Expert Systems Development for Contingency Transportation Planning

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Ensuring that the daily movement of millions of passengers and tons of goods in the Metropolitan Region of Rio de Janeiro—with a population of more than 10 million people—can be satisfactorily and safely accomplished is a complex task. It involves several transportation modes; federal, state, and local agencies; public and private operators; and skilled personnel. Very often parts of the system become ineffective. For many reasons, such as system component failures, strikes, accidents, disasters, or environmental catastrophes, special operational plans must be performed in order to recover service. In some of those agencies, plans are available for such conditions, but in most cases they are restricted to individual circumstances, mainly caused by equipment failures. Coordination among agencies and operators is almost nonexistent, but they work together when a critical situation arises. Another problem that has been addressed and that requires similar treatment is evacuation in the event of a nuclear disaster at the nuclear power plant in the state of Rio de Janeiro. For these numerous ill-structured problems, in which human behavior, social and political considerations, and multiobjective decision making are involved, the potential of expert systems technology was considered and is included in the contingency transportation planning of the Rio de Janeiro State Department of Transportation.

Presented in this paper is the research approach to contingency transportation planning taken by the Rio de Janeiro State Department of Transportation (SECTRAN/RJ).

The completion of operational plans for recovering transportation service in cases of disruptions caused by emergency or contingency conditions (restricted to a specific public or private operator) or joint plans (those involving more than one agency or operator) will be followed by the development of the corresponding expert systems to help in the decision-making process involved in that activity.

The inclusion of the expert systems technology in the project resulted from the 3-day Workshop on Expert Systems for Transportation, recently held in Rio de Janeiro, with the cooperation of the TRB Task Force on Expert Systems and ASCE Committee on Expert Systems. The workshop was organized by the Center for Transportation Technology (CETEC), an agency of SECTRAN/RJ, to disseminate within the transportation environment of Rio de Janeiro, especially among top administrators and transportation personnel at several federal, state, and local government agencies and private operators as well, information on the potential of expert systems applications in the transportation field. Besides the workshop, CETEC will address the development of expert systems for solving transportation problems, with emphasis on SECTRAN/RJ's contingency transportation planning research project, and will possibly focus on the development of special hardware for applications that may require such equipment. The first application, which is the subject of this paper, addresses the question of contingency transportation planning.

PROBLEM IDENTIFICATION

The Metropolitan Region of Rio de Janeiro (RMRJ) is made up of several towns, with a resident population of more than 10 million people. Figure 1 shows a map of the transportation systems that operate in RMRJ. The modal split of passenger trips by public transportation service is shown in Table 1.

Besides the importance of service provided by the first three modes (commuter train, ferry, and subway), some lines or corridors carry more than 150 buses per hour per direction, in addition to the regular traffic of passenger cars and heavy trucks. Any interruption in the operation of the main components of the transportation network, especially during peak hours, leads to critical conditions, because there is no reserve of operational capacity in the system.

In the last 10 yr, some 15 strikes paralyzed the four modes mentioned above. In some cases, disruption of service lasted so long that the RMRJ was in total chaos. (The strike of commuter trains in February 1988, for example, lasted 11 days.) There were so many accidents and riots that people could not go to work or get back home.

As a result of the critical economic situation that the country has been experiencing in past years, social tension is a strong reason for authorities to worry about the potential of new events to cause operation of the transportation

