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Problems of Hazardous Materials Transport in Texas and the Potential Applicability of ITS Solutions

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16. Abstract

This report considers the application of intelligent transportation systems (ITS) technologies for problems associated with the transport of hazardous materials. For the most part, previous research linking ITS technologies and hazardous materials transport has focused mainly on integrating these technologies into commercial vehicle operations (CVO). This report takes a different approach by focusing on local institutions and processes that are involved in preparing for and responding to hazardous materials incidents. The objective of this approach is to inform decision makers about the utility of ITS technologies in the local environment, rather than limiting them to the transport vehicle itself. This report reveals that the focus on the vehicle ignores important considerations and potential applications for ITS technology at the local level regarding the potential impact of hazardous materials through Texas communities.

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SUMMARY

This report considers the application of intelligent transportation systems (ITS) technologies for problems associated with the transport of hazardous materials. For the most part, previous research linking ITS technologies and hazardous materials transport has focused mainly on integrating these technologies into commercial vehicle operations (CVO). This report takes a different approach by focusing on local institutions and processes that are involved in preparing for and responding to hazardous materials incidents. The objective of this approach is to inform decision makers about the utility of ITS technologies in the local environment, rather than limiting them to the transport vehicle itself. This report reveals that the focus on the vehicle ignores important considerations and potential applications for ITS technology at the local level regarding the potential impact of hazardous materials through Texas communities.

Chapter 1 presents a discussion of the general issues and problems associated with the transport of hazardous material. Chapter 2 briefly reviews previous research on hazardous materials transport in general, ITS and commercial vehicle operations, and ITS applications specifically for the transport of hazardous materials. Chapter 3 discusses the responsibilities for hazardous materials compliance and incident response of the various local, state, and federal agencies. Three case studies of Texas communities and their hazardous materials incident response plans are presented in Chapter 4. Chapter 5 presents the findings and recommendations from this study.

The findings from this study show first that previous research on ITS applications for the transport of hazardous materials is primarily focused on post-incident applications and route selection applications. Most of the studies focus on commercial vehicle applications. Little work has been done on shipment tracking and monitoring for public safety, or on pre-incident applications. The rationale for this focus is that pre-incident applications are too costly for the trucking company to assume. The researchers also find that, based on the three-city review of incident response plans, there are many potential incident response participants and agencies for which ITS-derived information would be of value.

Recommendations found in this report can be summarized as follows:

- Consider integrating ITS/haz mat applications into larger programs for community safety.
- Certain types of hazardous cargo can be tracked on an ongoing basis in order to reduce the risk to communities through which these shipments go on a recurring basis.
- A statewide survey should be conducted focusing on public perception of risk from the transport of hazardous materials.
- Research should be encouraged and supported that goes beyond both traditional cost-benefit analyses and the CVO perspective of linking ITS technologies with the transport of hazardous materials.
- The difficult issue of shifting the perspective of the ITS community from an economic focus to a public safety focus regarding the transport of hazardous materials needs to be addressed within state and local agencies.
- Local hazard incident response plans need to reflect unique characteristics and vulnerabilities of these communities. ITS applications can be integrated into existing plans, most readily for post-incident response and management.
- State-level ITS plans need to reflect the importance of, and potential risk to the public from, transporting hazardous materials on Texas roadways.

CHAPTER 1. HAZARDOUS MATERIALS TRANSPORT

On February 11, 1998, the chemical hydrogen fluoride, or hydrofluoric acid, was expelled into the air as a result of a late night accident on Interstate 10, near Sonora, Texas, in which the driver of the 18-wheel rig lost control. Breathing hydrogen fluoride vapors can be fatal, and 10 families in the immediate vicinity of the accident were evacuated. The cleanup process closed the interstate for three days, resulting in the re-routing of traffic off the interstate and through small adjacent communities ill-equipped to handle the increased levels of traffic congestion. The detour covered 160 kilometers (100 miles) of back roads and two-lane highways without shoulders. An estimated 5,600 vehicles pass along I-10 at this point every 24 hours. The truck carrying the hazardous cargo was owned and operated by DuPont, who then upheld the responsibility for cleaning up the material (Herrick 1998).

In December 1997, three trucks arrived at a Nevada Test Site carrying leaking low-level nuclear waste containers. Although no material leaked out of the trucks, the incident prompted the suspension of over-the-road shipments of nuclear waste in the types of containers identified in the incident. The incident also spawned renewed protests in the area against the Yucca Mountain national nuclear waste dump, as well as concern over the route taken by the transport of nuclear waste in the area, which takes trucks over Hoover Dam and through Las Vegas (Schulz 1998).

