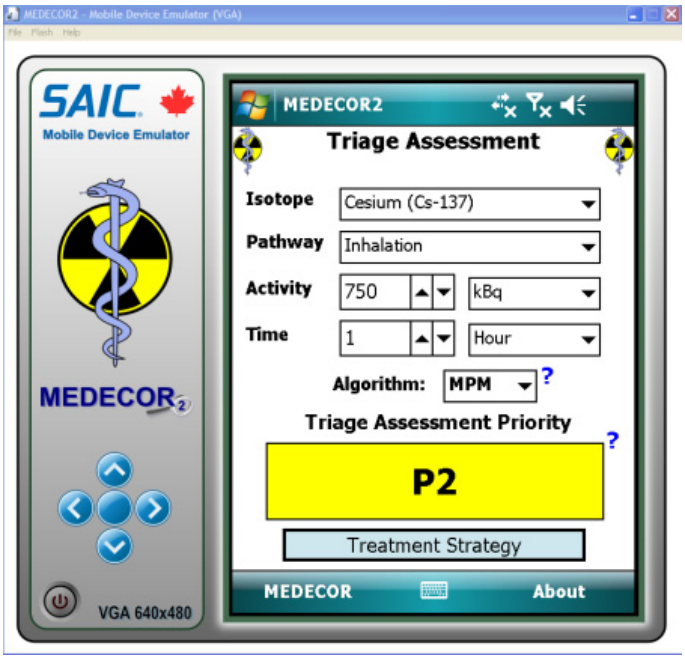

Figure 5: Screen shot for MEDECOR2 Triage Assessment module

Three (3) distinct triage algorithms were developed for the MEDECOR2 tool:

1. **MPM – Multi-Parameter Model**; This algorithm utilizes a variety of exposure parameters to build a decision matrix for determining a hierarchical triage priority similar to that used in the TMT (Triage, Monitoring and Treatment) handbook [4]. Primary parameters required for this assessment include isotope, route of intake, intake amount, dose conversion factor (DCF) and time since exposure. All of these parameters (or variables) are obtained through the combination of physical assessment of the radiological scenario (physical measurements), knowledge of the exposure scenario and/or interviews with the exposed persons. The model is based on the committed effective dose to the person based on intake and the elimination time factor based on first-order biokinetics. The tool then provides a triage priority (P1: Requiring immediate medical attention → P4: No need for treatment) based on the inputs and computational results. This model is based on the one described by Waller in [5].

2. **CDG – Clinical Decision Guidance**; This algorithm is based on clinical decision guides which are operational quantities defined in the National Council on Radiation Protection and Measurement (NCRP) Report 161 [6]. They were developed to provide a measure that medical personnel might use to determine if treatment would be warranted for internally contaminated individuals. The algorithm utilizes effective, red marrow and lung doses based upon estimated intake to determine a threshold between critical and

non-critical cases. It should be noted that the CDG is set at a conservative level for deterministic effects. The output from the tool is simply "Treat" or "Dismiss".

3. **ALI – Annual Limit on Intake**; This algorithm simply compares an intake against the calculated ALI for a nuclear energy worker (20mSv). It is important to note that an ALI is not typically a quantity that is used for triage assessment however it may be a comparison that is readily understandable by a number of stakeholders present during a radiological emergency and may therefore be useful as a screening tool for intakes that are not of immediate medical concern. This model is based on an operational approach proposed by Sugarman [7]. Similar to the CDG algorithm the tool output is guidance on whether to "Treat" or "Dismiss".

The default triage algorithm in MEDECOR2 is the MPM. The two other developed algorithms are based upon NCRP161 guidance (CDG) which was established from years of operational experience by radiation medical management personnel, and on REAC/TS guidance (ALI) based upon operational rule-of-thumb.

More detailed descriptions for each of the triage algorithms can be found in reference [8].

4.1.2 Treatment Module

Once an initial assessment has been done to determine triage priority, MEDECOR2 provides a simple way for medical personnel to determine treatment options. The treatment module is not algorithm-based but is rather a repository on treatment modalities for both adult and children (when data are available) and includes therapeutic dose information when available (Figure 6).

Upon entering the treatment screen, the user must select the element of interest. It is worthy to note that decorporation strategies are not usually dependent upon the radioisotope, as it is the elemental chemical form that is important for biokinetics. The treatment that appears is the default, or primary, treatment (i.e. the treatment of choice). Other treatments may be available on a drop down menu, preceded by [ALT], which denotes alternate treatment. Alternate treatments are those that have been investigated for the element of interest, and have demonstrated potential for positive decorporation action.

It is worthy to note that there is a small cohort of pharmaceuticals approved for treatment of radionuclide incorporation (for example, Health Canada has approved Potassium Iodide for iodine). However, most treatments described in this module will be characterized as 'off-label' use. When physicians prescribe approved medications for other than their intended indications, this practice is known as off-label use. MEDECOR2 does not indicate when a treatment modality is off-label, as this is regionally dependant. In addition, the treatment module does not generally provide guidance regarding contraindications.

Figure 6: Screen shot of MEDECOR2 Treatment module

4.1.3 Continuing Care Module

The goal of the continuing care module is to provide medical staff with an estimate of risk reduction based upon potential dose savings from using decorporation therapy (Figure 7). The primary parameters required for the assessment are: the isotope, intake amount, therapy strategy being used, treatment start time post exposure and therapy stop time. For this algorithm, the route of intake is assumed to be inhalation as this is what most of the data in the literature was based on (although it is likely that decorporation strategies will work for ingestion as well). Decorporation efficacy data was obtained for four elements: americium, cesium, cobalt and strontium and this is what was included in the application. Based on the user's inputs the software will calculate the committed effective dose (CED) assuming no therapy (in Sv), the percent risk reduction based on dose savings with therapy as well as provide any contraindications to therapy or precautions that should be considered.

