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The FALCON decision support system: Preparing communities for weapons of opportunity

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Abstract

Since September 11, 2001, awareness of potential terrorist targets has increased greatly. Industrial chemicals, either in storage or transport, are now considered dangerously accessible materials that could be used to cause substantial harm. In response to this new threat, emergency organizations are beginning to plan for such possible chemical releases. Currently there is no tool that allows a community to track, analyze, query, and display data about these chemical ''weapons of opportunity'' and the readiness of the communities around them.

Decision support systems are computer environments designed to assist decision makers within a particular problem-solving context. A particular type of DSS, environmental decision support systems (EDSS), assists environmental scientists and planners in making environmental management decisions. A hazardous materials decision support system called ''FALCON'' will assist emergency organizations by integrating information describing chemical inventories, security, health readiness, geography, and population into one information system. Emergency organizations will be able to assess response readiness of a community for chemical releases and prioritize antidote stockpiling, training, and security. Emergency organizations and first responders will use the FALCON DSS to simulate and prepare for real-time events, assess possible casualties, and receive emergency contact information. And with the help of FALCON, law enforcement and security personnel will be able to evaluate and augment protection of the most dangerous facilities.

Keywords: Environmental decision support systems; Chemical weapons of opportunity; Chemical risk assessment

1. Introduction

As local communities plan for possible terrorist attacks, industrial chemicals have been recognized as potential ''weapons of opportunity.'' The need has arisen for a comprehensive and easy-to-use method of determining possible outcomes of hazardous chemical releases. Decision support systems (DSS) can help decision makers plan responses to potential catastrophic events associated with the release of hazardous materials (HAZMAT). Decision support systems are computer environments designed to assist decision makers within a particular problem-solving context. A particular type of DSS, environmental decision support systems (EDSS), assists environmental scientists and planners in making environmental management decisions. Focusing on specific problems and decision makers, these systems work by integrating data and analytical tools within a single application environment. The information in a DSS must be timely with respect to the dynamics of the decision problem, accurate in relation to the information requirements and easily obtainable, in order to provide relevant information to the user quickly and reliably. The available decision support systems addressing hazardous materials are lacking in three major areas: they lack risk assessment scales that rank the risk posed by a potential release depending on the toxicity of the chemical; they do not make provisions for preparedness of hospitals in the region, which will respond to chemical emergencies; and they do not consider the security systems which

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may or may not be employed to protect industrial chemicals from criminal actions.

The FALCON decision support system has been designed to facilitate hazardous materials vulnerability assessment and will be used at both a local and a regional level throughout the United States. The system will integrate chemical inventory data, toxicity data, health care readiness data, population data, security data, risk assessment models, and air and water dispersion models. Using FALCON, emergency managers will be able to simulate possible scenarios and determine the potential outcomes. More importantly, emergency response planners, health care providers and emergency medical services (EMS) training personnel will also have the ability to evaluate community preparedness in response to catastrophic spills or releases and will therefore be able to prioritize training and resources. Finally, law enforcement and security personnel will be able to identify facilities most in need of additional security system development.

2. The problem

Advance preparation and planning is the best method of dealing with any type of catastrophe, and it is essential for saving lives. The need for the FALCON DSS exists because there is currently no system that will allow an emergency response planner to query, analyze, and display chemical inventory data, health readiness data, geographic data, and population data, while at the same time creating dispersion models and response readiness assessments. Without these capabilities, planners are ill prepared to prioritize training or allocate proper resources for possible chemical emergencies based on vulnerability.

Emergency planners lack a tool that integrates an inventory of hazardous materials in the community with health planning data, response readiness assessment models, and security system assessments. These planners need the ability to make decisions using ''what if'' scenarios based on comprehensive risk assessment of the chemicals stored in their regions and the toxicity of these chemicals. Then, with this knowledge, emergency managers can begin to assess the response readiness of their regional hospitals regarding a chemical emergency and to address prioritizations for antidote stockpiling and training of hospital staff. During a real chemical event, first responders will need to identify the chemicals in the facility and their toxicity information, as well as with any nearby chemical storage or transport sites that could be impacted by the event. First responders also need to be able to identify the locations and contact information of all health care facilities within a specified distance, and project the number of exposures and potential casualties from the event over a period of time while preparing for the safety of other emergency responders. Law enforcement and security personnel need to be able to identify those facilities which have the weakest security system and which present the greatest health risk in the event of a catastrophic release. These facilities may then be the focus of security improvement efforts, or enhanced patrol/protection during periods of heightened alert.

