Date: November 10th, 2006

Short Title of project (no more than 200 characters): Development of an Intelligent Threat Assessment System for First Responders

LEAD PARTICIPANT ORGANIZATION

CriSys Limited

TOTAL AMOUNT REQUESTED

	Year 1	Year 2	Total
Total	$268,602	$356,053	$624,655
Precarn Contribution	$128,730	$170,643	$299,373

LEAD PARTICIPANT CriSys Limited,

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OTHER PARTICIPANTS

Organization Name:	York University	Ryerson University
Mailing Address:	4700 Keele Street, Toronto, Ontario	350 Victoria Street, Toronto, Ontario M5B 2K3

OTHER PARTICIPANTS

Organization Name: Brandon University

Mailing Address: 270 18th Street, Brandon, Manitoba

OTHER PARTICIPANTS

Organization Name: Ontario Association of Fire Chiefs

Mailing Address: % Peterborough Fire Department, 210 Sherbrooke Street, Peterborough, Ontario

The following Fire Departments have committed to contributing domain expertise by making experienced staff available for interviews, and in participating in the field trial(s): Belleville Fire Department, Brantford Fire Department, Cambridge Fire Department, Clarington Fire Department, Grande Prairie Fire Department, Kitchener Fire Department, Moncton Fire Department, Orillia Fire Department, Oshawa Fire Department, Pickering Fire Department, Quinte West Fire Department, Saint John's Regional Fire Department, Saint Albert Fire Department. Sault Ste. Marie Fire Department and St. Thomas Fire Department.

Development of
An Intelligent Threat Assessment System
for First Responders

CriSys Limited, in conjunction with Ryerson University, York University, Brandon University and The Ontario Association of Fire Chiefs (as well as fifteen Canadian Fire-Rescue services), propose to develop an expert system to assist emergency response agencies in performing the assessment of the nature and extent of the threat posed by an emergency situation.

Concept Outline

Currently, emergency services use simplified, “one size fits all” procedures to decide what quantity and type of resources to send to each situation. These procedures are based on principles established decades ago, and are generally static in nature. They then rely on the judgement of the experienced officer who arrives at the scene first to make a dynamic evaluation and request additional units if appropriate.

Unfortunately, the first officer typically doesn’t arrive on-scene for 4 to 8 minutes, and if additional resources are required, it’s another 4 to 8 minutes before they arrive. In the intervening 8 to 16 minutes, lives can be lost, additional injuries suffered, and considerable additional property damage incurred. At the same time, the one-size-fits-all approach sometimes over-commits scarce resources that could be better used elsewhere.

In the event that there are injuries or fatalities, or that a significant property loss occurs, departments are increasingly being sued for damages (especially in the litigation-prone United States). When this happens, the department usually has no better explanation of why a specific set of vehicles was dispatched than “that is our standard procedure” possibly supplemented with “refined over many years of experience”.

It appears, however, that most of the factors that the officers consider when performing their “on-scene size-up” analysis are available, or can be inferred, from information sources that are available as soon as the call reporting the emergency is received. Furthermore, a methodic application of these factors, using an expert system based on the very “years of experience” that the departments cite, would be capable of providing a detailed after-the-fact explanation of why various actions were taken, and would constitute a powerful liability defence.

The intent of the proposed system is to allow these agencies to perform the majority of the “initial size-up” analysis within the first 30 seconds after they become aware of the incident, and to make the decisions about the number and type of resources to send to the incident at that time, instead of having to wait until the first experienced officer arrives on-scene.

Potential Benefits

The primary potential benefits of such a system are considerable; by making the size-up analysis in the first few seconds of an incident, the potential exists to:

- save hundreds of lives per year (which can have real and potential value to society in the millions of dollars of productivity)

- mitigate injuries suffered in fires and accidents, saving millions more in healthcare costs, and
- to reduce property damage by millions of dollars per year

There is also a significant secondary benefit: such a system would, for the first time, provide emergency response agencies with a comprehensive listing of the factors that guided the decision to dispatch the resources sent, which would constitute a powerful defence in an “inadequate response” lawsuit.