Figure 7: Screen shot of MEDECOR2 Continuing Care Assessment module

4.1.4 Other features of the software

In addition to the Clinical Assessments component of the tool, there are additional resources within the tool for the advanced user. Under the Advanced tab the user will find information about advanced treatments, bioassay sampling guidance and clinical lab assessment guide. The Advanced Treatments page allows users to browse advanced and experimental decorporation treatment information while the Bioassay Guidance page provides guidance on the utility and instructions for collecting samples for bioassay analysis. The Clinical Lab Guide provides the user with advice on various clinical laboratory assessments available depending on the type of radiation contamination suspected (all radiation injuries, external contamination, and internal contamination) including the samples required, and the usage and protocols. There is also a Definitions/Glossary page which allows users to look up decorporation and technology definitions related to the MEDECOR2 software.

4.2 Field Testing of the MEDECOR2 Software Tool

The MEDECOR2 tool was invited to be field tested during a Czech military exercise by our international partner LCT Dr. Jan Österreicher in the Czech Republic in September 2010. The exercise had many objectives relating to CBRN medical response, defence and adherence to NATO STANAG procedures. The participation of Dr. Ed Waller and our Canadian software tool was the only international involvement. It should also be noted that an additional tool, the Radiation Triage Mask (RTM), developed and patented by Dr. Waller for first-responder use to detect and quantify radioisotope contamination in the oro-facial region was also tested during the same exercise. Its outputs (isotope and activity) provide valuable input for the MEDECOR2 tool.

As part of the exercise, training on the MEDECOR2 tool was provided prior to the scenario introduction (Day 1). It was done in ½ hr with on-the-fly translation. A laminated quick reference card was provided to medical personnel for use during the exercise.

On Day 2, two PDAs loaded with the MEDECOR2 software were provided; one to the triage team and one for the physician. Several scenarios involving different isotopes; Cs-137, Am-241 and Sr-90 were conducted to determine how the medical personnel would triage the victims. Trauma injuries were also injected to test that the triage team would tend to those patients prior to the radiological injuries (should always be the case). For each of the "victims" readings from the RTM were used as input for MEDECOR2 to provide a triage priority. Victims assessed with internal contamination were given a priority (1 through 3) and sent to the physician for determination of medical decorporation treatment again using the MEDECOR2 tool (Figure 8).

Figure 8: Physician assessment for treatment options using MEDECOR2

Overall, the triage teams performed very well. An example of the results from a scenario with Sr-90 is shown below. All patients were triaged according to the true priority.

Table 1: Data from Sr-90 trial during field testing of MEDECOR2 in Czech military exercise

Total personnel = 10 Total contaminated = 6 Time since exposure = 1 hr				
No.	Value	Unit	Assigned by nurse	TRUE priority
1	50	kBq	P3	P3
2	7	kBq	P3	P3
3	596	kBq	P2	P2
4	83	kBq	P3	P3
5	6	MBq	P1	P1
6	689	kBq	P2	P2
3 physical traumas (2xP1; 1xP3)				

The length of time it took for assessments to be made was carefully recorded and it was seen that on average the triage medical team could assess a patient using the software in 57 seconds and the physician was able to determine the appropriate treatment strategy at the rate of approximately 1.5 minutes per assessment. However, these time estimates did not take into account any transit time between triage area and the physician. A more realistic estimate of time to complete each patient is likely closer to 5 min for a full triage and treatment assessment.

The feedback from the physician, nurses and paramedic staff obtained over the 2 day exercise was invaluable to the project. The team reported that the tool was easy to use with minimal training required and allowed for timely triage and prioritization of victims with a high rate of success. Specific suggestions such as 'presenting the best decorporation treatment option (for a particular isotope) first and up-front and have the other information follow or in an alternative location', allowed the developers to incorporate these improvements in the final version of the software at project completion ultimately improving the functionality of the tool. Insight for future considerations for field testing of the tool was also gained.

4.3 End-user Testing

Upon delivery of the final software tool by SAIC at the end of March 2012, project partners from Department of National Defence Canadian Forces Health Service (CFHS) Operational Medicine and Director Nuclear Safety (DN Safe), Health Canada and AECL were invited to download the tool and explore its functionality. Comments and feedback were solicited. A scenario-based

training package was included in the final technical report from Dr. Waller [8] and a User Guide [9] was distributed with the tool. Feedback from the partners was overwhelmingly positive. General comments included ease of use, intuitive, and user-friendly interface. The Continuing Care Assessment module was thought to be very practical and knowing how much difference treatment would make was considered to be helpful and of medical relevance. Specific comments included concern about the triage and continuing care modules requiring an estimate of intake and how first responders might not have this, as well as the suggestion that it would be nice to be able to adjust the decision points in the triage module, lower if only a few people were exposed and higher if it was a mass casualty event.

All end-user comments were collected for review and possible implementation in future revisions of the tool.