3. Existing software

There are several software packages currently available which have similar components to the FALCON DSS.

3.1. Cameo

Developed by the Environmental Protection Agency's (EPA) chemical Emergency Preparedness and Prevention Office (CEPPO) and the National Oceanic and Atmospheric Administration Office of Response and Restoration (NOAA), Computer Aided Management of Emergency Operations (CAMEO) is a system which incorporates a few software applications to assist first responders in gaining accurate information quickly during a time of emergency or for use in planning for possible chemical release situations. CAMEO has a chemical database, an air dispersion model, and a simple mapping capability. Widely used to plan for and respond to chemical emergencies, it helps its users meet the chemical inventory reporting requirements of the Emergency Planning and Community Right-to-Know Act (EPCRA or SARA Title III). It was created primarily for firefighters, police and local emergency response personnel who did not have accurate information about chemicals nor the proper safety response actions readily available to assist them. CAMEO is also now being used by industries, schools, environmental organizations, state emergency commissions (SERCs) and the Tribal Emergency Response Commissions (TERCs).

CAMEO is really a suite of three separate software applications – CAMEO, Marplot and Aloha. The original application contains a database of hazardous chemicals, with chemical-specific information on cleanup procedures, health hazards, fire and explosive hazards, firefighting techniques, and protective clothing. The user could enter basic information taken from the EPCRA Tier II forms (or their equivalent) required by the EPA from the chemical inventory of a facility. Included are additional templates to store EPCRA information. Another part of the software is MARPLOT, allowing the user to display maps from the U.S. Bureau of Census TIGER/Line files, displaying data such as roads, facilities, and schools. MARPLOT could be combined with ALOHA, an atmospheric dispersion model, allowing the user to estimate the downwind dispersion of a chemical cloud based on atmospheric conditions and the chemical's physical characteristics. A ''cloud footprint'', plume, can be plotted on maps. A separate software application, LandView can also be used to display demographic/economic information and EPA environmental databases.

Primarily used as a database of over six thousand hazardous chemicals, the database does not include health readiness data, a ranking of chemicals that pose the greatest risk in terms of potential health impact, potential number of casualties over time (how many, how fast), ease of detecting exposure, need for rapid treatment and complexity of medical treatment. The FALCON DSS, on the other hand, would also include medical facility locations, which facilities are prepared for that an event if a chemical event were to occur and types of antidotes, training and equipment that are available and

broadcast proper medical response. CAMEO's ALOHA can produce only a "cloud footprint" by estimating some atmospheric conditions, while the FALCON DSS can produce a dispersion model about the chemical event's location and physical data, such as wind/temperature conditions, that would be fit to the data and necessary for time-dependent profiles of exposure and projected casualties.

3.2. Enviromapper

Another program developed by the EPA, Enviromapper, is a web-based interactive Geographic Information System (GIS) that allows the user to display environmental information such as the location of water discharges, hazardous waste, toxic and air emissions, and Superfund sites. The interactive maps, in addition, show important geographic attributes such as roads and railroads, hospitals, schools, churches, populated places, and other water bodies within the US. It is available in three different spatial levels – county, state and national.

Enviromapper is an interactive GIS allowing the user to display environmental information about hazardous waste, water discharges, and toxic and air emissions along with geographic attributes. This program though does not allow users to input specific information for their regions. No data is inputted from the local communities, such as facilities and information pertaining to that particular location, chemical inventory and contact information, medical facilities and public locations with population data, resources and contact information. This system is only a web-based GIS and does not include any response readiness assessment or a real-time event.

3.3. Riskware

RISKWARE is an EDSS created by Environmental Software and Services, a company in Gumpoldskirchen, Austria. This software focuses on risk assessment, risk management, and technical training. It contains databases that combine information such as hazardous installations, safety reports, and hazardous substances with a geographic information system and several assessment models used to simulate and evaluate accidental emergency scenarios. This system allows the user to input, query, and analyze data about hazardous chemical releases.

