Risk Assessment and Emergency Management Information Tools for Planning and Real-Time Applications

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Abstract

Manufacturers, transporters and regulators of hazardous materials, as well as other stakeholders, are recognizing the value of risk-based decision making to improve safety performance. Attention is being focused on the entire life cycle, including the production, storage, consumption and disposal of hazardous raw materials, intermediates, finished products and wastes.

Two important components of risk-based decision making in this context are the ability to properly assess the risks associated within an operation and to effectively manage incidents should they occur. Pro-active risk management programs approach these considerations from both an advanced planning and real-time perspective.

To successfully address these issues, a considerable amount of spatial information is needed to characterize facility operations, facility proximity to human health and environmental receptors, and the location of qualified response resources. These information requirements are particularly challenging in the transportation components of the life cycle, since multiple modes of shipment may be used, and each mode offers thousands of miles of routes comprised of varying characteristics within the transport corridor. Fortunately, advanced information tools have been developed to assist decision-makers in performing environmental risk assessments and managing emergencies that apply not only to the transportation sector, but to other parts of the life cycle as well.

This paper focuses on the need for these decision-support tools, how they are being developed, what is available off-the-shelf today, and the value-added they provide in protecting human health and the environment. Case studies are provided to illustrate common uses of these tools in environmental risk assessment and emergency management applications covering both planning and real-time situations.

Introduction

A number of government regulations and industry initiatives have been and are continuing to be directed at reducing the likelihood of harmful events and mitigating their effects on public safety and the environment. Included in this set of concerns are both man-made and natural disasters, such as chemical spills, terrorism, hurricanes, tornadoes, forest fires, nuclear incidents, earthquakes, floods, avalanches and mud slides.

In each instance, managing the risks associated with these potential events involves both advanced planning and real-time decision-making. Advanced planning involves the use of risk assessment to characterize and prioritize operational risks. Highly ranked risks can then be examined from the standpoint of implementing more effective risk management controls with a goal of incident prevention and mitigation of serious consequences should an event occur. Real-time decision-making involves the integration of prior risk management planning with current information so that emergency managers can make time-sensitive decisions to protect human health and the environment through proper communication, deployment of response resources and related actions.

Within the chemical industry, the need for "world-class" environmental risk assessment and emergency management practices is well understood. This is codified in a variety of regulations, including the EPA Clean Air Act and Clean Water Act, OSHA Process Safety Management, DOT OPA-90 and various state EPCRA rules and laws. This concern has also carried over to industry-sponsored initiatives such as ISO 14000, Responsible Care® and other trade association safety programs. Increasing public

interest in environmental justice suggests that additional requirements are likely to be added to this plate.

Heightening this awareness are recent developments in tort liability. Negligence is now being measured against "reasonably foreseeable" risk, implying that regulatory compliance alone does not ensure that this standard has been met. In essence, judges and juries expect compliance and look further to see whether foreseeable risks have been adequately addressed in determining negligence. Given the size of punitive damage awards, this interpretation is receiving considerable attention in the boardroom.

Stakeholder Needs

A variety of stakeholders are interested in these issues and have become actively involved as participants in the process, either as a responsible party or in an oversight/consultative capacity. Stakeholders include:

- City/county officials
- Federal/state agencies
- Fire departments
- Hospitals
- Law enforcement officials
- Hazmat teams
- Manufacturers
- Transportation/bulk storage operators
- Clean-up/disposal companies
- Consumers

- Public citizens
- Community service groups
- Financial/legal professionals

This scenario is creating a daunting task for industry executives as they attempt to develop and implement cost-effective policies and procedures that meet the aforementioned expectations. Central to this mission is the provision of rapid, concise and complete information with related analytical capability so that environmental risk and emergency managers can make critical decisions in a timely and informed manner.

Among the functions that need to be performed in this capacity are the following:

- Maintain a central source of environmental risk and emergency management information
- Identify at-risk populations and sensitive environments
- Assess and prioritize facilities/locations in need of risk management attention
- Evaluate the potential scope of an incident
- Develop and enforce risk management policies and regulations
- Track major events during and after they occur
- Locate and deploy response resources
- Calculate initial damage estimates for mitigation reports
- Communicate risks to the public
- Monitor compliance with environmental health and safety regulations
- Satisfy industry safe practice certification standards

To successfully address these issues, a considerable amount of spatial information is needed to characterize facility operations, facility proximity to human health and environmental receptors, and the location of qualified response resources. These information requirements are particularly challenging in the transportation components of the life cycle, since multiple modes of shipment may be used, and each mode offers thousands of miles of routes comprised of varying characteristics within the transport corridor.