4.4 Animal Studies to Validate Sr-90 Model

The objectives of the animal studies were to validate the MEDECOR2 outputs for strontium (uptake and therapeutic decorporation) as well as acquire supportive data where information is lacking or limited in the literature. Furthermore, the animal experiments were designed to study the biosolubility and biodistribution of strontium titanate in rats that have been internally exposed via inhalation and to study the ability of several agents and methods to minimize the whole body retention of strontium (decorporation). Strontium titanate (ceramic powder) was the form of strontium chosen for the study as it is used in thermoelectric generators and thought to be a likely choice for use in an RDD.

The experimental animal work was approached in 2 phases: a pilot study with fewer animals to initially examine the biodistribution of strontium and establish experimental protocols and a main study focusing on decorporation of the strontium titanate ($SrTiO_3$) ceramic powder. Male Long Evans rats were used throughout both studies and all work was conducted according to approved animal ethics protocols [10].

4.4.1 Pilot Study

The pilot study was conducted to determine the normal biosolubility and biodistribution of "inhaled" (instilled into trachea) strontium titanate in rats as well as the initial testing of recommended decorporation therapies. The best performing decorporation treatment was to be selected for use in the main study. The pilot study also allowed training of new AECL staff on techniques such as intratracheal instillation and, gavage in rats, as well as providing an opportunity to establish whole body counting protocols and analysis of bioassay samples post-collection.

Following an extensive literature search, little information was found regarding decorporation of strontium titanate. The agents selected for use in the study were identified in the literature for decorporation of soluble strontium (i.e. strontium chloride) and were chosen based on a) whether or not they were licensed for use in humans, b) low toxicity, and c) reported effectiveness. Decorporation therapies examined in the pilot study included calcium gluconate, calcium gluconate with vitamin C and vitamin D, Gaviscon® (sodium alginate), and Ca DTPA/Zn DTPA.

Twenty-five (25) rats were used in the pilot study with five animals per treatment group. All animals with the exception of the negative controls were instilled with 100 mg $SrTiO_3$ powder (all particles in the respirable range; <10 μm) on Day 0 that had been activated to contain a sufficient amount of gamma-emitting Sr-85 so that it could be easily detected using a whole body counter. The negative control animals received only a saline solution and no Sr-85. The rats were given their first decorporation treatment 4-5 hr after instillation and then daily for 4 days for a total of 5 treatments during the first week and then 2-3 additional treatments the following week. All animals were euthanized at 10 days post instillation.

Whole body counting was conducted daily to measure residual radioactivity in the lungs of the rats, or ultimately the body burden of Sr-85. Daily fecal samples taken from the animals over the ten day experiment were radioactive indicating that physical clearance from lungs was occurring. To obtain additional information on the distribution of strontium throughout the body once it was taken up from the lung, various tissues including the lungs, gastrointestinal tract, femurs and remaining carcass/blood were collected at the end of the experiment for radioactive counting. Decorporation efficacy results from the pilot study are shown below.

Table 2: Decorporation of $SrTiO_3$ results from pilot study

Treatment Group	Mean Clearance rate (λ)	Standard Deviation	T ½
Control	0.0172	0.02	40.30
Calcium gluconate/Vit C/VitD	0.0240	0.01	28.88
Gaviscon	0.0178	0.01	38.94
DTPA	0.0214	0.03	32.39

Upon analysis of the data, the only decorporation therapy that may have increased clearance from the body was the calcium gluconate/Vit C/Vit D combination; however, the result is not statistically significant. This treatment may have prevented the absorption of Sr in the gut (cleared from the lungs and deposited in the gut) and thus preventing Sr incorporation into the bones of the animals. Regarding the biodistribution, count data at euthanasia confirmed the expectation that a significant percentage of the strontium was distributed in the bones and soft tissue of the rats.

During the pilot study it was noted that, as expected, the strontium titanate was not very soluble and remained largely in the lungs as discovered post-mortem. The amount of strontium titanate powder used was too much and perhaps hindered the clearance from the lungs and thus inhibited the decorporating agents from having an effect. However, this amount (100 mg) was used to ensure the radioactive signal could be detected accurately by the rat whole body counter throughout the duration of the experiment. These observations were taken into consideration for the main study.

4.4.2 Main study

With the results of the pilot study, it was decided that calcium gluconate/ Vit C/ Vit D would be the decorporation strategy used in the main study and that a larger number of animals would be used to obtain improved statistics. In addition, since the main method of removal of Sr from the body appeared to be via the ciliary bronchial tree, two additional treatments (use of an expectorant and housing rats in a humidified chamber) would be used to help expedite physical removal of the powder from the lungs. Due to the finding that a large amount of $SrTiO_3$ was still in the lungs after 10 days, efforts were made to increase the Sr-85 content in the powder by irradiating it longer so that less volume could be used. In addition, a new whole body counting systems for rats was constructed using 4 NaI crystals to improve the sensitivity and therefore less activity per rat would be required to get accurate counts.

The treatment groups for the main study are shown in Table 3.

