COMMERCIALIZATION OFFICE - PILOT OPERATIONAL REQUIREMENTS DOCUMENT

Crisis Decision-Support Software

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1. General Description of Operational Capability

Among the most difficult of decisions are those made in crisis or an unstable situation of extreme danger or difficulty. Examples of crisis decision environments range from emergency response to disaster management, anti-terrorism response, emergency room triage, and even military (battlefield) operations. Decision failures can literally cost lives of first responders and members of the public, not to mention billions of dollars in failed missions, ruined infrastructure, and lost economic capability.

Much attention is focused on providing more and better data and information to decision makers. While admirable, there is a compelling and unrecognized need to improve the decision process itself, how decision makers use available information to reach effective decisions in a crisis.

The capability described in this operational requirements document (ORD) shall support decision makers by learning and applying effective decision-making techniques in real-world situations. Success is achieved by thinking the way that successful crisis decision makers think and to compress experience by bringing the knowledge of experienced decision makers quickly to bear, even for "crisis management rookies."

The needed system will support decision-making for a broad range of crisis-like situations through a plug-and-play software application, deployed as a field-portable hardware/software capability. The system will help decision makers rapidly reach correct "good enough and/or optimal" decisions in high-stress, multiple-distraction environments.

The software may apply the recognition-primed decision model (RpDM) or other similar prediction models, in which observed event characteristics are used to force recognition of a similar scenario from a knowledge base. A major benefit of this method is the search for the first available "good enough" solution rather than more traditional normative decision processes that search all options for the "optimal" answer.

The core of the capability will be an extensive database of decision scenarios – combinations of events, key observable indicators, and resulting decisions. This database will form the knowledge base for the recognition-primed process. The software rapidly "walks" a decision maker through a limited set of questions to a choice of a scenario. An automated interview will terminate as soon as a base scenario is found that adequately matches the limited information available to the decision maker. The decision-support system then adapts the base scenario to actual event conditions as known at decision time, "tuning" the decision for the specific event. Finally, the system will identify key additional information that can significantly refine the decision, focusing the decision maker on extracting critical information from chaos.

1.1. Capability Gap

A gap currently exists in the training and real-time support for effective decision-making processes in crisis situations. Research and observation of operational crisis decision-making have shown that excellent decision makers do not normally use traditional "rational choice" decision techniques. Instead, they rely on past or shared experiences to guide them through difficult decisions. They do not pursue perfection, rather they find the first "good enough" solution to a problem, implement it, and move on to the next urgent decision in the crisis. The psychological label given to this natural style of decision-making is often referred to as RpDM.

Today's crisis decision makers face specific gaps in decision-making capability:

- Novice decision makers usually do not know how to apply RpDM based on personal experiences in crisis situations and are not always equipped to make the judgments necessary to quickly reach a conclusion and act
- Experienced decision makers often do not have a personal knowledge base of past or shared experiences broad enough to cover unfamiliar events such as terrorist attacks or natural disasters

A system is required that can rapidly supply the decision maker with "like-experiences" from the past and from others across the field (e.g., fire fighting, earthquake response, hazardous materials response, etc.) and can guide a decision maker to a rapid "good enough" decision. Many systems have been designed to aid decision makers in data collection and organization. However, a user-centric approach matched with an expansive database of past decisions and a proven method to quickly reach critical decisions in high pressure environments for wide operational use is needed in the first responder community as well as other communities.

1.2. Overall Mission Area Description

Crisis decisions often share a common set of characteristics:

- Time urgency
- Complex event or decision characteristics
- Rapidly changing event or decision conditions
- A chaotic surrounding environment
- High physical and/or emotional stress
- Severe consequences for decision failure
- Poor data availability and quality
- Competing demands for the decision maker's attention
- Frequent interruptions during the decision-making process

Below are a number of diverse activities that require of crisis decision-making, including:

