A LOCOMOTIVE WITH A STEERING WHEEL: RESPONSE PLAN DESIGN ISSUES

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ABSTRACT

Developing response plans for highly stochastic events is a challenging project. Emergency response planners must decide whether to spend their time developing a large number of plans in an effort to anticipate a wide variety of hazard behaviors or develop a smaller number of plans, assuming that hazard behavior is relatively predictable across a given span of time. Regardless of which approach is taken, planners must also decide on the degree of detail to which each plan is written. Should the plans be highly detailed so as to provide a more accurate assessment of the total response time and resources required, even at the risk of plan inflexibility, or should flexible, "generic" response plans be developed at the risk of underestimating time and resource demands? The use of risk analysis has suggested that a compromise is possible.

ISSUES IN RESPONSE PLAN DESIGN

What is the best approach to response plan design for emergency planners who must deal with stochastic hazards? Should a relatively large number of response plans be developed in the hopes of having a plan ideally suited for a given hazard, or should a smaller set of response plans be created in the belief that hazard behavior is adequately predictable over the time-scales involved? Having selected one of these philosophies, should the planner build plans which are very detailed or relatively generic?

The creation and availability of large libraries of response plans presents the problem of the time and expense involved in plan development as well as the possibility of response options "overload" should an event occur. As bad as not having a suitable response plan may be having too many to choose from. Smaller plan libraries reduce this potential problem but run the risk of not containing a plan suited for the hazard in question. Detailed plans provide more accurate response time and resource demands, but they may be inflexible in the face of a sudden change in hazard behavior. Finally, generic plans offer the benefit of flexibility at the risk of underestimating the time and resources required to respond.

Detailed response plans suffer the "locomotive" syndrome. They are guaranteed to get you to the place you *planned* to go, but you cannot steer them to the place you *want* to go if you change your travel plans. Generic response plans suffer the "automobile" syndrome. They can take you where you *want* to go, but without a detailed map and adequate resources you may never get there. What planners in this situation need is a locomotive with a steering wheel. The application of some basic risk analysis techniques suggests that this is possible.

CSEPP

There are eight sites in the continental United States where chemical agent weapons are stockpiled. The Chemical Stockpile Disposal Program was initiated in 1985, when Congress passed Public Law (P.L) 99145. This law mandated that the Department of Defense (DOD) destroy at least 90 percent of the entire stockpile by September 30, 1994. In 1990, P.L. 101-510 extended this date to July, 1999. The CSEPP was crated to assist military and civilian response meet this mandate. This program has provided significant support to military personnel at stockpile sites and civilian emergency response personnel in the communities near these sites in an effort to help them plan for the unlikely event of an accidental release of chemical or nerve agents.

For several years, IEM has been engaged in providing support for organizations involved in the CSEPP. One component of this support has been to assist these organizations in developing comprehensive, integrated response plans for their sites. In the course of this project, IEM analysts have discovered that there exist almost as many planning philosophies as there are emergency planners. Planners at some sites, because of site characteristics or basic planning philosophies, have chosen to create extensive and detailed libraries of response plans. Planners at other sites, for the same reasons, have chosen to create smaller plan libraries.

Our involvement with over twenty CSEPP jurisdictions and hundreds of response personnel has revealed that at least a partial solution to the dilemma outlined above is possible. If planners are willing to seek such a compromise, several options are available through risk analysis--one may reduce the number of conceivable hazards by deriving probability distributions, one may reduce the variant behaviors of this subset of hazards by conducting similar analysis of the factors affecting hazard behavior, and one may design response plans which contain both "generic" tasks (suited for any hazard that is likely to occur) and a smaller group of hazard-specific tasks. The first two elements of this approach have been applied at one CSEPP site.

CSEPP EVENTS

CSEPP events may be characterized as "low probability/high consequence" hazards. There are a variety of chemical agents involved in the CSEPP--some are vessicants, or blistering agents, such as mustard (HD); others are nerve agents. These agents may be stored in various quantities in a wide variety of munitions--from small land mines to large bulk containers. Some of the munitions contain explosive or propellant components while others do not. In short, there are a significant number of agent/munition combinations which will define the nature of a CSEPP hazard should one occur. Add to this the virtually infinite set of meteorological conditions which may exist at a CSEPP site and you may get an idea of the challenge faced by CSEPP planners and responders.

Nevertheless, the possibilities are not as endless as they may seem. For most sites, the mix of agents and munitions is quite limited. At one site, for example, a single agent type is stored in a single munition type. Other sites have increasingly heterogeneous mixes of agents and munitions; however, for a given site there will not be a maximum number of permutations of agents and munitions.

Another factor reducing the uncertainty for CSEPP planners is to provide them with insights into the likelihood of a given CSEPP event occurring at their site. This has been done through risk analyses conducted early in the CSEPP on a site by site basis. Not all conceivable CSEPP events are possible at all sites (because of agent and munitions configurations), and where certain CSEPP events *are* possible at a given site, these events are not equally likely. This alone reduces the scope of the task faced by local planners.