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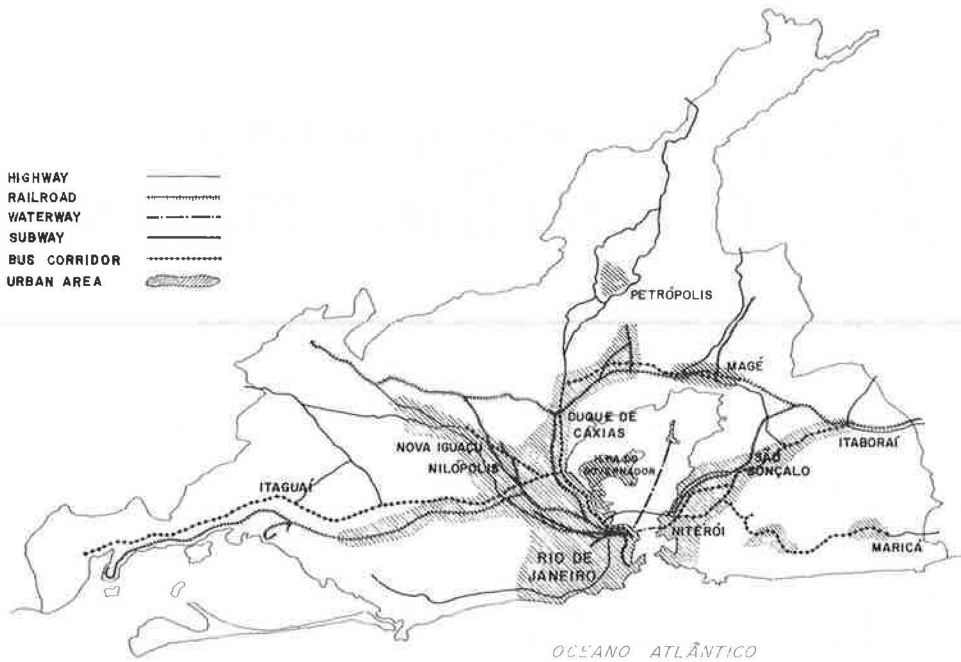

FIGURE 1 Transportation system in the Metropolitan Region of Rio de Janeiro.

TABLE 1 MODAL SPLIT OF TRANSIT IN RMRJ

Mode	No. of Lines	Passengers per Day No.	Percent	Type of Operator
Commuter train	6	700,000	8.5	Federal government
Ferry	2	180,000	2.2	State government
Subway	2	300,000	3.7	State government
Local bus	850	7,000,000	85.6	Private
Total trips		8,180,000	100.0	

SOURCE: SECTRAN/RJ.

system to collapse. They are also afraid of serious injury to people and damage to the physical installation and rolling equipment. Records of such situations show that there have always been such undesirable consequences.

- In July 1988, a technical problem at a power station of the commuter train company caused disruption of service for 2½ hr, riots ensued, and five 12-car trains were damaged.
- The sliding of a barrier at the entrance to a highway tunnel in October 1987 and flooding in the suburban areas of Rio de Janeiro in January 1988 blocked traffic for 2 and 3 days, respectively, in the surrounding affected areas.
- Brazil started a nuclear power plant program years ago and built three plants at Angra dos Reis, in the state of Rio de Janeiro (Figure 2). The first plant suspended service 2 yr ago when a problem in a component of the reactor was detected.

These conditions were viewed as emergency situations for which special operational plans had to be prepared and performed.

In the event of an accident or nuclear disaster, a complex operation of transport mobilization must be carried out at once, in order to evacuate the population of towns and villages within the range of zones at risk and also allow for the necessary action to control and combat the problem.

It was also recognized that plans must be available for coping with such potential conditions and that strict cooperation between the agencies and operators involved must be exercised and implemented. After the Workshop on Expert Systems for Transportation, authorities agreed that expert systems constitute a convenient tool for the development and implementation of contingency transportation planning.

CONTINGENCY TRANSPORTATION PLANNING

SECTRAN/RJ (*1–5*) and its agencies (*6–10*), as well as non-transportation-related agencies (*11, 12*), have been working on the development of contingency transporta-