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4. How the FALCON DSS improves on existing software

The FALCON DSS is similar to RISKWARE in that it integrates object database management for hazardous chemicals and risk objects such as chemical plants and hospitals, links to a geographic information system, integrates multiple simulation and assessment models for strategic analysis and planning tasks, and fast emergency simulation. But RISKWARE does not address the problem of trying to integrate a system of response readiness assessment in the manner that FALCON DSS does. RISKWARE does not have the software to prioritize response readiness planning based on the potential for emergency, types/severity of casualties, potential numbers of casualties and readiness of local health care emergency responders. Also, RISKWARE lacks the risk assessment capacity to rank the risks posed by the simulated dispersions, allowing the user to determine how dangerous the chemical releases might be depending on the release method and the toxicity of the chemical

5. Solution

The proposed solution is to create an integrated decision support system (DSS) that integrates health readiness, a chemical inventory database, and risk models into a geographic information system framework. Integrated environmental decision support is not a new concept (see, for example, Frysinger, 1995, and more recently Lam et al., 2004; Denzer, 2005; Lim et al., 2005). But the FALCON DSS is novel in its integration of disparate technologies to support three categories of users and uses, i.e. security, first response, and health care delivery.

The FALCON DSS will be maintained at a regional level to ensure accuracy. The system will include chemical inventory data, health readiness supply data, hazardous chemical data, population data, and geographic data. The FALCON DSS will contain an event simulation component that will allow the user to simulate possible chemical releases using dispersion models and Monte Carlo Simulation. The DSS will also include a response readiness assessment component by which users can query chemicals located in the region and determine where the most planning and resources are needed.

5.1. The user community

The primary users of this system will be those individuals responsible for regional response readiness planning and coordination. Possible examples include the following: police, fire and rescue, poison centers, hospitals, regional HAZMAT teams, EMS, and emergency management organizations. It is assumed that the user audiences all have some emergency response training and at least a high school education. Moreover, it is assumed that all users will have basic computer skills and are comfortable with the Windows operating system. No GIS expertise is assumed. Some primary users will have experience with environmental software such as CAMEO. Poison centers, regional HAZMAT teams, and emergency management organizations will probably use the system most frequently in order to plan for unexpected chemical emergencies. Police, fire and rescue, hospitals, and EMS will probably use the system only occasionally but will likely work under the direction of the emergency management organizations in order to better plan for emergencies.

5.2. Needs assessment

The specific needs for this project were based on input given by the Blue Ridge Poison Center, in Charlottesville, Virginia and members of the Harrisonburg and Rockingham County Police and Fire Departments, in Harrisonburg, Virginia. The Blue Ridge Poison Center is a team of medical professionals and toxicologists that are the main source of information for poison emergencies for the 62 counties in Central and Western Virginia. Both of these groups qualify as first responders, and their input has indicated the need for each of the main components of the FALCON DSS. The main concern of the Blue Ridge Poison Center was the need to prioritize training efforts. Without knowledge of the locations of hazardous chemicals, the staff has a difficult time determining where chemical training would be most beneficial. The Harrisonburg Police and Fire Department would welcome an easily accessible program to provide toxicity information on each chemical located in the region. This toxicity information needs to be available to give to the first responders arriving on the site of chemical emergencies to prevent injury or exposure.

5.3. System components

The FALCON DSS will include several components (Fig. 1).

- A DATA MAINTENANCE facility whereby regional community planners can input relevant chemical and health readiness data.
- A CHEMICAL INVENTORY GIS in which users can view maps showing chemical storage locations or routes of chemical transport. For any specific site, users will be able to retrieve information on the chemicals stored at the site and the toxicity ratings of those chemicals
- An EVENT SIMULATION facility that can simulate various types of chemical events and generate time-dependent profiles of exposures and projected casualties.
- A REAL-TIME EVENT MANAGER that first responders can access during a real chemical event. This facility will allow users to:
  - Identify the chemicals stored in the facility at which the chemical event has occurred, along with information on their toxicities.
  - Specify any nearby chemical storage or transport sites that could be impacted by the event.
  - Project the exposures and potential casualties from the event over time.
  - Identify the locations and contact information of all health care facilities within a specified radius of the event.
  - Define the readiness of those facilities for responding to the event.
- A RESPONSE READINESS ASSESSMENT facility that will allow the user to assess and prioritize the risks associated with chemicals in the database. This facility will allow users to:
  - Evaluate response readiness of health care providers in the community.
  - Prioritize training and resources.