Table 3: Study cohorts for main animal study on decorporation of $SrTiO_3$

Group #	# of rats	Instillation Solution	Decorporation Therapy	Time of Euthanasia
1 (Positive Controls)	12	Minimum of 10 kBq of Sr-85 in 2-10 mg of strontium titanate powder.	No therapy given. Serves as positive controls.	21 days post-instillation
2	20	Same as controls	Calcium gluconate intraperitoneally or subcutaneously. Vitamin D and C orally. (or Vitamin C subcutaneously)	21 days post-instillation
3	20	Same as controls	Calcium gluconate intraperitoneally or subcutaneously	21 days post-instillation
4	8	Same as controls	Guaifenesin orally by gavage. Housed in humidified air	21 days post-instillation
5 (Negative controls)	6	Sterile physiological saline and 0.1% Turgitol		21 days post-instillation

Similar to the pilot study, all rats with the exception of the negative controls were instilled with a minimum of 10 kBq Sr-85 on Day 0. Whole body counting was performed following instillation and on days 1, 3, 6, 14 and 21. Based on the literature, it was decided that the experiment would be extended to 21 days at which point all animals would be euthanized and tissue samples (lungs, GI, carcass/blood) collected for radioactive counting. Decorporation treatments began 4-6 hrs post-instillation for a total of 10 treatments over the 3 week experiment. The same doses were used for the decorporation agents as were used in the pilot study.

The decorporation results from the main animal study are shown below in Figure 9. Radioactive counts from the whole body counting were used to calculate the percentage of strontium remaining in the body over time. Interestingly, no significant differences in clearance rates were observed between the decorporation methods examined and the positive control animals. All treatments resulted in a ~2% loss of strontium per day which was similar to the untreated animals relying only on physiological clearance alone.

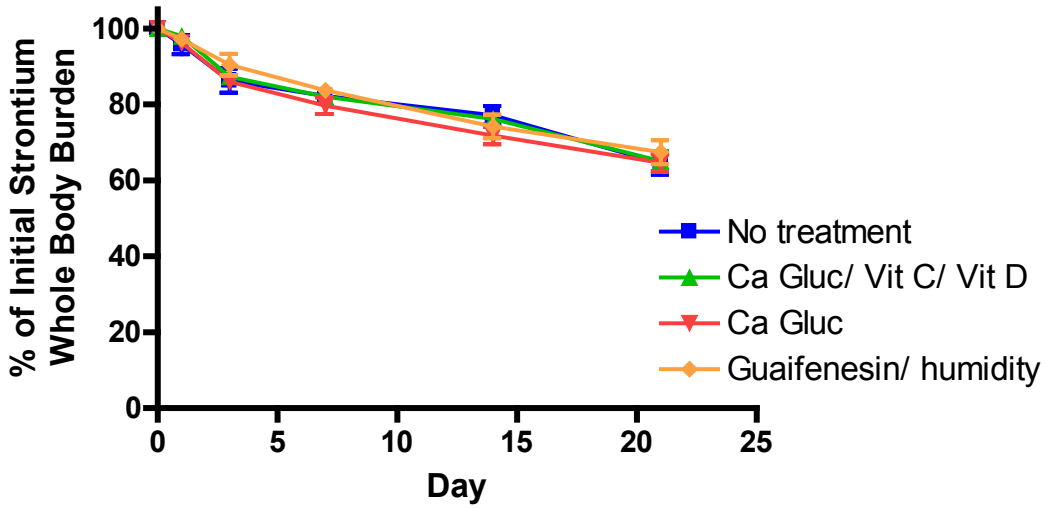

Figure 9: $SrTiO_3$ decorporation results from main animal study

Unfortunately the results from the animal study did not provide validation of the strontium decorporation models in MEDECOR2. Nonetheless, the studies were worthwhile and provided scientific knowledge and protocol development for doing these types of experiments. Little to no information on the decorporation of insoluble strontium existed in the current literature and thus this work represents the first of its kind.

5 Transition and Exploitation

5.1 Follow-on Development

Several recommendations from the field testing exercise in the Czech Republic as well as from project partner testing suggested that there is always room for improvement of the tool. As new information becomes available and decorporation strategies evolve there will be a requirement to update the advice in MEDECOR2. For this reason, version control will be imperative. Furthermore, due to the rapid change in portable computational device technology, a smart phone "app" or tablet version may be more applicable than the PDA version. Transitioning the computational code to the new environment would require a follow-on contract with software programmers.

Although a functional, optimized tool has been delivered as a result of this project, it is still recommended that further field testing be conducted. Considerations for future field testing exercises include: exercising with more realistic trauma scenarios (in the Czech exercise, trauma injuries were on paper), practicing contamination control, and examining what happens after the physician prescribes a treatment (availability/access of treatment).

5.2 Transition to End Users

The software tool, MEDECOR2, developed from this project is a user-friendly, fieldable guidance tool for first responders and medical personnel to be used following a radiological event where triage and treatment of internal contamination is a concern. The product developed is at a Technology Readiness Level (TRL) of 7-8 and has undergone field testing and project partner testing. The current version of the application is ready for distribution and will be made available to those interested. Commercialization was never the goal for the software tool as it is likely to have only a niche market. From project conception, it was envisaged that the tool would be freely distributed. Discussions are currently underway with the sub-contractor on the project, RadSci Research, and Dr. Waller on how to effectively handle distribution and versioning control for the tool likely through licensing of the IP. The tool and foreground IP will be disseminated to government project partners for non-commercial use and distribution as appropriate.

Following project partner testing by DND's CF Health Services, there was much interest on how best to integrate this tool within the CF. Promoting the tool at every opportunity will be key to getting it in hands of those that can use it most. Recommended end-users with the Canadian Forces include, CANSOFCOM, Medical Nuclear Emergency Response teams as well as implementation into the Basic Medical Officers course. Furthermore, discussions are on-going with Health Canada's Radiation Protection Bureau to explore the opportunity of including MEDECOR2 in their METER training which educates emergency room physicians and nurses on the management of radiation casualties.