- Natural disaster response: Bringing together a wide variety of people to solve group-centric problems in time-sensitive and chaotic environments both domestically and abroad
- Anti-terrorism response: Crisis and consequence management for domestic and foreign terrorist attacks
- Hazardous materials emergency response: Managing, resolving, and mitigating consequences of hazardous materials releases due to accident, terrorist, or other actions
- Police response: Managing, resolving, and mitigating consequences of criminal, violent, or high-hazard events
- Fire response: Managing, resolving, and mitigating consequences of fires, explosions, and other high energy events
- Emergency medicine: Managing, resolving, and mitigating consequences of urgent medical crises for individuals and mass casualties

- Search and rescue: Managing, resolving, and mitigating consequences of disasters trapping persons in high hazard environments

1.3. Description of the Proposed System

The decision-support system shall, through a database-oriented software capability, integrate decision processes, decision-support tools, and a knowledge base needed to make effective decisions in a recognition-primed (or other performance-equivalent or superior types) decision environment. The system will interact with a decision maker to:

- Pose and answer key questions about the event in an interview environment
- Choose an analogous event and decision from a knowledge base
- Modify the analogous event and decision based on the actual conditions
- Provide a recommended decision that a user can quickly and unambiguously implement

The field-portable software system will combine knowledge databases, artificial intelligence database search functions, scenario modification tools, and an interface that operates on hardware platforms and operating systems typically available and used by crisis decision makers (e.g., MS Windows XP or Vista desktop computers, laptop computers, portable digital assistants [PDAs], etc.).

1.4. Supporting Analysis

DHS's experience has shown a genuine interest by various personnel involved in natural or man-made crisis decision makers in possessing cost-effective field-deployable decision tools/systems to aid crisis decision makers save valuable time in order to save lives and property.

1.5. Mission the Proposed System Will Accomplish

The proposed system will accomplish three key decision-support activities for crisis decision makers:

- Real-time support for crisis decisions that have decision time-frames of > 5 minutes
- Training support for enhancing decision-making skills and personal knowledge for both novice and experienced decision makers
- Development and distributed sharing of community-wide (e.g., hazardous materials response community, etc.) decision knowledge bases

1.6. Operational and Support Concept

1.6.1. Concept of Operations

A system will support a variety of key decisions across a wide range of crisis decision-making.

A system will integrate two processes: How decision makers recognize and size up a situation and how they evaluate the course of action by imagining it and rehearsing process and outcomes.

The basic decision-making steps directly supported by the software system will be:

1. Size up the situation using available information
2. Search a knowledge base (of decision maker experience) and recognize the first case that adequately matches the situation at hand
3. Diagnose the historical case against the situation at hand
4. Adapt and modify the solution of the historical case to work in the situation at hand
5. Rehearse the solution to verify that it is likely to realistically work
6. Put the solution/decision into play

In practice, the decision maker will work from a decision-making location (e.g., event scene, emergency operations center, etc.). The decision-support system will be resident on a hardware device (e.g., a laptop computer or a PDA device) already in use by the decision maker for other response or functional purposes, etc.

The decision maker likely will follow seven basic operational steps:

1. Size up the event situation, gathering information about the event during a limited period of time
2. Activate a decision-support software system
3. Answer questions from the system as it walks the user through a rapid selection of a base event scenarios
4. Answer further questions from the system as it walks the user through modification of the base event scenario
5. Simulate and evaluate the final scenario to confirm applicability
6. Simulate and evaluate the recommended decisions to confirm appropriateness and practicality
7. Implement decisions

1.6.2. Support Concept

Maintenance requirements for the system will be minimal. Each unit will be sold as licensed software with implementation and end-user support. Follow-on contracts should be available for continued support after an initial included support period. Software design will allow for easy implementation in multiple hardware / operating system configurations and as a purely web-based application. Upgrades distributed via the internet will address software bug fixes and product advances.

2. Threat

Response to and management of any terrorist event will involve multiple crisis-type decisions, in both the crisis management and consequence management phases of events. Though not classic "threats" in the terrorism sense of the word, natural disasters, accident-based emergencies, fire response, police response, medical response, and search-and-rescue all involve threats to public health and welfare. Crisis-type decisions will always be involved in these or similar events.