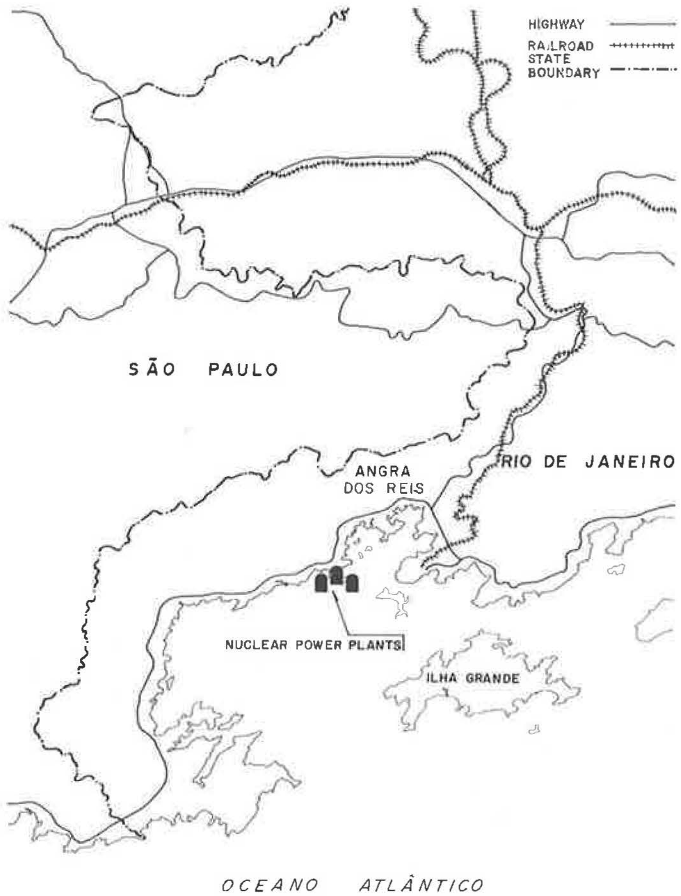

FIGURE 2 Location of nuclear power plants in Brazil.

tion plans in order to minimize the effects of service disruption and the inherent consequences of such conditions. However, it was recognized that without coordinating with other agencies of the federal and local government, as well as with private operators, inefficient action would result. The key word is preparedness, and this should involve all segments of the transportation system in the state of Rio de Janeiro, rather than agencies of the state of Rio de Janeiro.

To implement an alternative transportation operation for an emergency condition, it is necessary to count on the cooperation of other segments or components of the transportation system located in the affected area in the state.

This is exactly the critical issue of the problem being addressed: In addition to the conduct of research on individual problems of the several agencies with different statuses, structures, and objectives, the core problem to solve is how to address the institutional questions and the coordination of plans produced at those agencies.

Therefore, for expert systems development, the problem context comprises three main components: (a) contingency plans restricted to a specific transportation agency or operator, for emergencies that affect only a segment of the transportation system, the one for which a particular agency or operator is responsible; (b) joint contingency plans among agencies or operators, or both, for emergencies that affect more than one mode or segment of the transportation system in the RMRJ; and (c) a general contingency plan, which will be triggered at any agency or operator in a potential contingency condition but control of which will be centralized. Thus a first response of the plan is to recognize whether under the prevailing conditions there is in fact a contingency condition and, if so, whether it is restricted to only one or whether it also affects other system components.

Because of the complexity of the subject in the geographical area and from past experience and consequences that have resulted from such contingency conditions, the problem addressed constitutes effectively a challenging task for both strategists and knowledge engineering researchers. Furthermore, the issues involved in the research and development of a tool to help decision makers in such critical situations are particularly timely in the state of Rio de Janeiro.

The contribution of expert systems to the expected solutions should include not only reliable advice to operations managers and decision makers, because of the exemption from human weakness under critical circumstances that automated and well-tested systems present, but also a lasting methodology for problem solving under contingency conditions and a powerful tool for training managers in the various segments of the process both in individual mode agencies and at the central control agency.

Besides the expected benefits from the availability of contingency transportation plans, the research will induce managers from the individual agencies to organize and store their knowledge. It was found that in many of those agencies, very little had been written on preparedness and operational plans for contingency conditions, and the retirement of those experts meant that their knowledge was lost. However, some agencies developed very good manuals of procedures to cope with that situation, but again, most of them are restricted to cases of equipment failure.

The authors' particular interests at their corresponding agencies match those of SECTRAN/RJ, that is, structuring and supervising the development of a research methodology for the improvement of contingency transportation planning, which includes adoption of expert systems technology.

Nevertheless, even if adequate expert systems software will provide reasonable advice during consultation sessions for decision makers, make their work easier and more reliable, and reduce the risk of human failure, the applicability of such proposed expert systems strongly depends upon the completion of a preliminary phase of the research: the proper coordination among experts of the agencies and operators involved.

Fortunately, experts are available at most of those agencies. Despite the fact that there is usually one expert for a small part of the entire task at a particular agency or operator, which means that an extensive information collection task will be required, an in-house team at the central agency is organizing procedures for interviewing the experts, to prevent routine problems from being disregarded in the contingency plans.

RESEARCH PHASES AND CURRENT STATUS

As shown in Figure 3, the research is composed of three main phases.