In 1995, an article in the Houston Chronicle citing potential problems with Mexican trucks crossing the international border as a result of NAFTA-induced trade stated that there were:

> ". . . 5000 Mexican trucks already crossing the border into Texas every day, carrying everything from televisions to corrosives, chemicals, explosives, jet fuels, toxic wastes and pesticides. But only one in 10 of the trucks are inspected, and only one in four of those meets Texas safety and insurance standards" (Beachy 1995).

These examples involving the transport of hazardous materials illustrate their significant potential danger to the general public. Much like the dramatic crashes of airplanes, however, the occurrences of hazardous materials transport accidents are relatively rare considering their constant presence on the roadways. When an incident does occur the impact can be significant to those living in the immediate area, and to the environment in general.

One group of technologies recommended for mitigating these hazards and reducing the risks associated with hazardous materials transport are intelligent transportation systems (ITS) technologies. For the most part, previous research linking ITS technologies and hazardous materials transport has focused mainly on integrating these technologies into commercial vehicle operations (CVO). This report takes a different approach by focusing on local institutions and processes that are involved in preparing for and responding to hazardous materials incidents. The objective of this approach is to inform decision makers about the utility of ITS technologies in the local environment, rather than limiting them to the transport vehicle itself. It is the position of this report that the focus on the vehicle ignores important considerations and potential applications for ITS technology at the local level regarding the potential impact of hazardous materials through Texas communities.

The purpose of this chapter is to first introduce general definitions, characteristics, and perceptions of hazardous materials transport. The impact of hazardous materials transport on the state of Texas is then discussed. Previous state and national ITS plans are reviewed regarding the integration of hazardous materials transport projects into the broader perspectives on ITS. Finally, the relevance of this current report to TxDOT's ITS deployment strategy and the larger, national ITS plan, is then considered.

1.1 HAZARDOUS MATERIALS TRANSPORT: DEFINITIONS, CHARACTERISTICS, PROBLEMS, AND PERCEPTIONS

The Transportation Research Board (TRB) estimated that between 10,000 and 20,000 truck transportation incidents occur each year resulting in the release, or potential release, of hazardous materials (TRB 1993). The shipment of hazardous materials is regulated under the Hazardous Materials Transportation Uniform Safety Act of 1990 which defines a hazardous material as "a substance or material in a quantity or form that may pose an unreasonable risk to health, safety, or property when transported in commerce" (CFR 49; TRB 1993). Examples include: petroleum products; agricultural chemicals, pesticides and fertilizers; explosives; manufacturing and refining acids and gasses; consumer products; and hazardous wastes and materials and infectious substances. The "Table of Hazardous Materials Classes" is shown in Table 1. These products are shipped in bulk, in tank trucks holding between 200 and 1,000 gallons, in intermodal tanks holding up to 5,000 gallons which can be carried on flatbed trucks, or as nonbulk shipments with other materials (TRB 1993).

By far, most reported incidents involving hazardous materials involve truck transport on highways. In 1997, for example, of the almost 14,000 hazardous materials incidents reported, 11,794 were highway related. Five were by water, 1,015 were by air, and 1099 involved railways. The cause of the highway-related incidents are as follows: 9,828 by human error, 1,509 by package failure, 253 by vehicle accident, and 160 were caused by other means. The majority of incidents involving hazardous waste material are also attributable to highway modes of transportation. Of the 457 hazardous waste incidents reported in 1997, 377 of them were highway-related (RSPA 1998).

A key element in any ITS technology or application is data, or information, just as it is in the transport of hazardous materials. The communication of hazard material shipping information is accomplished through four mediums: shipping papers, labels, markings, and placards. Shipping papers are the primary record of transport and storage and must be accessible within the drivers' compartment at all times. Information on the shipping papers will include the following:

- Proper shipping name of the material;
- Hazard class or division number;
- Identification number (according to the Hazardous Materials Table); and
- Total quantity being shipped.

