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EMERGENCY MANAGEMENT: CAPABILITY ANALYSIS OF CRITICAL INCIDENT RESPONSE

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ABSTRACT

Since the 9/11 terrorist incident, homeland security efforts and the readiness of local emergency management agencies have become focal points in the war on terrorism. A significant issue faced by front line responders has been the significant increase in the number and type of potential incidents they must be prepared to handle. This paper describes a simulation-based approach that allows local county-level emergency management agencies to more quickly develop, test, and refine robust plans for an ever increasing list of potential threats. The focus of the simulation environment is on the information flow, coordination, and response of medical, police, and fire resources.

1 INTRODUCTION

Prior to 9/11, emergency management agencies focused primarily on weather, traffic, and industrial-related incidents. Well-developed emergency response plans have been developed for major incidents in these categories and numerous physical simulation drills have been performed throughout the last several decades to refine these plans. These disaster drills provide validation for current emergency plans along with operational insights that are incorporated into revised plans.

Since 9/11, federal and state emergency agencies along with the Homeland Security Department have developed new guidelines related to funding for disaster relief. A significant component of the guidelines require that local emergency management agencies have plans in place for a host of new, terrorism-related incidents. This presents local agencies with a dilemma since terrorist type incidents are difficult to define, and the risk for these types of incidents are relative to the infrastructure and make-up of a particular county's economy and population.

Laporte County is one of ninety-two counties in the state of Indiana. It is located in the northwest corner of the state, roughly sixty miles southeast of Chicago and has a population of 110,000. Two cities contain nearly fifty percent of the county's residents. In terms of area, the county consists of 598 square miles, including nearly 250,000 acres of farmland. There are roughly 45,000 housing units in the county. Nearly fourteen percent of Laporte county residents are over the age of 65, contributing to a large number of health care and nursing-related facilities. There are a number of small to medium size industries in the county that employ nearly twenty seven percent of the county population. The county also possesses significant shoreline along Lake Michigan, which includes a large boat marina and a gambling casino. Interstate 94, a major east-west thoroughfare in the United States passes through the county. Numerous major railroads pass through the county, as it is the eastern merge point for the Chicago rail industry. Much of this rail traffic is transcontinental intermodal, which in itself presents a large security threat. Many interstate high voltage transmission lines and natural gas pipelines traverse the county. Laporte County also contains two of Indiana's largest prisons, each containing nearly 2,000 inmates. While considered primarily rural, Laporte county contains one of the widest assortments of potential threat opportunities in the state.

Emergency-related activities for the county are coordinated by the Emergency Management Agency, a governmental unit that reports to the County Commissioners. The Emergency Management Agency has the responsibility for developing emergency response plans for the county and is also responsible for coordinating response efforts amongst the various local and county police, fire, and ambulance units when incidents occur. The coordination of emergency responses is a complex task, since each city, town, and municipality have their own fire and police units. The county also has a sheriff's police force and assistance from the Indiana State Police. There are three major hospitals in the county, with each maintaining an ambulance service.

Due to the breadth of potential threats faced by Laporte County, a simulation environment was chosen as the primary means to develop, test, and refine new emergency response plans to a series of defined terrorist threats.

These threats have been developed in conjunction with various agencies involved in the federal government-based Homeland Security Initiative. The Emergency Management Agency did not have any experience with any of the suggested threats, nor did it have any emergency response plans in place for them. Thus, the use of traditional physical drills was deemed as too costly, too time consuming, and most importantly not realistic enough to provide any benefit to the county. Additionally, the element of surprise is often lost during the planning of mock disaster drills. Facing increased time pressure to develop emergency plans to meet federal guidelines, computer simulation was deemed as the most effective tool for county. The expectation of the computer simulation environment was to give county emergency planners a reference model to analyze county risks, measure capability to respond, identify weaknesses in response capability, and use modeling results to mitigate future response plans. Along with the development of response plans, a major objective of the simulation environment is to assess the readiness, capacity, and integration of the county's private health care system into the emergency response network. The primary issue of concern to the county emergency planners is the capability and capacity of local health care providers to quickly accept, process, and treat large numbers of potential victims.