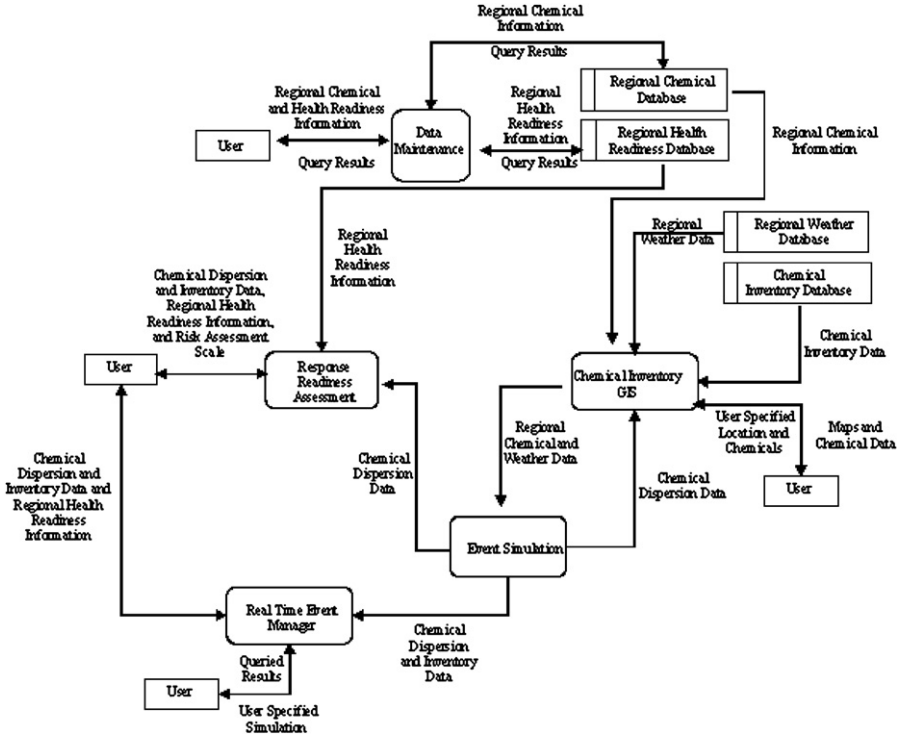

Fig. 1. Systems components diagram.

- Identify highest risk events to guide regional community planners, law enforcement, and health providers.
- Create an assessment tool kit for community health response readiness.

5.4. Technologies used

Within the development of this DSS, there will be several technologies used. The system will run within Microsoft Windows for Microsoft XP. The GIS portion of the system will be created using elements of the ESRI software. The specific elements are unknown at this time. The database that will store chemical inventory data, toxicity data, health care readiness data, and population data will be designed in Microsoft Access. Internet Explorer will likely be the browser used when making the system web-based. The specific version has yet to be determined.

5.5. Data and mathematical modeling

Within the Event Simulation component, users will be able to create air and water dispersion models for specified chemicals. They will also have the ability to generate time-dependent graphs of chemical exposures and projected casualties related to that dispersion. The dispersion models will be produced using Monte Carlo simulation techniques. Since Monte Carlo simulation calculates multiple outcomes based on a given distribution, the user will gain information about the most probable outcome of a chemical emergency.

5.6. Current status and future work

The FALCON DSS is now in its first prototyping phase. The need for the DSS has been established through several user interviews, and the system functionality has been defined.

Pieces of the database have been designed and constructed. For the purpose of the prototype, portions of the database are being populated with data from Tier II forms, which were provided by the LEPC of Harrisonburg City and Rockingham County, Virginia. GIS data for both Rockingham County and Harrisonburg City have been obtained, but no new data layers have been added.

6. Conclusion

As the awareness of potential chemical weapons of opportunity arises, the need for an integrated tool that will assist emergency planners and first responders in preparing and responding has become more evident. Although some current systems contain pieces of the problem, none provides a comprehensive risk assessment involving chemicals stored at a regional level and the preparedness of emergency organizations to respond to these potential events. Emergency planners are currently unable to prioritize training or allocate proper resources for possible chemical emergencies based on vulnerability within one system. The FALCON Decision Support System will accomplish this goal by integrating chemical inventory data, toxicity data, health care readiness data, population data, risk assessment models, and air and water dispersion models. Through use of the FALCON DSS emergency planners and first responders will have the ability to evaluate community preparedness in response to chemical spills or releases and will therefore make better decisions about the prioritization of training and resources within a community.

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