Table 1. Hazard Class and Divisions with Example Materials

HAZARD CLASS AND DIVISION	NAME OF CLASS AND DIVISION	DEFINITION REFERENCE (49 CFR)	EXAMPLES	BRIEF DESCRIPTION OF HAZARD
1.1	Explosives	173.50(b)(1)	Black powder	Mass explosion
1.2	Explosives	173.50(b)(2)	Rocket motors	Projection hazard
1.3	Explosives	173.50(b)(3)	Fireworks, Type C	Fire with minor blast or projection
1.4	Explosives	173.50(b)(4)	Squibs	Devices with minor explosion hazard
1.5	Explosives	173.50(b)(5)	Water gels	Insensitive article bus mass explosion
1.6	Explosives	173.50(b)(6)		Insensitive article/no mass explosion
2.1	Flammable Gas	173.115(a)	Propane	
2.2	Nonflammable Compressed Gas	173.115(a)	Compressed oxygen	Contents under pressure
2.3	Poison Gas	173.115(b)	Chlorine	
3	Flammable Liquid	173.115(c)	Acetone, paint	Flash point equal to or less than 60.5°C
	Combustible Liquid	173.120(b)	Diesel	Flash point between 60.5°C and 93°C
4.1	Flammable Solid	173.124(a)	Safety matches	Readily combustible, self-reactive
4.2	Spontaneously Combustible	173.124(b)	Wet cotton	Self-heating materials, ignite or heat when exposed to air
4.3	Dangerous When Wet	173.124(c)	Calcium carbide	Reacts with water to yield flammable or toxic gas or becomes combustible
5.1	Oxidizer	173.127(a)	Potassium bromate	Yield oxygen and fire potential
5.2	Organic Peroxide	173.128(a)	Peroxyacetic acid	Thermally unstable, burns rapidly, sensitive to impact
6.1	Poisonous Material	173.132(a)	Parathion liquid	Toxic to humans
6.2	Infectious	173.134(a)	Virus culture	
7	Radioactive	173.403	Uranium-233	Specific activity levels
8	Corrosive	173.136(a)	Caustic soda	Damages skin on contact or corrodes metal

Table 1. Hazard Class and Divisions with Example Materials, continued

9	Miscellaneous	174.140(a)	Molten sulfur	Causes oxygen deprivation
ORM-D	Not Applicable	173.144	Consumer commodity	Reclassification exception

Source: Transportation Research Board (TRB 1993).

Additional descriptive information may be required, according to the type of material being shipped and by what mode. The shipper's certification is also noted on the shipping papers, which establishes the shipper as the responsible party in the event of an incident. Individual containers must also be marked, as required by 49 CFR and USDOT, and will include information about the shipment. Labels are also required, which specify the proper handling and storage requirements. Placarding is, perhaps, the most visible information regarding the type of material. These are the 273 cm by 273 cm (10 inch by 10 inch) signs that are displayed on the truck and provide immediate hazard class information on the contents of the hazardous materials being shipped (Cropp and McMillan 1993). These mediums provide a significant amount of immediate information on the shipment of hazardous materials.

An examination of the literature focusing on hazardous materials transport presents a wide variety of issues and problems. General problems that have been identified include:

- Lack of information and poor records management;
- Improper, misleading, or missing placarding;
- Regulatory problems and too few inspectors;
- Conflict over the proper jurisdiction for enforcement (state or federal);
- Too little research;
- Too much reliance on industry to regulate itself;
- Lack of local information on what is passing through on the roadway;
- Complexity of haz mat compliance; and
- Difficulty in tracking shipments (Elder 1993; Hoffman 1994; Long 1989; Parrish 1992; Weart 1998).

While the definitions and characteristics of hazardous materials are well documented and defined, the public perceptions of these materials are not nearly so well defined, particularly in regard to the risks involved (Oakes and McBeth 1997-98). As illustrated by the examples presented at the beginning of this chapter, transporting hazardous materials, and related incidents, can evoke significant public outcry. A recent study on hazardous materials transport risk perception found that people do make distinctions between different types of hazardous materials and the perceived risks involved in transporting these materials (Jenkins-Smith, et al. 1996). For example, there was a higher risk assumed for the transport of spent nuclear fuel over that posed by medical-related radioactive material. The study recommended that those designing and implementing hazardous materials transport programs be aware of these perceptions and make sure that the program intent is clear as to the type of material being transported and that all known risks made public. This issue of perception will be revisited later in this report and in the final recommendations.

1.2 HAZARDOUS MATERIALS TRANSPORT AND TEXAS

The Sonora spill described above is only one example of the real and potential danger to the citizens of the state of Texas from the transport of hazardous materials. Two other situations in the state are drawing attention to the problems of hazardous materials transport: the proposed, and now rejected, nuclear waste disposal facility site in West Texas, and the broader issues of Texas-Mexico border transportation, the North American Free Trade Agreement (NAFTA), and transborder shipments of hazardous materials.