Phase I has three activities. In Activity 1.1, basic criteria were developed at SECTRAN/RJ to identify what conditions should be of interest for contingency planning. In Activity 1.2, preliminary work was taken in order to identify what agencies should be involved in the contingency planning process and how to establish communication and coordination among them. It had already been determined that for many of the potential conditions that characterize a contingency situation and that may require mobilization of the transportation system, several non-transportation-related agencies must also be involved in the research and in the planning process as well. This caused considerable expansion of Activity 1.2, the current status of the research. In Activity 1.3, the basic criteria developed in Activity 1.1 will be reviewed and adjusted to the particular conditions of individual agencies. Then the alternatives of action that must be considered in any particular contingency condition will be selected. As the work progresses, at least two university research centers will be incorporated into the project. It is important to note that one set of procedures or actions will be considered for issues or problems restricted to each individual agency or operator and other sets for issues or problems related to one or more agencies or operators.

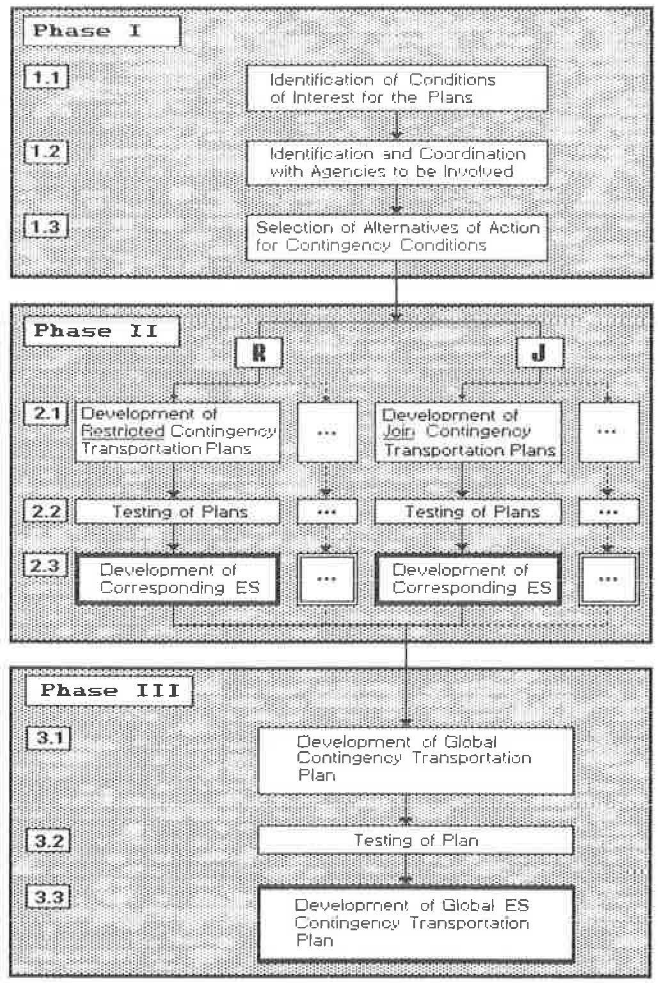

FIGURE 3 Phases of research.

Phase II has three types of activities. Activity 2.1 corresponds to the development of the Contingency Transportation Plan and Activity 2.2 to the testing of the plans. As a particular plan is tested, the corresponding expert system will be developed (Activity 2.3). However, there may be as many restricted plans and their corresponding expert systems, which individual agencies will have identified in Activity 1.3, as there are joint plans and their corresponding expert systems, which the research will also have identified in Activity 1.3.

Phase III differs from Phase II only in that rather than developing restricted or joint plans and expert systems, the coordination of those plans will be established and a Global Contingency Transportation Plan will be developed and tested, followed by development and testing of the Global Expert Systems Contingency Transportation Plan.

CONCLUSIONS

The current status of contingency transportation planning addressed by SECTRAN/RJ focuses on the replacement of individual action taken under contingency conditions by agencies and operators by an organized methodology and the contribution of the expert systems technology.

There are still many difficulties to cope with until the development of expert systems can take place in the process. A research approach, based on the key word "preparedness," was scheduled by SECTRAN/RJ, particularly at CETEC.

The research will lead managers and decision makers to contribute their expertise in the development of a lasting methodology for contingency planning by which their knowledge will be preserved. The final product of the research is likely to be very useful to the users and practitioners of transportation in operations, especially those who have to make decisions on how to recover service under the critical conditions of a contingency. The results will also serve for training new managers and decision makers in the field.

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