Information Tools

Fortunately, advanced information tools are being developed to assist decision-makers in performing environmental risk assessments and managing emergencies that apply not only to the transportation sector, but to other parts of the life cycle as well. By supplying critical information that is timely, precise and easily understood, these tools are revolutionizing the way in which environmental risk and emergency management can be performed.

A critical component in this development is the use of geographic information systems (GIS), an electronic spatial referencing system that allows several layers of geographical information to be represented, related and manipulated in support of management decision-making. GIS-based software products provide powerful and versatile problem-solving capability, captured in an easy-to-use, illustrative reference. Some provide an integrated system of databases, maps, analysis modules and management reporting, resulting in a single source for managing environmental risk and emergency management applications. Among the product features are the ability to:

- "zoom" to a specific location
- access historical and current information
- visualize the impact area
- highlight problem spots
- model worst-case and alternate scenarios
- access a variety of custom and proprietary databases showing the locations of special populations, response resources, transportation networks, sensitive land uses, industrial facilities, political boundaries, etc.
- import company-specific data or create new data layers
- create professional quality maps, graphs and reports
- utilize built-in spreadsheets with statistical functions
- interface with other risk management software (e.g., dispersion models)
- transfer information electronically to other agencies, communities, field units, etc.

Common Applications

In the discussion to follow, a few environmental risk and emergency management applications are shown to illustrate the power and versatility of available information tools. Some of the selected applications pertain specifically to chemical transport, while some also represent other life cycle activities in the chemical industry that depend on the use of environmental risk assessment and emergency management.

Tracking a Hazardous Chemical Shipment for Incident Notification

This application involves the movement of an extremely hazardous chemical along a route from its shipment origin to a specific destination. In anticipation of a potential incident at any point along the route, it is helpful to know who might be impacted and

how to contact them in the event of an emergency. For nuclear shipments, this application might be extended to advance notification of designated agencies along corridor communities.

Using available GIS-based tools, Figure 1 shows how this problem is addressed if the shipment involved movement along I-35 through Sanger, Texas. As noted in Figure 1, an impact "band" is defined as a GIS layer, and receptor layers are displayed corresponding to schools, houses of worship and day care facilities in proximity to the potential incident site. To simulate other scenarios, bandwidths could be varied to represent impact ranges specific to the type of hazardous material, as well as consideration of other receptors in addition to or instead of the ones shown.

Beyond the value of providing a visual depiction of the scenario, data residing underneath each point in each receptor layer can be extracted for analysis or reporting purposes. In this instance, the name, address and phone number of each impacted receptor has been selected and formatted into a report as shown in Table 1. This enables an emergency manager to promptly identify who to contact and how to reach them.

Figure 1. Hazardous Material Shipment Tracking and Notification

Table 1. Impacted Receptors and Contact Information

Risk Assessment Using a Worst-Case Scenario

Chemical facilities are heavily involved in identifying worst-case scenarios and forecasting the consequences to human health and the environment. Often, this includes the use of dispersion models to develop release scenarios and determine dose-response based on the characteristics of the event. The resulting impact area "footprint" can be imported as a GIS layer and related to other data layers representing human health receptors and environmentally sensitive land uses. Statistics can then be generated to assess the overall impact of a release by measuring the population and sensitive land use exposed to the chemical dispersion, segmented by various health effects, if desired.

Figure 2 shows an example of this application for Horizon Chemical, a hypothetical chemical facility sited in Columbus, Ohio. The figure displays dispersion model results representing a release scenario that has been imported into the GIS-based tool. Also included on the map is a layer representing the major roadway network in vicinity of the facility. Included in this analysis but not shown on the map are the GIS-based Census population counts for the impact area in question.

By overlaying the impact zone on the population data, statistics are generated that appear in Figure 3. This graph provides an estimate of the population that would be affected if the profiled scenario were to take place. Moreover, Figure 3 also segments the affected population into minority and impoverished categories as required for environmental justice studies.