After four years of review, the Texas Natural Resources Conservation Commission (TNRCC) ruled that a proposed site in West Texas was unsuitable for the disposal of low level radioactive waste (Gonzalez 1998). Intense local, state, national, and international opposition and support raised awareness of this proposed facility and the related issue of hazardous materials transport in the State. The small community of Sierra Blanca, in Hudspeth County, near El Paso, narrowly missed being the recipient of nuclear waste shipped from Maine, Vermont, and New York. The waste was to consist of dry, low-radioactive material, such as medical tools and equipment, and would have been shipped by truck in special containers. The prospects of receiving shipments from over 3220 kilometers (2000 miles) away has generated significant controversy in the state (Hershey 1998; Klein 1998). Figure 1 illustrates the proposed radioactive waste transport routes that would have terminated at the Sierra Blanca facility.

The second situation of concern is the impact of NAFTA and the transborder shipment of hazardous materials. Two related concerns have been expressed: potential problems with Mexican trucks operating on Texas and U.S. highways, and the transborder shipment of hazardous wastes from maquiladora plants operating in Mexico. One of the provisions of NAFTA was that the southern U.S. border was to be opened for commercial trucking after December 17, 1995. Although the borders have yet to be completely opened, this potential event stirred considerable controversy over issues of safety, regulation, registration, and infrastructure (ITS RCE 1997). From the haz mat transport perspective, the opening of the U.S.-Mexico border suggested, to many, the dangerous presence of unsafe Mexican trucks carrying undocumented hazardous materials into the state. Although this is the worst-case scenario, the issue has yet to be settled and this vivid image still persists.

Many of the more than 1,800 maquiladora plants along the southern border are owned by U.S. companies such as Ford and IBM who contribute a significant amount of foreign capital to the Mexican economy. Hazardous wastes generated by these maquiladora plants in Mexico must be exported back to the United States according to special international provisions that require the return of these materials to the country of origin of the raw materials used in the production process. The procedures for transporting maquiladora-produced waste rely on a complex tracking system based on the written shipment manifest. Negative impacts of this program that are frequently cited, however, are the environmental degradation that has occurred along the border and the inherent dangers involved in shipping waste back across into the United States (Engfer et al.1991; Rappoport 1993).