3. Existing System Shortfalls

The classical approach to decision-making, termed "rational choice decision-making," is a conceptually straight-line (and straightforward) process to:

1. Define the problem and objectives for solution

2. Identify decision options or alternatives
3. Identify methods for evaluating the options against each other
4. Gather necessary data to define and evaluate each option
5. Score the decision options
6. Choose the best decision from among the available options
7. Implement the best decision

This analytical approach or variations has been espoused and applied in a variety of fields. This is also the decision-making approach almost universally applied in developing formal methods, processes, and tools for crisis decision-making. In particular, emergency management decision makers and battlefield decision makers are taught to use the rational choice approach and provided tools and technology in support.

Much of the effort in decision system development for crisis management has been focused on improving the rational choice method, computer-based comparisons, more data capture, training methods, etc.

Key requirements for this approach include well-defined options, clear objectives, availability of extensive data for event and decision options, uninterrupted time for analysis and comparison of multiple options, and an environment that allows complex mental processes. Very often, none of these requirements is met in real-world decision-making.

Some research has shown that that the most effective crisis decision makers do not use in fact the rational choice approach even when taught and required to use it. For instance, a study found that only 30 percent of crisis decisions by fire ground commanders and wildfire incident commanders were made in this way. Additional research with experienced emergency Incident Commanders has routinely rejected rational choice decision systems, aids, and training, declaring them to be unworkable in the real world.

4. Capabilities Required

4.1. Operational Performance Parameters

This section lists the minimum operational performance parameters (note: T= Threshold and O= Objective).

4.1.1 Operate in plug-and-play mode for different crisis decision environments with capability to treat both analytical and heuristic decisions

- Allow interchangeable crisis environment/decision modules, with plug-and-play by end-user
- Allow user-authoring of crisis environment/decision modules
- Allow upgrade/revision of knowledge bases from central source
- Support modular, interchangeable processing of analytical decisions and decision components
- Support processing of heuristic decisions and decision components
- Support experienced decision makers
- Support inexperienced decision makers

4.1.2 The first "good enough solution" is found and implemented without characterizing or comparing all options to find the optimal solution

- Develop, incorporate, and maintain a knowledge base of event/decision pairs sufficient in spectrum and depth to support decision-making
- Allow interchangeable event/decision knowledge base modules, with plug-and-play by end-user
- Allow user-authoring of event/decision knowledge bases
- Produce decision recommendations within the time allowed for effective decision making
- Allow upgrade/revision of event/decision knowledge bases from central source
- Produce decisions that adequately meet the decision need

4.1.3 Expectations are developed for "what next" and, if not matched, the change is quickly captured and the decision modified

- Predict the envelope of expected inputs for the next stage in the decision process and the envelope of possible decisions (outcomes) based on previous inputs
- Dynamically change predicted envelope of expected inputs for the next stage in the decision process and the envelope of possible decisions (outcomes) as interactive user input process proceeds
- Dynamically inform user of predicted envelope of expected inputs for the next stage in the decision process (O) and the envelope of possible decisions (outcomes) (T)
- Dynamically inform user of trend in convergence/divergence in envelope of possible decisions (outcomes)
- Dynamically identify key inputs that can lead to rapid convergence toward single decision (outcome)
- Dynamically inform user of key inputs that can lead to rapid convergence toward single decision (outcome)

4.1.4 Implement within the system both operational and training modes and toggle between them

- Implement a full training mode for the system
- Capture and present training scores and statistics to the user
- Capture training sessions and grow even /decision knowledge base
- Capture training sessions and grow knowledge base of observation/decision pathways
- Implement a capability to improve the ability to predict decision (outcomes) from each training session

4.1.5 Produce a system that works all the time, always reaches an answer, and produces the same results for the same input information

- Mean rate of failure to operate ≤ 0.5%
- Mean rate of failure to reach an answer when system operates ≤ 0.5%

- Mean rate of failure to reach expected answer when an answer is reached ≤ 0.5%
- Mean rate of failure to produce identical answers for identical inputs 0%

4.1.6 Produce a system that is cost-efficient

- Price for system implementation is <$3,000 (T) / < $1,000 (O) in high volume quantities

4.2. Key Performance Parameters

This section lists the minimum key performance parameters.

