GIS FOR SAFETY OF FOREIGN NUCLEAR FACILITIES

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ABSTRACT

A GIS can be a valuable tool in *ex post facto* analyses of concerns related to plant siting as information captured in the GIS can be used to effectively manage risk and to properly prepare resources for accident response. The Office of Foreign Intelligence (OFI) of the Department of Energy (DOE) is developing a GIS-based Foreign Intelligence Nuclear Information System (FINIS) to respond to requests for information and support from US policy makers within 24 hours of a notice of an incident at a foreign civil nuclear reactor. Ideally, the GIS would contain information based upon a probabilistic risk assessment (PRA) of each of the more than 300 foreign reactors. However the cost and duration of performing PRAs makes this impractical. To identify for capture in the GIS the most important information on the most dangerous reactors, we used a methodology called the Vital Issues process (developed at Sandia National Laboratories) to involve key stakeholders in the use of both the GIS and its products in the identification of relevant information categories. This paper discusses the development of the FINIS.

IMPORTANCE OF MANAGING INFORMATION ON FOREIGN NUCLEAR REACTORS

The economic and environmental implications of the use of nuclear energy outside the US is a relatively new program within the Department of Energy's Office of Foreign Intelligence . The DOE has traditionally focused its resources on nuclear weapons and proliferation issues. However, following the Chernobyl accident in 1986, the US intelligence community began to focus on nuclear energy issues in addition to proliferation. The Chernobyl accident raised questions within the intelligence community about how well it was prepared to address nuclear safety issues and whether intelligence could help policy makers respond to future problems. The Vital Issues process - a strategic issue identification process initiated by OFI in FY 1992 - identified reactor safety as a key area for programmatic focus (Glicken and Engi 1992a, 1992b).

To this end, OFI has since committed itself to improving its support of US policy makers on nuclear energy issues in foreign countries. In 1991, a program was established dedicated to monitoring information on foreign nuclear power programs and to providing related warning information and analysis. The scope of interests of the Nuclear Energy Intelligence Program includes everything from markets for nuclear fuels to environmental issues arising from the handling and storage of nuclear wastes. The primary issue, however, is safety.

There are numerous parties - public and private, US and foreign, hostile and sympathetic - that are examining nuclear safety issues. OFI has neither the resources nor the desire to duplicate them. It is convinced, however, that intelligence could be contributing more to the study of nuclear safety issues overseas than it has. One of the key challenges OFI faces in doing so is determining how to maximize the use of its limited resources;

it needs to ascertain how to direct them towards the nuclear safety issues most needy of its attention and where intelligence is likely to have the greatest impact.

One of the key areas of OFI contribution is its support to federal policy makers (within DOE as well as other government agencies) through the timely provision of appropriate information. This requires that OFI has available to it the right information in a usable format when it is needed. OFI has recognized the role a geographic information system (GIS) could play in its support of policy makers in the event of a foreign nuclear reactor incident and has asked Sandia National Laboratories (SNL) to support it with the development of a GIS-based Foreign Nuclear Information System. In order to satisfy the requirement for the right information at the right time in a world of limited resources, there must be a credible and effective mechanism for identifying and prioritizing the 'right' information. SNL has used the Vital Issues process to do just that.

GEOGRAPHIC INFORMATION SYSTEMS

A GIS is an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. 1

The task of providing information relevant to developing an international response to a nuclear incident is heavily dependent upon the geographic location of the plant. Not only knowing the location, but being able to query and draw inferences from the results of those queries, is extremely useful. A GIS provides true topological reference data that permits those queries.

The GIS we are developing at SNL for OFI (the FINIS) will have an easy to use graphical user interface (GUI) which directs the user through pre-established queries, reports, and displays. There is also a possibility of performing ad-hoc queries as the sophistication of the users increase.

The GIS can be expanded into a much more sophisticated decision support tool with the addition of a relational data base management system (RDBMS), statistical packages, simulators, and expert systems, which permit the incorporation of information that may not be strictly geographic.