2 THE SIMULATION ENVIRONMENT

The Laporte County Emergency Management Agency simulation model was developed using ProModel simulation software. ProModel was chosen primarily for its ability to provide run time versions of the model. Emergency planners are located in several areas of the county and the county financial status is very precarious, eliminating any possibility of purchasing multiple software licenses.

The simulation model contains four major activities; the incident, the response, the assessment, and the action plan. While the potential exists for each incident modeled to differ significantly, they all take place over the infrastructure of the county. Thus, the basic framework of the model consists of the county's road and railroad network, major buildings, and emergency responder locations. Figure 1 shows the simulation representation of the county infrastructure. The background graphic consists of a detailed county map that was provided by the county surveyor's office.

The incident consists of the emergency threat and is the trigger event for the simulation. Each incident is defined by an arrival time, a location(s), a seriousness value, and a latency effect. The seriousness value defines the number of people directly affected by the incident. For example, an incident occurring at a shopping mall in mid-afternoon would possess a large seriousness value. The latency effect is used to represent concepts such as toxins that may be spread as the incident unfolds. Within ProModel, the incident is modeled as a process.

Figure 1: Simulation Model Environment

The incident triggers a response that consists of first responder arrival at the incident location. Depending upon the particular incident and the discovery of it, any available police and fire departments respond. Within the model, preference is placed upon the nearest resources. Upon arrival, the first responders make an initial assessment of the incident. Depending on the assessment, numerous options exist. These options, modeled as probabilistic routings, often involve calling in additional resources such as medical personnel. The assessment activity also invokes the emergency management action plan. Action plans are dependent upon the incident and consist of very specific sequential checklists. Specific components of nearly every emergency plan include such activities as alerts, notifications, assignments of resources, backup requests, and communications chains of command. Nearly all action plans contain events that require feedback concerning incident assessment before proceeding on to the next step. These types of events present significant complexity to simulation modeling efforts. In this model, these types of situations are modeled using ProModel's WAIT and WAIT UNTIL statements. These statements allow the incident processing logic to be held until further information becomes available. The combination of these statements and conditional routing allow complex emergency plans to be modeled simply and concisely.

As the incident unfolds and the emergency resources are activated, they are subject to constraints that represent such items as traffic congestion, railroad crossings, and routine county infrastructure activity. Within Laporte County, eleven municipalities possess police and fire units. There is a county-wide ambulance service in addition to seven municipal ambulance units, and three hospital-based units. Each of these police, fire, and ambulance units are represented in the model as resources. Using the standard ProModel resource construct, each unit contains a capacity, a downtime distribution and a working schedule. Since a majority of the municipalities in the county are volunteer-based operations, the ability and capacity for a particular resource to respond to a request is highly variable. For volunteer-type resources, a multiple resource request is generated in which a volunteer and the particular vehicular piece of equipment are required. This type of resource request involves a time delay, since volunteers must first travel to the station before proceeding to the emergency location. For larger city fire and police resources, the pieces of equipment are considered staffed according to employee shifts and are available according to the number of employees on shift. Unlike the volunteer situation, there is not a delay for the employee to travel to the particular fire or police station.

All of the emergency response resources included in the model contain distributions that represent frequencies and durations for normal activity. These 'normal' activities are a critical component of the model, as the timing of an incident is usually never convenient and an accurate status of all potential responders is necessary for model realism and emergency plan completeness. The 'normal' activities for each resource have been determined by using an FBI database for incidents over the last ten years in the county. Using this data, accurate utilizations have been determined. These normal activities are not modeled simply as unavailable time for the resource, but as actual events following probabilistic occurrences and stochastic time distributions. Thus, contention for emergency resources during an incident does affect response time and emergency plan effectiveness. This adds an extra level of realism that is often not possible during live, preplanned disaster drills.