5.3 Intellectual Property Disposition

Background intellectual property for this project largely resulted from work done previously on the original MEDECOR tool developed by DRDC Ottawa and Dr. Ed. Waller. Foreground intellectual property resulting from this CRTI funded project, CRTI-07-0186RD, rests with the Crown, as stipulated in the project charter and contract with SAIC Canada. Management and administration of this IP has been handled by DRDC Ottawa and made available to the Project team. Discussions are ongoing between RadSci Research and DRDC Ottawa about the possibility for RadSci Research to host, distribute and update the MEDECOR2 software tool via the granting of licenses. However at project completion, no decision had been made on proceeding with licensing of the IP for the tool.

6 Conclusion

The aim of the CRTI funded project CRTI 07-0186RD was to develop a field-deployable medical decorporation software tool to assist in triage, provide treatment data, optimize benefits and minimize risks to the exposed individuals. The completion of this project, on time and within budget, resulted in the successful delivery of the optimized MEDECOR2 tool.

Extensive data harvesting from the literature aided in the development of health physics-based models and algorithms that ultimately provide the user with a measure of risk reduction (based on dose savings) from the time-dependent administration of decorporation treatments. To our knowledge, the MEDECOR2 tool is the first of its kind to incorporate both treatment regime and risk/benefit of treatment when making assessments.

During any R&D project, scientific risk is inherent. As part of this project, animal studies were conducted to validate the outputs of the tool for the strontium model and to provide information and data where it was lacking or limited. Since the literature search for decorporation of strontium compounds, particularly strontium titanate, yielded little information, the animals studies were extremely useful and well designed in that regard. Had the animal experiments provided novel decorporation efficacy data for insoluble strontium compounds, the findings would have been incorporated into the software tool. Unfortunately this was not the case and the results from the animal work did not provide usable data for the tool since there was no mechanism within the tool to distinguish between soluble and insoluble forms. Mitigations had been put in place such that the timely delivery of the final tool was not impacted by this outcome.

Radiation/nuclear casualty management, which is not a routine component of medical practice, will benefit from this user-friendly, accessible interface for determining treatment strategies following a mass casualty event where internal contamination is a concern. Due to the nature of the tool, MEDECOR2 is equally applicable for use following a number of RN scenarios: improvised nuclear device, nuclear weapon, radiation dispersal device (RDD) or nuclear reactor release events. Furthermore, the tool is useful to a broad spectrum of professionals ranging from government agencies, first responders, emergency medical departments, emergency managers and nuclear power utilities with the ultimate impact on radiological/nuclear casualties.

References

[1] SAIC Canada, *MEDECOR2 Software Design Document, Version 4* April 2011.

[2] SAIC Canada, *MEDECOR2 Software Requirements Specification, Version 4* March 2012.

[3] Waller, E. *Exercise Boleslavska hraba: Operational testing of Medecor2,* Trip Report. October 2010.

[4] Rojas-Palma, C, et al. *TMT Handbook – Triage, Monitoring and Treatment of people exposed to ionizing radiation following a malevolent act*. NRPA www.tmthandbook.org

[5] Waller, E. and Wilkinson, D. *MEDECOR – A MEdical DECORporation tool to assist first responders, receivers, and medical reach-back personnel in triage, treatment and risk assessment after internalization of radionuclides*. Health Physics 99(4): 581-590, 2010.

[6] National Council on Radiation Protection and Measurements, *Management of Persons Contaminated with Radionuclides: Handbook.* NCRP Report No.161. Bethesda, MD. 2008

[7] Sugarman, S; Toohey, R; Goans, R; Christensen, D; Wiley, A. *Rapid Internal Dose Magnitude Estimation in Emergency Situations Using Annual Limits on Intake (ALI) Comparisons.* Health Physics, 98(6): 815-818, 2010

[8] Waller, E. Models for Triage, Treatment and Risk Assessment for MEDECOR2 Decorporation Tool. DRDC Ottawa Contractor Report, CR 2012-###, June 2012.

[9] SAIC Canada, MEDECOR2 User Guide for Software version 1.1, Version 0, January 2012.

[10] AECL Technical Outline Protocol BRF-09-06: Decorporation of Strontium 90 in Rats, Nuclear Platform Research and Development 153-121111-EXP-007. Prepared by H. Wyatt, March 2010

Annex A Project Team

This project was led and managed by DRDC Ottawa, with SAIC Canada as the prime contractor and AECL, Health Canada, Directorate of Nuclear Safety (DN Safe) and Canadian Forces Health Services (CFHS) within the Department of National Defence as project partners. RadSci Research Inc and the international partners, AFRRI and Czech Republic Military Medical Academy were subcontracted under SAIC Canada.

DRDC Ottawa was responsible for preparing all project management documentation, such as the project charter, satisfying CRTI project reporting requirements and managing the CRTI funds supplied to the project. In addition, DRDC Ottawa provided key scientific and technical support, including establishing animal study requirements, provision of technical staff to support main animal study and evaluation of the software.

SAIC and RadSci Research were responsible for data harvesting and analysis of decorporation data for top ten radioisotopes, determining the software and hardware requirements for the tool, and ultimately delivering the final computational code for the software tool.

Partners at AECL's Chalk River Laboratories were responsible for conducting animal studies to aid in the validation of the MEDECOR2 outputs for the strontium model. This included the design of the experiments as well as the provision of their facilities for the experiments to take place.

DN Safe, CFHS and Health Canada provided health physics validation, medical information and therapeutic strategy input, and radiochemistry advice respectively. All partners contributed end-user feedback on developed tool.