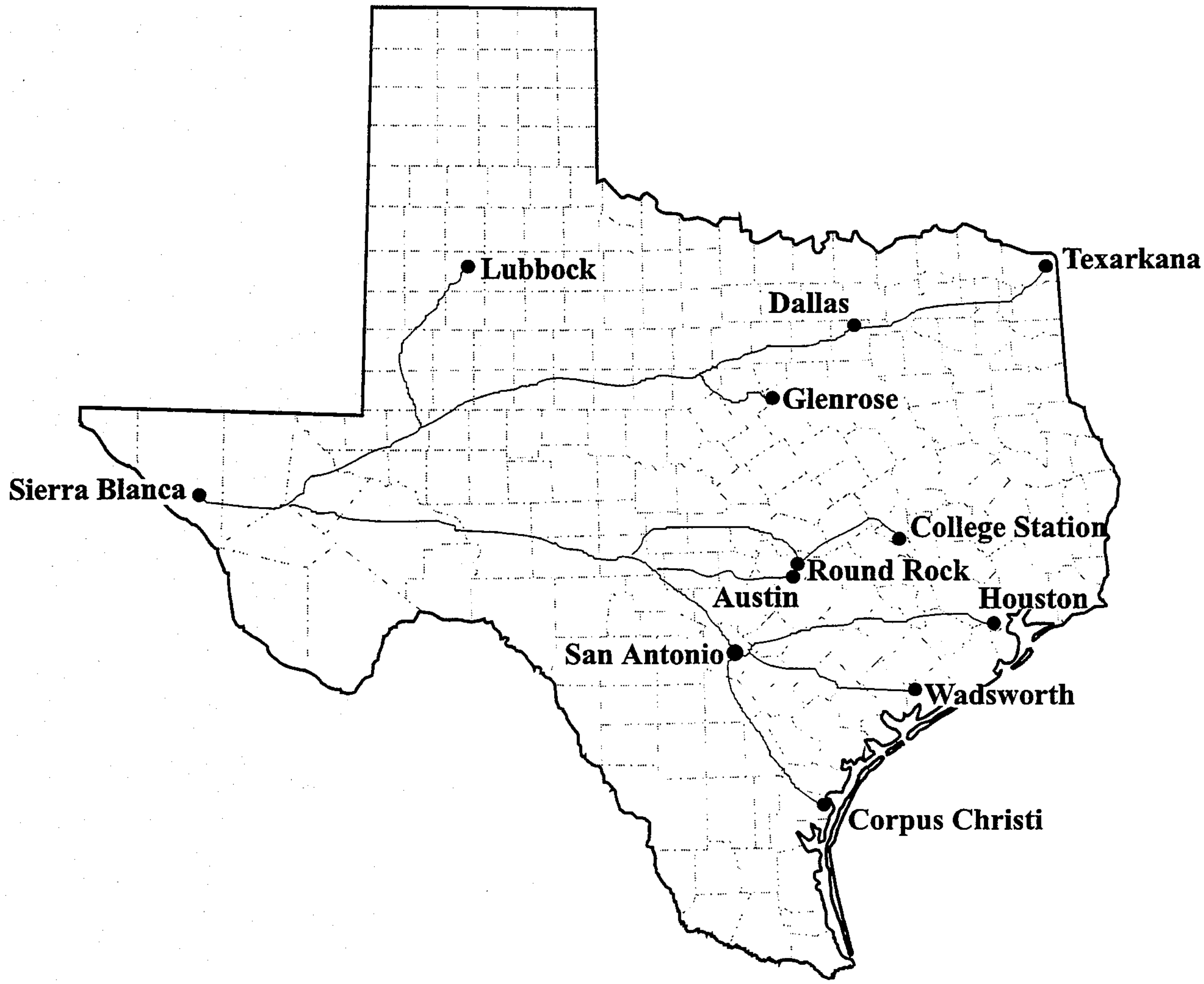

Figure 1. Texas Highway Routing for Waste Generators

1.3 HAZARDOUS MATERIALS TRANSPORT AND ITS PLANS

Considering the issues raised in the previous sections, how have hazardous materials transport been integrated into ITS plans? Several major ITS planning initiatives have been developed over the past few years and are reviewed here. At the national level, ITS America has been at the forefront of plan development. At the state level, too, ITS strategies and plans have been developed. This section looks at how haz mat transport issues have been integrated into these planning initiatives.

In 1992, the Intelligent Vehicle-Highway Society of America (IVHS America) published their *Strategic Plan of IVHS in the United States* (IVHS America 1992a). This document was prepared at the request of the United States Department of Transportation (USDOT) in order to satisfy a congressional mandate for an IVHS plan. The purpose of the plan was to establish national IVHS goals, identify challenges, and outline a course of action for IVHS deployment and testing. Five functional areas were identified:

- Advanced Traffic Management Systems (ATMS)
- Advanced Traveler Information Systems (ATIS)
- Advanced Vehicle Control Systems (AVCS)
- Commercial Vehicle Operations (CVO)
- Advanced Public Transportation Systems (APTS)

The issue of hazardous materials transport is not addressed in the Executive Summary of the plan, and the CVO functional area description is limited to a brief summary of the benefits of automated toll collection technology and automated vehicle identification (AVI) systems. In the document text regarding CVO applications, however, the applicability for hazardous materials transport is recognized under the heading of "Hazardous Materials Information Systems," which describes electronic HAZMAT tracking technologies that could be used for incident response purposes. "Automated Mayday Capabilities," or the use of technology to monitor emergency situations onboard commercial vehicles, could also be used for hazardous materials transport purposes. At the time of the plan, no hazmat-specific tests or deployments were listed (IVHS America 1992a).

The IVHS Society of America strategic plan was integrated into the *Federal IVHS Program Recommendations for Fiscal Years 1994 and 1995*, prepared, again, at the request of USDOT. The recommendations are divided into research and development and operational test categories, and prioritized within these categories. One hundred and four overall projects are listed according to their priority within the research and development category. Of these, the highest ranked CVO project was number 60, "Hazmat Communication System Testbed," which would have integrated hazmat and emergency responder data research into existing CVO deployment projects. Of the 19 overall operation test priorities listed, no hazmat-related projects were included (IVHS 1992b).

Further development of national ITS plans is found in the "National ITS Program Plan," prepared by ITS America with funding from the USDOT (ITS America 1995). Organized around 29 user services identified through the development of the plan, hazardous materials transport applications can be found in several sections of the plan, including incident management and CVO. The User Service Development Plan for CVO includes the "Hazardous Materials Incident Response" system, which outlines potential ITS applications for providing information on hazardous materials to emergency response personnel following an incident. The focus in this user service area is post-incident, rather than tracking potentially dangerous shipments (ITS America 1995).

At the state level, the Texas Department of Transportation (TxDOT) recently developed an ITS deployment strategy (TTI 1996). While it does not specifically address the issue of hazardous materials transport, it does include two emphasis areas—incident management and smart emergency services—that relate to this issue. Both of these emphasis areas would include ITS/ hazardous materials for incident response only, not for any regulatory or tracking purposes. Hazardous materials transport is considered, in particular, in the "Draft Deployment Priorities" section of the strategy plan. For example, under commercial vehicle operations, hazardous material incident response is included as a potential ITS application, although the report states that "technologies are not sufficiently mature at this time to establish whether deployment can be realistically expected in the near future" (TTI 1996).