Potential for Commercialization

There is excellent potential for commercialization of a successful system;

- CriSys Limited already supplies the emergency response software used by over 125 agencies serving almost 4 million Canadians in more than 200 communities,
- CriSys has an office in Washington D.C., is planning to open a second office in Boston, MA to support sales & marketing operations to the U.S. market, and plans to open an office to serve the European market in 2008/2009, and
- the total available market for emergency response software with such a capability is approximately $5.2B/yr (North America and Europe, public- and private-sector systems, including on-going support revenues)
- there are more than 1,950 public-sector Fire-Rescue Departments in North America alone that match the operational profiles of the 12 pilot-program departments, each of which would benefit from implementation of such a system

Work to be Done

To achieve this capability, however, considerable work needs to be done, some of it with significant challenges:

1.) a **prototype system** must be created to test the underlying premise and identify potential problem areas

2.) a **domain model** must be designed that is sufficiently rich to support reasoning about the nature and extent of threat posed to a community by a given set of conditions. The model must support abstraction of the threat to a level that will allow the model to deal with a very wide, diverse range of conditions (although the field trial will focus on achieving success in a single set of scenarios - sizing up a structural fire - only). To fully commercialize the resulting capability, however, a formalized process must be defined that will support on-going expansion, verification and maintenance of the model.

3.) the **knowledge base** used by an experienced officer to perform an initial incident size-up must be elicited, formalized, reviewed and encoded. Furthermore, as it is anticipated that the reasoning applied will vary from department to department based on criteria such as the size of the community served (perhaps as a proxy for the size and capability of the department itself), and the nature of the community served (i.e., rural vs. urban, industrial vs. residential, etc.), the rules elicited, and underlying domain model that they will be run against, must have sufficient flexibility to accommodate these factors. As noted above, successful commercialization of the resulting capability will require that the process used to develop this component of the system must be sufficiently formalized to support on-going expansion, verification and maintenance of the knowledge base.

4.) a unique **explanation engine** must be created that is capable of providing a human-readable, plain-language explanation of the reasoning and factors behind a given decision, in either a “condensed” mode suitable for use within the dispatch centre and in a “verbose” mode suitable for use as a liability defence.

5.) the system must be **field-tested** to evaluate it's performance, and to adjust it's design, implementation and operation as necessary.

Expected Advances, Team Members & Anticipated Collaboration

There are two specific areas where this project expects to advance the state of the art on intelligent systems implementation:

i) one of the main objectives of this proposal is to undertake directed research aimed at establishing a type of high-level domain modeling that supports both knowledge and meta-knowledge with strong and varying spatial and temporal components. Previous attempts at domain modeling for emergency response (including CriSys' own work) have tended to use too-specific domain models, to assume fixed spatial relationships, or to ignore temporal components (usually all three). In this project, we seek to establish an emergency response ontology at a level of abstraction sufficient to support reasoning in the face of uncertainty and/or rapidly changing circumstances. As part of this effort, we expect to define a new type of object-oriented model that will support the reasoning engine's need to deal with uncertainty and elements which vary over time and under certain decision contexts. This portion of the work will involve:

- Camiel Wolsing and Dale Paus of CriSys Limited (supported by Sandra Gilchrist and Jennifer Jones), who bring with them more than 35 years of experience working with emergency response decision-support tools, and
- Dr. Ali Asgary of York University's Emergency Managment Program, and Dr. Jason Levy of Brandon University's Emergency Managment Program, who will bring their considerable experience in urban risk mitigation and formal decision-support methodologies for emergency response

ii) the other main objective of this proposal is to undertake targeted research related to expert systems learning. We wish to better understand and remedy the shortcomings of expert systems and work to augment their functionality with a form of learning. To this end, we will utilize advances in the complementary fields of neural networks, stochastic approach to uncertainty (e.g. Bayesian belief networks), approximate reasoning (e.g. fuzzy set reasoning) and hybridization of such methods to improve the performance of such systems. We will develop methods for the design and implementation of a class of expert systems that can learn from past experience, automatically or semi-automatically evolve and improve their performance, and which will perform acceptably in the presence of noise or incomplete information. We aim to formulate a design methodology that will use approximate reasoning to deal with uncertainty; and employ reinforcement learning and neural networks to update the structure and parameters of modular expert systems in a temporal fashion without human intervention. As part of this work, an engine will be created that is capable of providing multi-level, plain-language explanations of the factors considered and the decisions made. This work will be conducted by:

- Dr. Alireza Sadeghian of Ryerson University's Department of Computer Science (assisted by two graduate students in the Department), who has extensive experience with neural networks and fuzzy reasoning, working with
- Camiel Wolsing, Mike Pot and Dale Paus of CriSys Limited (supported by Somsack Tsai, David Wang and Amy Sun), who collectively bring over 50 years of experience in the design, development and implementation of advanced emergency response systems

Testing & Validation Plan

In order to test the ability of the reasoning engine to operate on the new type of domain model, we will require a rulebase sufficient for a specific case of initial size-up. For the field trial, we propose to use a rulebase intended to allow analysis of a structural fire type of emergency. To provide a suitable cross-section of scenarios, we will work with experienced Fire Captains from a total of twelve Canadian Fire Departments, representing a range of sizes and community types (as shown in the table on the next page).

Dale Paus, Sandra Gilchrist and Jennifer Jones from CriSys, working with Drs. Asgary and Levy from York University's and Brandon University's (respectively) Emergency Management Programs, will conduct structured interviews with the Fire Captains, eliciting the process that they use to perform an initial fire scene analysis in their community, and the factors that they consider in a range of scenarios, and documenting the answers using a formalized tool (TBD). One or more follow-up interview sessions are anticipated, and the whole process is expected to take several months to complete.

Size & Characteristics:	Small Town (<50K)	Small City/Region (50-100K)	Medium-Sized City/Region (100K - 200K)	Large City/Region (>200K)
Rural/Agricultural	St. Thomas Fire Department	Clarington Fire Department	Brantford Fire Department	
Residential	Orillia Fire Department	St. Albert Fire Department	Pickering Fire Department	
Light Industrial base	Belleville Fire Department	Moncton Fire Department	St. John's Fire Department	Kitchener Fire Department
Heavy Industrial	Grande Prairie Fire Department	Sault Ste. Marie Fire Department	Cambridge Fire Department	Oshawa Fire Department

While this work is progressing, Development Staff at CriSys will be working with the team of graduate students from Ryerson University under the tutelage of Dr. Sadeghian, to explore methods of creating an expert system that meets the goals of temporally-bounded reasoning and an enhanced ability to recognize failures and learn from them.

As soon as we have completed the bench testing of the reasoning engine, we will perform field trials. We propose to install a single PC at each of 12 Canadian Fire Departments listed in the table above. The PCs will run the knowledge base and reasoning engine, and will be notified by the main system of events. The expert system will then fire in response to real-world events, determine it's recommendation, and save this for later review and comparison to what actually happened and the actual officers' on-scene assessment.

Financial Plan

	CriSys Limited	Ryerson University	York University	Brandon University	ESRI Canada	Ontario Association of Fire Chiefs (and depts)	Total
precarn Funding Requested	208,566	35,842	34,875	20,090	0	0	299,373
Industry Contribution	208,566	35,842	34,875	20,090	12,000	13,908	325,281
Total Project	**417,132**	**71,684**	**69,750**	**40,180**	**12,000**	**13,908**	**624,654**

The amounts shown for CriSys include \$11,400 for 3rd-party software tools (to be used by all parties), \$12,084 for hardware (primarily PCs with high-resolution displays for building the domain model), \$29,184 for field trial expenses at the 14 departments (including hardware and travel costs), and \$78,660 in expected patent costs.

Commercialization Plan

Successful completion of the field trial will lead directly to commercialization of the technology. Initially, CriSys will implement the reasoning engine as a parallel process to the conventional process used by our existing system, so that the reasoning engine can evaluate the fixed response recommendations. Where differences are detected, the reasoning engine will propose modifying the response to the dispatcher, and will offer an explanation as to why. Where the dispatcher does not accept the revised recommendations, or in any case where the on-scene commander subsequently requests different response resources be dispatched, the system will analyze the differences and identify potential new rules and/or cases for future consideration. At the same time, CriSys, in conjunction with our clients and industry partners, will continue to develop rules and cases to match other types of emergency situations (i.e., vehicle accident rescues, medical calls, etc.).

When the reasoning engine has performed for at least one year with better than 95% accuracy, CriSys will modify our existing software to make the reasoning engine the primary method of specifying emergency resources for response, with the older fixed responses continuing to be evaluated against the dynamic response recommendations.