The detailed list of project team members and their affiliations is found in Table 1.

Table 4: Project team and project review committee (PRC) members

Position	Name	Title	Phone Number	E-mail Address
Project Champion	Ms. Maria Rey	Director General, DRDC Ottawa	(613) 998-2303	Maria.Rey@drdc-rddc.gc.ca
Portfolio Manager	Mr. Ian Summerell	R/N Portfolio Manager, DRDC CSS	(613) 943-2504	Ian.Summerell@drdc-rddc.gc.ca
Project Manager	Ms. Hillary Boulay Greene (Dr. Diana Wilkinson)	Defence Scientist, DRDC Ottawa	(613) 998-1101	Hillary.Boulay@drdc-rddc.gc.ca

Health Canada PRC Member		Head, Radiation Protection Bureau		
Health Canada Partner	Dr. Chunsheng Li	Chemist	(613) 954-0299	Li_chunsheng@hc-sc.gc.ca
Health Canada Partner	Dr. Gary Kramer	Head, National Internal Radiation Assessment Section	(613) 954-6668	Gary_H_Kramer@hc-sc.gc.ca
AECL PRC Member and Partner	Dr. Nicholas Priest	Head, Radiological and Analytical Sciences	(613) 584-8811	priestn@aecl.ca
AECL Partner	Dr. Heather Wyatt	Veterinarian	(613) 584-8811 x 44734	wyatth@aecl.ca
CFHS PRC Member and Partner	Dr. Slavica Vlahovich	Advisor, Medical Countermeasures	(613) 945-6896	Slavica.Vlahovich@forces.gc.ca
DN Safe PRC Member	Mr. Martin Pierre	Director, Nuclear Safety 3	(613) 996-0699	Martin.Pierre@forces.gc.ca
DN Safe Partner	Mr. Roger Hugron	Senior Nuclear Specialist	(613) 995-9506	Roger.Hugron@forces.gc.ca
SAIC PRC Member	Mr. Glen Brown	Division Manager – Information, Environmental and Engineering Solutions	(613) 683-3291	brownG@saiccanada.com
SAIC Partner	Mr. KT Walsh	Senior Systems Specialist	(613) 563-7242	walshK@saiccanada.com
RadSci Research Partner	Dr. Ed Waller	Health Physicist	(905) 718-0997	Ed.waller@radsci.ca
Advisor – Radiation Biology	Dr. William Blakely	Senior Scientist and Program Advisor	(301) 295-0484	blakely@afrri.usuhs.mil
Advisor – Operational Testing	Dr. Jan Österreicher	Professor, Purkyne Military Medical Academy		J.Osterreicher@seznam.cz

Annex B Project Performance Summary

B.1 Technical Performance Summary

The overall objective of the project was to enhance the existing medical decorporation tool (MEDECOR) with algorithms based on health physics models that took into consideration treatment times and risk reduction strategies for the top ten high risk radioisotopes. Significant software development work was done to develop several new modules for medical personnel (Advanced Treatments module, Bioassay Guidance module, and Clinical Lab module), integration of the risk assessment data and porting models into a new computational platform. The project's objectives for the software toll were successfully delivered in the final version of MEDECOR2, which is capable of operating on the Windows Mobile environment and PC platforms and includes modules that assess risk as a function of continuing care for decorporation methods. The TRL level of the delivered tool is assessed to be at TRL 7-8. It represents the first tool for first responders, nurses, physicians and other medical personnel which compiles existing radionuclide decorporation therapy data and allows the user to perform simple triage leading to appropriate decorporation strategies based on risk-benefit models.

A secondary objective of the project was to conduct animal studies to validate MEDECOR2 outputs for strontium intake and therapeutic decorporation. A large rodent study was undertaken to achieve this objective however the results from the study failed to yield data for this purpose. Unfortunately, the decorporation agent selected for the final study failed to accelerate clearance of Sr from the body when compared to normal clearance rates. Although a null result for the decorporation agents tested, these results provide relevant data where gaps in the strontium decorporation data existed, particularly for insoluble Sr..

B.2 Schedule Performance Summary

The original schedule and revised completion dates for all major project milestones are shown in Table 2. Overall, the project ran smoothly and adhered well to the schedule put forward in the Charter. There were some delays at the onset of the project with getting the major software development contract to SAIC in place; however, over the lifetime of the project no major delays were seen. Some delays were encountered with the start of the full animal study due to difficulties ensuring the radioisotope tracer (SrTiO3) had sufficient activity; however, mitigation strategies were put in place to ensure minimal impact on the software development. In the end the results from the animal study did not yield results that could be integrated into the software tool.

Due to the delays in the animal work at the end of the project, an extension for close-out of the project from March 2012 to June 2012 was agreed upon by the project partners and CSS at the last PRC meeting in November 2011.