Constructing the GIS

The application is a computer based system containing critical information, information that would be required by policy makers to respond within 24 hours to a nuclear accident. This system will provide access to information about geographically referenced foreign nuclear reactors. Additional textual information associated with a geographic feature will be included, e.g. reactor engineering information. The foreign nuclear reactor system GIS may then be used to answer questions relating to locations, conditions, trends, patterns, and will provide the ability to model scenarios through the use of menu-driven pre-defined queries. The three principal paper outputs of the system will be: 1) a two page summary of reactor engineering data and reactor event history, 2) a summary of the hypothetical consequences of a specific accident at a reactor, and 3) a map, on one page, of a 150 Km radius circle around the reactor showing key geographic features.

GIS is the core through which this information will be linked. It provides a topological referenced data set for the reactors which permits the inclusion of geographic features into the analysis of accident risk and consequences.

The system is configured to run on a SUN workstation using ARC/INFO as the GIS and Informix as the RDBMS. The map system relies upon the Digital Chart of the World (DCW) (scale 1:1,000,000) provided by ESRI from the Defense Mapping Agency.

The information content of the maps is constrained, in the near term, by the coverage of

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[1] ESRI, Inc. Redlands, CA.

the DCW. A Joint Applications Design (JAD) [2] session was held to obtain the data to be stored in the RDBMS. That data definition has been expanded over the last 10 months to include more nuclear fuel cycle information. This has been a direct result of expansion of the original scope by the DOE and an examination of the Vital Issues results.

An examination of its geographical setting with respect to accident consequences lead naturally to events and entities which supply reactors and the consequences, waste and disposal, of reactor operation. The inclusion of information about the entire nuclear fuel cycle was a natural extension. The system will now include information about the fuel cycle from mining to disposal. The Vital Issues results had the effect of looking at information that was not strictly related to reactor operation but was a substitute for a PRA.

There are over 300 foreign commercial nuclear reactors world wide (excluding the United States). Time and resource constraints dictate that all information on all reactors cannot be included in the GIS. Ideally, the GIS would incorporate information on the most dangerous reactors first, information acquired by conducting a probabilistic risk assessment (PRA) of each of these 300 reactors. However, the cost and duration of performing PRAs makes this impractical. The Vital Issues process was used to identify criteria for choosing the most dangerous reactors (and so a near-term information focus for the FINIS) and to identify information needs on the part of the ultimate users of the FINIS.

One of the lessons learned while constructing the GIS is the flexibility of the data. As the customers involvement increased more peripheral information was added to the original data model. Giving considerable attention to the data model from the start has allowed us to add information about fossil fuel sites, support and utility services to fuel cycle sites as examples.

[2] The JAD technique was originally developed by IBM. JAD is a facilitated session that brings together the stakeholders, usually of a computer system, to rapidly produce a system requirements definition.

THE VITAL ISSUES PANELS

The Vital Issues (VI) process is a structured methodology developed by SNL for using groups of experts with diverse backgrounds to clearly define a problem (or dimensions of a problem) and then identify and rank issues of importance to the resolution of that problem. The process is explicitly designed to develop consensus among individuals with divergent perspectives on a problem of relevance to them and on various aspects of an approach to problem resolution. The Vital Issues process requires a high level of stakeholder involvement, ensuring that stakeholder perspectives are incorporated into the solution and predisposing acceptance of the programmatic approaches to problem resolution by those stakeholder communities. As a general rule, participants on each panel represent the perspectives of government (both executive and legislative); industry/private sector; academe; and special interest groups.

The Vital Issues process incorporates two primary approaches: a qualitative, or transactional method which takes a synthesis approach, and a quantitative or net benefit maximization method which performs some analysis activities. The transactional method uses facilitated dialogue to identify and define the topic of concern and constituent issues. Net benefit maximization uses quantitative methods to do tradeoffs among the members of a set of given alternatives, asking the panelists to rank the issues against identified criteria. Output from each panel is a report documenting discussion and graphic representations of the quantitative ranking of issues which also shows the amount of disagreement amongst the panelists as to the rankings (Glicken and Engi *in press*).

We used Vital Issues panels for this project in three areas: to define criteria to identify a dangerous reactor, to identify information needed to understand consequences of an accident, and to develop possible policy responses by the US. Due to the differing nature of the topic under discussion, each panel had a different constituency with representation of the four perspectives identified above.