Response time is the performance measure of primary importance to emergency planners. Initial response time by first responders often dictates the assessment response and emergency plan activation components. Response time is broken down into four sections. The first section is termed communication delay and represents the time from incident discovery and reporting to initial emergency dispatch. This is a critical measure for the Emergency Management Agency since the quicker an incident can be detected and reported, the more likely a successful resolution can be made. Section two is the time from dispatch until first arrival of either police or fire at the emergency location. Section three is the time in which an assessment of the emergency is made. Section four is the time from assessment until all response units return to their respective stations.

Response time is an important parameter for evaluating emergency response. It is often used in determining equipment and manpower capacity levels. Additionally it is used to select locations for police and fire stations. In the past, response times have been estimated using historical data or by timing physical simulations. One conclusion reached is that response times are a function of the time of day, thus a single point estimate is often not an accurate representation of emergency response performance. The simulation model has been constructed to accurately portray varying conditions of the county infrastructure so that reliable response times can be built into emergency plans. Due to the large number of railroad crossings and high intensity train traffic present in the county, special effort has been made to include rail crossing blockage contingency plans into the emergency action plans themselves. Several options exist in the model for this purpose. The first option is the do nothing alternative in which emergency resources en route to the site simply wait for the train to pass. Option two involves dynamically rerouting emergency resources around the blocked railroad tracks. This option has added significant complexity to the simulation model. All roads in the county are modeled as a Path Network in ProModel. To speed up runtime, only major roads are modeled. However, to enable rerouting around rail crossings, numerous county roads were necessary to include as part of the network. Since a default option in ProModel uses the shortest path between the desired locations, the additional of auxiliary county roads often caused emergency vehicles to travel on seemingly illogical paths from their base station to incident locations even when railroad crossings were clear. To alleviate this situation, two scenarios are run for each incident, one with the potential for railroad crossing blockage and one without blockage.

3 MODEL USE

The simulation modeling environment will be used as a major component of virtual drills. These drills will be held in addition to live drills. Currently, live drills are conducted several times throughout the year. Threat scenarios are prepared and a time is assigned for the drill to take place. The live drill takes place and feedback sessions are held to judge performance and discuss the effectiveness of the emergency plan. Changes to the plan are made if they are viewed as an improvement. Although live drills are viewed as invaluable training aids, they are often viewed as unrealistic since most emergency units become aware of the drill in advance. More importantly, they usually only cover one set of emergency options and are only run once. During the post drill feedback sessions, many enhancements to the emergency plans are suggested, yet what-if capability for these suggestions are somewhat limited because they cannot be tested until the next live drill occurs. The addition of this simulation model gives the county emergency planners the ability to run virtual drills much more frequently. Virtual drills consist of four phases. Phase one is the development of a particular threat, prepared by the Emergency Management Agencies. Threats being considered today are much broader and involve significantly more complexity than those in the past. By using the simulation, emergency planners can develop incredible complex and wide ranging threats, thus giving them a much more robust environment in which to begin the development of a satisfactory response plan. Phase two involves gathering all necessary emergency personnel into a location, describing the threat incident, and running the threat incident and emergency response plan through the simulation environment. Personnel can see the incident unfold and get a big picture view of the response and emergency plan activation. Phase three consists of a critique of the threat and the response plan. At this point, a series of iterations between phases two and three take place using the simulation environment. Rather than simply discussing alternative actions and responses, they can be tested and evaluated using the simulation model. One of the more important issues in emergency management is the behavioral aspect of threat scenarios. The ability of the affected population to remain calm and carry out the specified emergency response plan is paramount for successful mitigation of disasters. As the size of the incident and the number of people affected increases, behavioral issues related to the control of large groups of people become key elements of emergency plans. Inclusion of behavioral elements into the simulation model are considered key aspects of determining realism. These behavioral elements are included into the simulation through the use of time delays for people movement. As the numbers of people being moved increase, the probability of crowd control incidents increases. When these incidents occur, additional time is added to movement activity durations. Once a realistic, acceptable response is achieved, the plan is be fully documented and distributed countywide. This activity represents phase four. The simulation model is then used as a training tool to describe the threat and action plan.