Figure 2. Horizon Chemical Release Scenario

Figure 3. Impacted Population

Another series of layers could have been included to represent environmentally sensitive land uses, such as national parks, wilderness areas, grasslands, Indian reservations, lakes, rivers and marshes. This would support the profiling of environmental quality and potential degradation due to a chemical release.

The primary interest in this application is the ability to represent alternative release scenarios, and evaluate the overall effect in terms of impact to human health and environmental quality. However, the maps that are generated as a by-product of this application can be of considerable value in communicating risk scenarios and prevention/mitigation plans to both internal and external stakeholders.

Natural Disaster Management

Natural disasters such as hurricanes, tornadoes and earthquakes threaten the chemical industry across all aspects of the life cycle, including transportation. In this application, a hurricane is tracked into a region heavily involved in chemical manufacturing and transport for the purpose of identifying high risk areas and deployment of response resources.

Figure 4 shows the track of Hurricane Bret as it moved on-shore in the vicinity of Corpus Christi. The hurricane impact zone is shown as three rings, corresponding to areas subjected to greater than 64, 50 and 34 knot winds, respectively. This is represented in the information tool by importing position reports and forecasts from the National Hurricane Center. Overlaid on this map are data layers corresponding to the locations of

Figure 4. Hurricane Bret Impact Area in South Texas

police, hospitals and building materials suppliers. These layers are a mere sample of the numerous responder types that could be represented as part of deployment to mitigate the effects of Hurricane Bret.

A companion report generated from this map is shown in Table 2. It provides a listing of the police departments, hospitals and building materials suppliers located in the portion of the Corpus Christi area that is contained in the above 50 knot region. This information includes addresses and telephone numbers, which can be used to facilitate immediate contact and response coordination. In fact, the open architecture of existing tools enables this information to be transmitted electronically to operations centers, field units or automated emergency broadcast communication systems.

At another level, Figure 5 provides a graphic tally of the overall resources available in the entire over 50-knot region, including Corpus Christi. This enables the emergency manager to quickly understand the aggregate resources available in the region, valuable information in organizing a response strategy and determining the level of additional outside support that may be required.

Use of these information tools extends well beyond the few applications illustrated here. Routing modules exist within these tools that enable selection of hazardous materials shipment routes that minimize risk, travel cost or a combination of criteria. The results of any application can be formatted to comply with regulatory reporting requirements, emergency notification protocols or other prescribed procedures. Response drills can

Table 2. Response Resources in Corpus Christi

Figure 5. Regional Availability of Response Resources

be simulated and emergency procedures can be evaluated. Additional applications will also come to mind as environmental risk and emergency managers recognize the power and versatility of these tools.

The Bottom Line

Based on evidence to date, it appears that environmental risk assessment and emergency management information tools can provide a variety of benefits, including:

- improved incident prevention and mitigation
- enhanced response and recovery
- decreased exposure to criminal liability and punitive damages
- reduced business and community disruption
- savings in time and money
- greater public acceptance

In today's business climate, it is important to be able to translate these benefits into monetary terms. Loss prevention experts have estimated the potential savings from avoiding the following economic consequences:

- $2,000,000 per fatality
- $200,000 per injury
- $1,000 per person evacuated
- thousands to millions of dollars in clean-up, property damage, product loss and environmental damage per incident

At a small fraction of these costs, the return-on-investment offered by these information tools appears to be extraordinary.

We are fortunate that advances in information technology have progressed to a point where environmental risk and emergency management applications involving planning and real-time scenarios can be performed at all levels across the country. Already available at this time are GIS databases that contain nationwide coverage of human health and environmental receptors, response resources, transportation networks, political boundaries and industrial facilities, as well as many other relevant layers. Off-the-shelf software can manipulate this data, perform analyses and provide results specifically for use in environmental risk and emergency management. Finally, communication protocols are available that transmit vital information derived from these tools to speed up incident notification and improve response coordination.

Regulatory requirements, industry standards and public interest are putting special demands on environmental risk and emergency managers. It has been known for some time that adequately meeting these needs would require creative use of emerging information technologies. With the advent of tools designed for this purpose, we can look forward to enhanced public safety and environmental protection, as well as the comfort of knowing that “best practices” are being applied to such a critical national concern.