1.4 SUMMARY

In summary, the state and national IVHS/ITS plans reviewed here include hazardous materials transport issues and ITS to a limited extent. This is understandable, considering the large number of competing technologies and interested participants in the overall area of ITS. The primary focus of these plans is on applying ITS technologies following an incident or spill in order to provide specific shipment information and characteristics to response personnel. In other words, ITS technologies could be used as high-tech placarding systems, yet this would be little improvement considering that the existing placarding system is often misleading to emergency responders (Elder 1993). The issues raised in this section regarding the impact of hazardous materials transport on the state of Texas, whether from NAFTA-induced trade or the approval of a new radioactive disposal site in West Texas, should provoke discussion and study.

One of the objectives of this report is to address this issue from the local perspective in order to determine whether other, pre-incident, ITS applications are desirable and feasible for reducing the risk from hazardous materials incidents and should be considered by TxDOT for further study and development. This report will complement existing ITS plans and research by presenting a bottom-up perspective on hazardous materials transport through the evaluation of local plans and processes. The following chapter reviews previous research linking ITS technologies with hazardous materials transport. Chapter 3 discusses the responsibilities for hazardous materials compliance and incident response of the various local, state, and federal agencies. The three case studies of Texas communities are presented in Chapter 4. Chapter 5 concludes the report and offers recommendations based on the case study findings.

CHAPTER 2. PREVIOUS HAZ MAT RESEARCH

This chapter focuses on previous studies related to the issues of hazardous materials transport and is divided into three sections. Section 1 reviews the issue of hazardous materials transport, in general. Section 2 reviews general studies of ITS applications for commercial vehicle operations (CVO). Section 3 links these through a review of previous studies of ITS applications specifically for hazardous materials transport. Additional detailed information on these references can be found in the Annotated Bibliography in the Appendix of this report.

2.1 HAZ MAT TRANSPORT IN GENERAL

The transportation research community has focused attention on several main issues of hazardous materials transport, including truck routing, planning and emergency management, and case studies of specific sites with significant hazardous materials transport presence. In addition to its Special Report on hazardous materials shipment information (TRB 1993), the Transportation Research Board has traditionally been responsible for publishing much of this research (see its *Transportation Research Records* 977,1020, and 1264, for example). This section briefly reviews some of these relevant studies.

Saccomano and Chan conducted a cost-benefit analysis comparing three routing strategies—minimizing truck operation costs, minimizing accident likelihood, and minimizing objective risk exposure—and determined that while a minimum risk strategy could be implemented, it would result in significant increases in truck operating expenses. Their study was based on an assumption that minimum risk routes might be more circuitous and, therefore, more costly to the trucking industry (Saccomanno and Chan 1985). Nuclear waste shipment routing is also a consideration in the study conducted by Abkowitz et al. (1990) for their impact analysis of nuclear waste site disposal facility location. Their study focuses on the design of a transportation management information and analysis system for the state of Nevada. The capability to analyze route alternatives depending on transportation systems operations and shipment characteristics was an integral component of the system. The general purpose of the study was to develop a system that could be used by policy and decision makers in Nevada.

Other studies have focused on the general characteristics of hazardous materials transport in specific locales for purposes of planning and emergency management. Gorys' study of dangerous goods transport in Ontario, Canada, is an example of this approach (Gorys 1990). The purpose of the Ontario study was to document the general issue of hazardous goods transport in the area, define the concerns, and document the incidents. The study also lists actions taken by the local government and shippers in response to public concern. These actions include reduced speeds in certain areas, designation of dangerous goods routes, and additional planning and training. In his conclusions, the author contends that if the general public still considers the risks too high, further actions would need to consider the larger economic, societal, and environmental costs of additional action.

Similar studies have been conducted in Texas, particularly in Brownsville and Laredo, both Texas-Mexico border communities. The Brownsville study represents the results of a Hazardous Materials Commodity Flow Study conducted in 1994 and 1995. The objective of the study was to describe hazardous materials transport activities in the Brownsville area and identify the related risks to the public from these activities. The need to prepare such a report was based on the recognition of the lack of information on these activities, the perceived risks to the general public, and to enhance emergency management activities. The surveys conducted of truck shipments in Cameron County, Texas, and at the International Bridges in the area revealed seven major concerns for the community:

- <u>Overloading</u>. Eighty-nine percent of observed trucks entering the United States through international bridges were overweight.
- <u>Improper Placarding</u>. Only 40 percent of those vehicles displaying placards had the proper placard displayed. Many had no placards, while some vehicles not carrying hazardous materials were displaying placards.
- <u>Unsafe Vehicles</u>. Many vehicles observed were poorly maintained with worn tires, no lights, and faulty brake systems.
- <u>Non-Spec Containers</u>. The survey observed many leaking containers and poorly patched containers.