RISK ANALYSIS

The next step was to take the probability distribution of CSEPP events at a given site and combine the various source terms in question with local weather conditions to derive another distribution which indicates the probability of hazard behavior. IEM has provided this analysis to one CSEPP site.

Since CSEPP hazard behavior is defined in large part by meteorological conditions, IEM collected several years worth of National Weather Service (NWS) data for the site and subjected them to rigorous statistical analysis on a seasonal level. Given that no one can yet predict the weather with great accuracy, IEM was nevertheless able to derive a probability distribution for seasonal weather at the site using a statistical clustering algorithm. In essence, IEM analysts took weather parameters critical to CSEPP events (wind direction, wind speed, temperature, etc.) and looked for "clumps" in a multidimensional data array. IEM analysts then took the probabilities and profiles of CSEPP hazards for this site, applied the clustered weather data, and created a library of several hundred hazard cases. It should be noted that the site in question contains the most heterogeneous mix of agents and munitions so we may expect smaller hazard case libraries to obtain at other sites if this approach is used.

This library thus reflected *more likely* events combined with *more likely* weather conditions. This analysis also identified specific populations affected, evacuation time estimates for these populations, and hazard impact times. Overall, this project has allowed response planners at the site to focus their efforts on designing response plans for higher probability hazards and hazard behavior.

BUILDING RESPONSE PLANS

Having reduced the number of possible CSEPP hazards and reduced this subset even further by deriving a list of probable event behaviors, it has fallen to CSEPP planners to design their response plans. The CSEPP has provided military and civilian personnel at CSEPP sites with advanced decision-support systems. These systems include Gaussian dispersion models, evacuation modeling applications, relational databases for resource loading, and plan-building applications. These systems are integrated in a fashion that allows planners to create response plans that include resource demands, to validate these plans against "real world" resources, and to associate each plan with a given hazard profile. Thus, should an event occur, responders need only model the real hazard, select a hazard from their libraries that matches or approximates it, and an associated response plan will be recommended.

The degree of detail to which CSEPP personnel choose to write their plans may vary. As one might expect, the risk analysis described above reveals that planners at "remote" CSEPP sites will have more generic plans than planners at sites where significant civilian populations exist. This is because changes in the factors involving hazard behavior are less likely to affect the potential impact of the event. Nevertheless, by reducing the overall number of hazards at a site, we may significantly reduce the burden to CSEPP planners.

EVALUATING RESPONSE PLANS

Again using risk analysis methods, response plans may be tested against the complete library of hazard cases for a given site. All response plans suffer from one limitation--the durations associated with each task in the plan are estimated and fixed. Usually, plans are modeled and a "total response time" is derived by summing the durations of tasks critical to migrate from hazard perception to public alert and protection.

As we know, plans are rarely so well behaved or accurate when put into action. A truly infinite number of factors now enters the response equation and tasks that were scheduled to take, for example, ten minutes may take twenty (or five). In short, a method is needed to build dynamic response models.

Using a risk analysis tool known as Crystal Ball©,[1] analysts at IEM have begun a project which seeks to test response plans in this fashion. This application uses the Monte Carlo method to assign random task durations to a plan, with these random values falling within certain probability distributions. For example, we may build a model that has a given task, say "run the hazard model", taking five minutes. We may then assign a "normal" distribution to this task which indicates that the task may take as little as three minutes (assuming users familiar with the use of the hazard model) or as much as fifteen minutes (assuming users less familiar with the model). We continue to assign durations and distributions to response plan tasks, and when we run the simulation, we derive a "total response time" figure that, we feel, is much more realistic than simply the sum of estimated and fixed task durations. Furthermore, sensitivity analysis can be conducted on the model to determine tasks which are critical for effective response.

We have already discussed the creation of seasonal libraries of hazard cases. Using the same simulation software we can also derive a "mean hazard impact time" for the entire seasonal case library. Obviously, we may compare the derived total response time noted above and the mean hazard impact time to determine a confidence interval for each plan. This can serve as an important benchmark for CSEPP planners seeking to refine their plans. Should this evaluation reveal low confidence intervals for certain plans, the process of modifying these plans--making them more or less detailed or increasing the number of available plans--becomes a manageable process.[2]

CONCLUSIONS

Risk analysis can significantly reduce the challenge faced by emergency response planners. Developing a compromise on the need for large and/or detailed libraries of response plans with smaller, more generic plans is an ongoing effort.

The effectiveness of the risk analysis discussed in the section on evaluating response plans remains to be seen. IEM analysts feel confident however, that this approach represents a new and exciting means of subjecting plans to rigorous testing through simulation.

[1] Crystal Ball©, is an risk analysis application developed by Decisioneering, Inc.

[2] Presentation of this paper at TIEMEC 1995 included a brief demonstration of how response plan assessment is being conducted by IEM analysts.