The first panel in the series defined what was meant by an 'accident' in the context of this project, defining it as "a nuclear event that results in significant release of fission products from the core" (Glicken 1992). The panel then identified criteria that could be relatively quickly applied to foreign reactors to determine the likelihood that they would have an accident. Those criteria were plant design; plant condition; conduct of operations; regulatory oversight; support infrastructure; natural external events; and socio-political environment. The information categories needed to apply the criteria were also identified. Panelists were individuals with experience in identifying dangerous reactors and came from academe, the NRC (Nuclear Regulatory Commission), the private sector and the national laboratories.

The second panel used the definition of an accident synthesized by the first panel and addressed the spectrum of the consequences of an accident (Glicken 1993). The purpose of the panel was to identify topical areas and information categories that a policy maker would need to make a decision regarding response to that accident. Topical areas identified were economics and energy; health and environment; political and security issues; social issues; infrastructure issues; and cross-cutting needs. Information categories within each topical area were then ranked by panelists perception of their cost of acquisition and value to the decision maker. Panelists included representatives from academe, special interest groups, the private sector and the national laboratories.

The third panel will focus on possible US policy responses to an accident, given the likely consequences. Each of the three panels identified and ranked information categories that will be incorporated into the GIS and allowed the builders of the computer system access to individuals with a different perspective on the issue (than that of a program developer).

<u>COMBINING THE TWO</u>

Using only the GIS and the accompanying database or just the Vital Issues panel results to aid in rapid response to an accident or event <u>does not exploit the synergism gained by the combination of the two approaches.</u>

First, the fusion of these two data sets will help to identify missing information (information 'gaps') in the geographic or Vital Issues data sets that may be important to policy makers in the event of a nuclear accident. An example, the technical design of the original RDBMS failed to record threat as an important determinant for accident probability as indicated by the VI results.

Second, results of the paired comparisons rankings of accident probability characteristics from the Vital Issues panels plus the GIS and database permit the application of three other approaches; expert systems, statistical analysis, and simulation to provide ad hoc reactor characterization.

The expert systems approach would take the knowledge developed by the pairwise comparison results from the expert panels and incorporate them into a rule based system for determining various degrees of accident likelihood, consequence severity, and mitigation possibilities. The statistical approach would examine the data base for trends, clusters, and explanations of variation in the data. Statistical presentations also aid in data visualization, presenting the intrinsic structure of the data visually to aid analysts in decision making. The simulation approach would permit the linkage of dynamic simulation techniques describing accident scenarios in a simplified manner. This is a logical consequence of reactor characterization and testing of various accident scenarios by policy makers.

We will first use statistical and expert systems models to choose and group reactors; and second will use simulation to study accident consequences. Once a model is developed for one reactor it can be applied to all reactors, or any combination of them, in a matter of minutes.

Events are frequently occurring at reactors which may affect their risk characterization. The FINIS system can be queried at any time after the database is brought up to date with new information. Additionally, characterization criteria may change over time. With a stable database and GIS, different aspects of reactor characterization can be tested in a minimal amount of time.

SUMMARY AND CONCLUSIONS

The FINIS will be a valuable tool to US policy makers in the event of an incident at a foreign civil nuclear power reactor site as it will provide in a timely fashion and a usable format the information necessary to formulate an appropriate policy response. The expansion of the GIS with 'what if' and other capabilities also will allow OFI to provide warning of possible incidents, allowing policy and decision makers to deploy resources in a proactive rather than purely reactive fashion.

Perhaps as important as the information provided through queries of the completed system are the lessons learned and benefits gained through the process of building the FINIS itself. The perspective of an *ex post facto* analysis of a reactor site provided by the GIS allows us to incorporate a much broader universe of information into the FINIS than was originally envisioned. Information on the movement of materials and people in and out of the reactor site and the tracking of nuclear materials through the entire fuel cycle (both being geographically referenced sets of data) were recognized as important as the model building activity turned to consequences and responses. The Vital Issues panels provided a mechanism by which the computer model builder could understand priorities of the user communities and access the decision logic employed by such users.

The understanding to be gained by policy analysts and decision makers of the intricacies of the foreign nuclear environment using the capabilities of and the information contained in the FINIS can significantly contribute to effective policy and decision making.

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