- Improper Manifesting. Sixty-six percent of the drivers presented improper manifests, and most of these did not include the required Materials Safety Data Sheet.
- Insufficient Insurance. Over half the trucks surveyed carried less than the required amount of insurance to be hauling hazardous materials.
- Drivers Licenses. Few of the Mexican drivers had the necessary driver's permit to transport hazardous materials (Code 3, Inc. 1995a).

A similar study was conducted in Laredo, Texas, which includes more detail and recommendations for increased compliance and enhanced emergency preparedness (Code 3, Inc. 1995b). The report, prepared for the city of Laredo and its Local Emergency Planning Committee, estimates the volume of hazardous and non-hazardous materials being shipped in the city, and provides information for hazardous materials routing. Many problems similar to those identified in the Brownsville study were also identified in Laredo. The recommendations presented in the study included:

- Place Haz-Mat Inspectors at the Bridges. This would reduce the non-compliance of drivers and trucks.
- Increase Enforcement of the City's Hazardous Materials Management Permit.
- Provide Compliance Training Opportunities.
- Evaluate Current Transportation Routes Used of Commodity Transportation. The study found that hazardous materials were being transported throughout the city, including through densely populated areas.

Also of interest to this report is the study conducted by Ashur et al. (1996), which attempts to develop a risk assessment model of transborder hazardous waste shipments between the U.S. and Mexico. Based on data from the United States Environmental Protection Agency (USEPA), their study points out the significant risk associated with transborder shipments of two kinds of waste: 1) raw materials transport from the U.S. to Mexico in support of the manufacturing process, and 2) shipments of hazardous waste back into the U.S. as a result of the maquiladora manufacturing process.

The studies reviewed here are illustrative of the growing body of research devoted to the transport of hazardous materials. The next section looks at how ITS has been linked to trucking, in general.

2.2 CVO AND ITS IN GENERAL

The previous section outlined several routing, planning, and site-specific studies. One of the commonalities in these reports is the emphasis on trucking as the most common mode of transporting hazardous materials. Considering the prominence of this mode, it is necessary to place the role of commercial vehicles and ITS technologies in perspective. This section briefly examines the prominent elements of ITS technology as it relates to CVO. For example, the *National ITS Program* Plan lists 29 ITS user services, compiled into seven bundles (see Table 2). Included in the CVO bundle, in addition to hazardous materials incident response, are such services as electronic clearance and automated inspection services (ITS America 1995).

Recent examples of the types of CVO/ITS research being conducted include the following:

- Electronic Clearance. ITS technologies are often recommended for use in the CVO area as a means of increasing compliance of regulations. Electronic clearance can also enhance transparent border projects as compliant trucks can by-pass the time-consuming clearance processes at borders (Titus 1996).
- Electronic Screening. The electronic clearance concept has also been integrated into corridor applications, such as the I-35 NAFTA corridor concept. ITS technology situated along the Texas-to-Minnesota corridor could reduce the time spent in weigh station queues, and also reduce fuel consumption (Maze et al. 1998).
- Real Time CVO Decision Making. From the user perspective, ITS technology has been suggested as a means of making real time decisions for commercial fleet operators. The benefits in this application are reduced costs related to dispatching and service quality improvements (Regan, Mahmassani, and Jaillet 1996).

Table 2. ITS Bundles and User Services

BUNDLE	USER SERVICES
1. Travel and Transportation Management	1. En route Driver Information 2. Route Guidance 3. Traveler Services Information 4. Traffic Control 5. Incident Management 6. Emissions Testing and Mitigation
2. Travel Demand Management	1. Demand Management and Operations 2. Pre-Trip Travel Information 3. Ride Matching and Reservation
3. Public Transportation Operations	1. Public Transportation Management 2. En route Transit Information 3. Personalized Public Transit 4. Public Travel Security
4. Electronic Payment	1. Electronic Payment Services
5. Commercial Vehicle Operations	1. Commercial Vehicle Electronic Clearance 2. Automated Roadside Safety Inspection 3. Onboard Safety Monitoring 4. Commercial Vehicle Administrative Processes 5. Hazardous Materials Incident Response 6. Freight Mobility
6. Emergency Management	1. Emergency Notification and Personal Security 2. Emergency Vehicle Management
7. Advanced Vehicle Control and Safety Systems	1. Longitudinal Collision Avoidance 2. Lateral Collision Avoidance 3. Intersection Collision Avoidance 4. Vision Enhancement for Crash Avoidance 5. Safety Readiness 6. Restraint Deployment 7. Automated Highway System

These examples represent only a small sample of the research conducted on applying ITS technology in the commercial trucking environment. However, they adequately represent the general focus areas under consideration in this area.