Currently, the model is being used to develop and test emergency plans for three threat scenarios. These scenarios have been suggested by the Emergency Management Agency in response to guidelines from the Homeland Security Department and possible risks faced by the county and it's infrastructure.

Scenario one involves a person depositing a briefcase containing an unknown explosive substance in a public place. The briefcase eventually blows up, and a large number of casualties occur. An embellishment of this threat includes the release of a toxic substance from the explosion that requires the evacuation of a large area. This scenario takes place at Purdue North Central, a regional campus in the Purdue University system. The campus has 3700 students and three main academic buildings. There are only two entrance and exit points to the campus, one a major highway, the other a county road. Once the explosion takes place, a random number of casualties takes place. This number is dependent upon the time of day of the incident and the particular location. The campus has a police department, but does not have fire or emergency resources, instead relying on local municipal units. After the assessment phase, it is determined that the explosive contains a toxic substance and the campus must be evacuated immediately. Since a toxin was present, evacuees must go to a predetermined off-campus site for evaluation and further treatment purposes. Although the emergency plan for this scenario is quite simple, it is not known if the plan can be accomplished in a time frame necessary to prevent major contamination and exposure problems. Of major interest to the planners is the requirement for the evacuation to use the major North-South highway in the county as the principal means of travel. If the evacuation time is not sufficient, major changes to the plan will be required. Emergency response plans for this scenario are currently being tested, with emergency medical facility capacity and highway traffic control being the primary determinant of plan performance.

Scenario two involves a county-wide evacuation. The critical issue for this scenario involves the evacuation of hospitals, nursing homes, and prisons. Each of these facilities requires specialized evacuation resources. Numerous options are being explored that focus on the capacity of egress roads and the routing schemes used for large population areas within the county. Additionally, special requirements for transportation of the prison population are being developed and studied. The performance measure of importance to this scenario is the elapsed time necessary to evacuate the county. Depending on the reason for the evacuation, latency effects of certain diseases or chemicals force the development of action plans that are based upon maximum and minimum evacuation times. This threat scenario is considered of extreme interest since it will require the cooperation of all the surrounding counties. At this point in time, it is not certain if the county can even be evacuated successfully with the current resource levels in effect. The use of the simulation model to predict performance is considered necessary, since a live drill to evacuate the county is deemed unfeasible.

Threat scenario three involves terrorist activity to a large interstate natural gas pipeline. The pipeline in question carries natural gas from Louisiana to Canada and is under very high pressure. Large, local evacuations and hazardous exposures are the primary focus of this scenario. Dependent upon the location of the incident, this scenario can be very simple or extremely complex. Contamination scenarios for this threat are being developed that include the prisons. Phase one of the response plan involves assessing and removing inmates from the prison to a secure environment. Phase two of the response plan involves investigating the ability of the local hospital and health care networks to process a large number of inmates outside prison walls. While response and evacuation time is an important issue for this threat, the primary objective is to test the mobilization capability of the county health care system.

Each scenario consists of a detailed threat that is composed of a sequence of events. Depending on the timing and location of these events, the model generates follow-on effects of the threat. Once the threat and emergency plans are defined, they are translated into the simulation model. Through the simulation process of verification and validation, the emergency response plan is evaluated and improved until it is deemed effective at mitigating the threat. Once this stage is reached, virtual training drills can be held.

4 CONCLUSIONS

In an increasingly uncertain world, the ability to respond to disasters and terrorist threats is critical to mitigate personal injury. Emergency management planners and health care facilities are faced with potential scenarios that may severely test their capabilities and conventional processes. This paper presents the development of a simulation-based environment that allows emergency planners and professionals to prepare more robust emergency response plans without using costly, time consuming physical drills.

AUTHOR BIOGRAPHY

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