4.2.1 Employ a naturalistic decision model that matches the psychology of rapid crisis decision-making

- Allow decision maker to characterize event size-up information as a starting point for analysis
- Support user in recognizing an analogous case from a decision knowledge base that is “good enough” for use as a start to decision-making
- Support user in analyzing a recognized case to determine if it adequately represents the crisis situation
- Support the user in customizing the selected analogous case to better fit the actual crisis conditions
- Support the user in mentally rehearsing the decision and action steps to evaluate if success is likely
- Support the user in implementing the final decision as an effective course of action

4.2.2 Employ case-based reasoning to expedite decision-making and take advantage of expertise and past experiences

- Implement an artificial intelligence or equivalent capability
- Implement a knowledge base of observation/decision pathways
- Populate the knowledge base of observation/decision pathways with sufficient cases to produce target performance by an artificial intelligence or equivalent capability
- Implement a capability to improve its ability to predict decision (outcomes) from each operational session
- Allow interchangeable observation/decision pathways knowledge base modules, with plug-and-play by end-user
- Allow user-authoring of observation/decision pathways knowledge bases
- Allow upgrade/revision of observation /decision pathways knowledge bases from central source

4.2.3 Trigger recognition with partial characterization of an event– traditional “paralysis by data collection” is avoided

- Allow “unknown” or fuzzy inputs

- Recognize an event or event component with specified level of limited information at specified frequency
- Allow a mixture of known and unknown information about an event
- Capture all known information quickly then focus on resolving unknowns

4.2.4 Use system parameters that the user is likely to already have available

- Operate on a standard Windows-based laptop computer
- Operate on a standard Windows-based PDA device
- Operate via the Internet from any computer device with an Internet connection and a standard Internet browser

4.2.5 Establish a central, Internet-based capability for training and knowledge base building

- Establish an Internet-based, game-oriented version for multiple targeted applications
- Implement a training mode for the Internet-based system
- Capture and present Internet-based training scores and statistics to the user
- Capture Internet-based training sessions and grow central event/decision knowledge bases
- Capture Internet-based training sessions and grow knowledge base of observation/decision pathways
- Implement a capability to improve the system's ability to predict decisions (outcomes) from each Internet-based training session
- Implement a gaming/competition mode for the Internet-based system
- Capture and present Internet-based gaming/competition scores and statistics to the user
- Capture Internet-based gaming/competition sessions and grow central event/decision knowledge bases
- Capture Internet-based gaming/competition sessions and grow knowledge base of observation/decision pathways
- Implement a capability to improve the system's ability to predict decisions (outcomes) from each Internet-based gaming/competition session

4.3 System Performance

4.3.1 Examples of Mission Scenarios

August 2005: Crisis managers during the Katrina hurricane response fail to mobilize and employ available transportation resources (buses and trains) to evacuate the population of New Orleans

The hurricane version of the system would be preloaded with key indicators of evacuation scenarios. Equipped with the decision-support system, decision makers will be able to weigh the risk involved in decisions and pull from an extensive knowledge base of past events in order to characterize the current situation. Once characterized properly, evacuation decisions can be made in the interest of key risk factors. Due to the rapidly available historical cases, precious time is saved, allowing for early evacuations of citizens.

May 2000: Fire managers at the Bandolier National Monument in New Mexico decide to initiate a prescribed burn in spite of forecasted high winds and dry conditions. Control is quickly lost and the Cerro Grande Wildfire burns hundreds of families out of their homes, resulting in more than $1 billion in damages.

The decision-support system would probe decision makers on key indicators in order to provide them with past experiences in very similar situations. The system would then characterize the risk and provide the user with a range of optimal decisions. Managers, noting that risk of fire spread is extremely high, decide to hold off until conditions are more favorable.

2009: A local response team responds to an apparent terrorist attack. A release has occurred from a suspicious package. A number of victims are down and exhibiting a variety of observable symptoms. The perpetrators are arrayed behind buildings wearing gas masks and shooting any responders that come near.