Table 5: Major Project Milestones for CRTI 07-0186RD: original schedule vs. actual completion dates

Milestone	Event	Projected Completion	Actual Completion
1.	Project Approval-in-principle	February, 2008	February 2008
2.	Project Implementation Workshop	March 2008	March 2008
3.	Project Charter and Signatures Completed	June 2008	July 2008
4.	Project Implementation Begins	July 2008	July 2008
5.	Project Kick-off Meeting	August 2008	December 2008
6.	PWGSC Contract Completed	January 2009	April 2009
7.	Re-evaluation of 10 "high-risk" radioisotopes	January 2009	June 2009
8.	Define project outcomes	January 2009	March 2009
9.	Existing MEDECOR code function ported to the new computational environment	October 2009	September 2010
10.	Results of data harvesting for review	September 2010	January 2011
11.	Animal Research Ethics Board Approvals	January 2010	March 2010
12.	Full animal study	January 2011	September 2011
13.	Integrated infrastructure code for risk assessment	January 2011	January 2012
14.	Test and debug the Model	March 2011	February 2012
15.	Animal study results	June 2011	March 2012
16.	Practical field-test of the Model (medical and health physics community)	June 2011	September 2010, April 2012
17.	CRTI Symposium Presentation	June 2011	June 2011
18.	Model modified to reflect animal-study results	August 2011	N/A (April 2012)
19.	Deployment training package	December 2011	April 2012
20.	Project Close-out Meeting	February 2012	June 2012
21.	Project Close Out Report	March 2012	June 2012
22.	Project Complete	March 2012	June 2012
23.	CRTI Annual Symposium Presentation	June 2012	June 2012

B.3 Cost Performance Summary

The original and final MEDECOR2 project costs broken down by partner are shown in Table 5. The budget for the project was $1,090,151.00 in CRTI funds with an in-kind contribution of $805,999.00 (45%). Overall, CRTI funds were under spent for this project however most of this occurred in first 2 years of the project. The original Charter was revised to reflect a roll-over of funds ($88, 832) from fiscal year 08/09 (project start-up) to FY 09/10 due to contracting delays at project start-up. Several partners provided greater in kind contributions to the project, mostly on project management and software development. The variances in in-kind contributions from our international partners are a reflection of the lack of their reporting on a quarterly basis.

Table 6: Budget allocations and expenditures for CRTI 07-0186RD

Partner		Projected in Charter*	Actual Expended	Delta
DRDC Ottawa	CRTI	$ 263,851.00	$ 232,899.16	- $ 30,951.84
	In Kind	$ 391,760.00	$ 444,496.30	$ 52,736.30
SAIC	CRTI	$ 385,450.00	$ 385,450.00	$ 0.00
	In Kind	$ 102,500.00	$ 114,718.37	$ 12,218.37
AECL	CRTI	$ 357,850.00	$ 282,312.00	- $ 75,538.00
	In Kind	$ 214,900.00	$ 212,403.27	- $ 2,496.53
Health Canada	CRTI	$ 56,000.00	$ 26,511.79	- $ 29,488.21
	In Kind	$ 69,600.00	$ 30,104.00	- $ 39,496.00
DND CFHS	CRTI	$ 13,500.00	$ 3,496.89	- $ 10,003.11
	In Kind	$ 9,300.00	$ 16,512.00	$ 7,212.00
DND DGNS	CRTI	$ 13,500.00	$ 3,920.91	- $ 9,579.09
	In Kind	$ 17,939.00	$ 15,914.00	- $ 2,025.00
AFRRI				
	In Kind	$ 30,000.00	-	- $ 30,000.00
Mil Med CZ				
	In kind	$ 60,000.00	-	- $ 60,000.00

Annex C Publications, Presentations, Patents

Wilkinson, D., et al. *Optimization of MEdical DECORporation (MEDECOR) tool for time and use and improved bioeffects*. Oral presentation at CRTI Summer Symposium, Edmonton, AB. June 2008.

Waller, E. and Perera S. *Assessing Risk from Low Energy Radionuclide Aerosol Dispersal.* Poster presentation at 12th International Congress of the International Radiation Protection Association (IRPA12), Buenos Aires, Argentina, October 2008.

Waller, E., et al. *MEdical DECORporation Software to assist first responders, first receivers and medical reach-back personnel in Triage, Treatment and Risk Assessment from Internalized Radionuclides*, Poster Presentation at 10th International Conference on the Health Effects of Incorporated Radionuclides, Santa Fe, NM, USA. May 2009.

Wilkinson, D., Waller, E., et al. *CRTI 07-0186RD: Optimization of MEdical DECORporation (MEDECOR) tool for time of use and improved bioeffects*. Abstract in proceedings of CRTI Summer Symposium 2009, Ottawa, ON. June 2009.

Wilkinson, D., Waller, E., et al. *CRTI 07-0186RD: Optimization of MEdical DECORporation (MEDECOR) tool for time of use and improved bioeffects*. Poster presentation at CRTI Summer Symposium 2009, Ottawa, ON. June 2009.

Waller, E. and Wilkinson D. *Quantitative Triage Assessment Indicators and Risk Aversion Models for Radionuclide Intake and Incorporation.* Oral presentation at 54th Annual Health Physics Society Meeting, Minneapolis, MN USA, July 2009.

Waller, E et al. *Overview of hazard Assessment and Emergency Planning Software of Use to RN First Responders.* Health Physics 97(2): 145-156, 2009

Waller, E. and Wilkinson D. *MEDECOR – A Medical DECORporation tool to assist first responders, receivers and medical reach-back personnel in triage, treatment and risk assessment after internalization of radionuclides*, Health Physics 99(4): 581-590, 2010.

Waller E. *A combined hardware-software strategy for triage of internally contaminated persons: project overview*. Oral Presentation at National Medical Scan Workshop, May 2010.

Wilkinson D., Waller, E., Boulay Greene, H. et al. *Optimization of Medical DECORporation (MEDECOR2) Tool for Time and Use for Improved Bioeffects. CRTI 07-0186RD.* Poster Presentation at Public Security S&T Summer Symposium 2010, Ottawa, ON, June 2010.