The decision-support system would walk the decision makers through a size-up process to gather key information about symptoms, weather, container type, etc., then help the incident commander identify likely scenarios from an event knowledge base. The incident commander would recognize a likely release of Sarin and further make effective shelter/evacuation/rescue decisions that include the competing risks from terrorist gunfire.

4.3.2 System Performance Parameters

4.3.3 Interoperability

The system shall:

- Operate on a standard Windows-based laptop computer running Windows XP or Windows Vista
- Operate on a standard Windows-based PDA device
- Operate via Internet from any computer device with an Internet connection and a standard Internet browser, including Windows Internet Explorer (Version 6 or higher), FireFox (Version 2 or higher), or Safari (Version 3 or higher)

4.3.4 Human Interface Requirements

The decision-support system will employ a user-friendly graphical user interface (GUI). The purpose of the GUI will be to walk a user through the RpDM (or performance-equivalent or superior) process using concise and clear interactions. The system will operate using common browser-based interface methods, requiring very little experience to use.

Once the browser-based application is downloaded, direct human interface with the system will be limited to interaction during performance. Installation will require little to no expertise as conventional software download techniques shall be applied.

Output data will be provided in concise reports both for training and information management purposes. The reports will be designed by the user and access to them will be at the user's discretion.

4.3.5 Logistics and Readiness

The system shall operate on a wide range of user field equipment (within the hardware/software listed above). This is key in assuring that most users can access and use the decision-making support without any additional equipment or modifications to existing systems. The system shall operate at a high level of reliability (> 99%) both in the field or at command or operation centers. It must be accessible 24 hours a day, 7 days a week with no noticeable delay beyond the time necessary to boot up the on-board internet browser. The system must have a stand-alone back-up method of accessing the knowledge base (database) to ensure that reliable operation is ensured if internet access is lost during a crisis event.

5. System Support

5.1 Maintenance

Maintenance will be provided through automatically downloadable patches. Additions and updates to the extensive knowledge base will be accessible to the user through a download system as well. Since the system is software-based, electronic help systems, electronic (pdf) user guides, and frequently asked questions will be provided to ensure proper installation and to troubleshoot software/hardware interface issues. User support will also be offered through online support forums as well as through direct contact with a system support organization.

5.2 Supply

Back-up copies of the decision-support software and knowledge bases for each user will be stored on a central server for download at user convenience. Users will also be able to download copies onto CD for local backup as desired. Manuals will be provided to the operator by the vendor and will include installation procedures, common problems, test cases, download instructions, and data retrieval procedures. When necessary, real-time diagnostics can be performed by system experts to ensure the system is operating properly.

5.3 Support Equipment

No support equipment will be needed for the system. Patches and system updates will be downloadable to ensure that system performance is optimal.

5.4 Training

Because the system will be browser-based, little, if any, training will be required to enable the user to start and operate the application. Offline tutorials (included with system downloads) and evaluated online training scenarios shall be provided to end users. Custom-designed training shall be available, on a mutually agreed fee basis.

5.5 Transportation and Facilities

Transportation will be at the sole discretion of the user, due to the software-based nature of the system. Cross-platform capabilities will be provided to ensure easy and highly reliable integration into the field.

6. Force Structure

The potential end-users of the decision-support system within the Department of Homeland Security (DHS) and DHS-supported crisis management community are extensive.

Multiple levels of users exist within each of these groups. For instance, the U.S. Coast Guard might deploy a decision-support system within each rescue helicopter, but they might also have a single or multiple systems within each regional command center to help deal with large amounts of incoming data. Therefore, in many of these organizations, there are needs at both the field-task level and the management or command center level.
For estimation purposes, two units of the system will be needed for each subgroup level in order to ensure maximum efficiency and to provide backup support. Based on estimates of the market, the need is approximately 50,000 units.

7. Schedule

A TRL-9 (fully deployable) product that satisfies user requirements, is required within 12 (T) / 6 (O) months.

8. System Affordability

Price for individual units shall be <$3,000 (T)/ ≤ $1,000 (O).