Waller, E. *Combined Hardware-software considerations for Triage of Internally Contaminated Personnel.* Radiation Protection Dosimetry 142(1): 24-28, 2010

Waller, E and Wilkinson D. *MEDECOR2- A Tool to Assist First Responders with Medical Decorporation.* Oral presentation at the International Workshop on Emergency Bioassay, Ottawa, ON, September 2010.

Waller, E. *Exercise Boleslavska hraba: Operational testing of Medecor2,* Trip Report. October 2010.

Waller E, Osterreicher, J., and Souková J. *Operational experience with radiological triage and treatment tools*, Oral Presentation at Health Physics Society 56th Annual Meeting. June 2011.

Boulay Greene, H. Wyatt, and E. Waller. *CRTI 07-0186RD: Optimization of Medical DECORporation (MEDECOR2) Tool for Time and Use for Improved Bioeffects.* Abstract in proceedings of the 2011 Public Security S&T Summer Symposium, Ottawa, ON. June 2011

Boulay Greene, H., Waller, E., Li, C., Vlahovich, S., R. Hugron, R. et al. *MEDECOR 2: Optimization of Medical DECORporation (MEDECOR) Tool for Time and Use for Improved Bioeffects*. Poster Presentation and technology demonstration at Public Security S&T Summer Symposium 2011, Ottawa, ON June 2011

SAIC Canada, *MEDECOR2 Software Design Document Version 4,* April 2011.

SAIC Canada, *MEDECOR2 Software Requirements Specification Version 4*, March 2012.

SAIC Canada, *MEDECOR2 Hardware Requirements Specification, Version 2*, March 2010

SAIC Canada, *MEDECOR2 User Guide for Software version 1.1, Version 0,* January 2012.

Waller E. *NATO Exercising of a Strategy for Rapid Triage and Treatment of Persons Exposed to a Radiological Dispersal Device*, Oral Presentation at Canadian Radiation Protection Association 2012 Annual Meeting, Halifax NS, May 2012.

Waller, E. *Models for Triage, Treatment and Risk Assessment for MEDECOR2 Decorporation Tool.* DRDC Ottawa Contractor Report CR 2012- June 2012.

Boulay Greene, H., Wyatt H., Waller, E. *CRTI 07-0186RD: Optimization of Medical DECORporation (MEDECOR2) Tool for Time and Use for Improved Bioeffects*. Abstract in Proceedings from 10th Annual Public Security S&T Summer Symposium 2012. June 2012

Boulay Greene, H et al., *MEDECOR2: Optimization of Medical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects*. Oral Presentation at 10th Annual Public Security S&T Summer Symposium, Ottawa, ON, June 2012.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Defence R&D Canada – Ottawa
3701 Carling Avenue
Ottawa, Ontario K1A 0Z4

2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.)

UNCLASSIFIED
(NON-CONTROLLED GOODS)
DMC A
REVIEW: GCEC JUNE 2010

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title.)

MEDECOR 2: Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects: Project Close-out Report for CRTI 07-0186RD

4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)

Boulay Greene, H.M.

5. DATE OF PUBLICATION (Month and year of publication of document.)	6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)	6b. NO. OF REFS (Total cited in document.)
July 2012	43	10

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Technical Report

8. SPONSORING ACTIVITY (The name of the department project office or laboratory sponsoring the research and development – include address.)

Defence R&D Canada – Ottawa
3701 Carling Avenue
Ottawa, Ontario K1A 0Z4

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
CRTI 07-0186RD	

10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.)	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)
DRDC Ottawa TR 2012-127	

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification.)

Unlimited

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Unlimited

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

The CBRNE Research and Technology Initiative (CRTI) funded the project CRTI 07-0186RD "Optimization of MEdical DECORporation (MEDECOR) Tool for Time of Use and Improved Bioeffects" to develop a field-deployable medical decorporation management tool that will provide treatment strategies for removal of internalized radionuclides by optimizing gain and minimizing risk. The project progressed well, was on time and adhered to budget. At project completion, the final software tool was delivered adhering to the specified performance criteria and objectives set at project conception. First responders and medical personnel now have at their disposal a fieldable guidance tool capable of providing the most current decorporation guidance for internalized radionuclides and recommends ideal risk aversion strategies based on treatment times and dose savings.

L'Initiative de recherche et de technologie CBRNE (IRTC) a permis de financer le projet CRTI 07-0186RD « Optimisation de l'outil de décorporation médicale (MEDECOR) en ce qui a trait au temps et à l'utilisation, pour l'amélioration des effets biologiques ». Ce projet visait à mettre au point un outil de gestion de décorporation médicale déployable sur le terrain, qui fournirait des stratégies de traitement pour éliminer les radionucléides ayant pénétré dans le corps en optimisant les avantages et en réduisant les risques. Le projet a bien progressé, et l'on a respecté les échéances et les limites du budget. Au terme du projet, l'outil logiciel final a été livré conformément aux critères de performance indiqués et aux objectifs fixés à l'étape de la conception. Les premiers répondants et le personnel médical disposent maintenant d'un outil utilisable sur le terrain et capable de fournir les consignes les plus à jour sur l'élimination des radionucléides ayant pénétré dans le corps et de recommander des stratégies idéales pour éviter les risques, fondées sur la durée du traitement et les économies de doses.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

medical decorporation; internal radionuclide contamination; software tool

Defence R&D Canada

Canada's leader in Defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

www.drdc-rddc.gc.ca