2.3 ITS AND HAZ MAT

How has previous research linked ITS with problems of transporting hazardous materials? This section provides a brief overview of some of the relevant studies in this area. Allen, early on identified potential applications of ITS technologies for the improvement of emergency preparedness and response, and regulatory enforcement of hazardous materials transport rules (1991). He recommended linking general CVO ITS applications, such as automatic vehicle location and onboard computing, to hazardous materials transport issues and identified four possible areas for applying ITS technology: electronic placarding, real time tracking, electronic manifests, and smart package or container. He also recognized that many institutional barriers would have to be overcome to implement these systems, yet they all showed promise in increasing the efficiency of hazardous materials incident response and regulation.

Turnquist (1991) also provides an early consideration of the potential for ITS applications for hazardous materials transport, particularly in the dynamic rerouting of shipments. Using real-time location of hypothetical shipments, he illustrates two possible applications, rerouting to minimize risk, and rerouting in response to an incident en route. While preliminary, this brief study develops a useful framework for designing and implementing hazardous materials and ITS linkages.

Several studies in Europe also contribute to our knowledge of ITS and hazardous materials transport. In particular, the ARTIS-7 project in Spain focuses on developing and testing a hazardous goods transport monitoring system. The system linked a traffic management center with Smart Card facilities and emergency services centers in order to track hazardous materials shipments, and to provide reliable information in the event of an accident. Telecommunications problems, with phone lines and satellite linkages, posed problems for the test, however, the basic system design shows applicability to other areas (Poveda 1994).

The FRAME Consortium in Belgium studied the integration of total quality management principles with hazardous goods monitoring for the purpose of evaluating the role of administrative entities in transport logistics (FRAME 1994). FRAME considers the hazardous materials monitoring system to be basically a systems architecture problem which can be solved through data management. This study points out the importance of data availability from all participants in the transport system. Another European project, PORTICO, also focuses on data management and traffic management in the transport of hazardous goods. Findings from this study suggest that costs of designing and implementing an ITS/hazardous materials system are prohibitive for many of the participants, yet with the increased use of onboard computer and telecommunications devices, it is foreseeable that hazardous cargo information could be integrated into these systems in the near future (Nailer and Queree 1993; Percival and Monteiro 1994).

Two more recent studies in the United States also focus on hazardous materials transport issues. First, the Tranzit *Xpress* system developed by the Federal Highway Administration and PennDOT is a vehicle fleet management and data management system aimed at improving hazardous material transport safety. The system includes three major components: the operations center, on-vehicle systems, and off-vehicle systems. The evaluation of the system was generally positive, however it revealed considerable differences in perceptions of system utility by incident responders and motor carriers. Responders were more favorable to a system that provided them with reliable information more rapidly, while motor carriers were concerned over increased costs of incident management if more information was made available in the event of an incident. Some carriers did not report certain incidents if they felt they could manage the problem themselves, without involving others (Goulias and Alam 1997).

Calvo et al. (1997), conducted a recent study on information technology and emergency response. The study identifies three categories of first responder information: identification of the hazardous materials incident, identification of the cargo or commodity involved, and identification of any specific risks involved with the cargo or commodity. The study suggests that each of these categories implies certain levels of practical technology. The study concludes that the most practical technological applications are those that provide communities with centralized response data. This data would be available from sources like CHEMTREC, and would be made available after an incident. The study does not consider the tracking of each individual shipment to be practical or feasible.

The previously mentioned TRB Special Report (TRB 1993) on hazardous materials shipment information includes a brief look at information technologies. The report identifies four information technology categories that could be applied to hazardous materials transport:

- Electronic Data Interchange. EDI, as a general systems concept, refers to the electronic exchange of information. This could be applied for transmitting shipment information between shipper, regulator, and response personnel.
- Shipment Tracking. These systems track packages and shipments and provide current information as to their location. As cargo passes checkpoints en route, location information can be relayed to shippers, for example. The rail industry uses this system for locating and tracking rail cars.
- Automatic Electronic Identification. AEI relies on transponder technology to identify and provide information on specific containers or shipments. The transponders could be used to transmit hazardous materials codes as they pass checkpoints along pre-determined routes.
- Geographic Positioning Systems. GPS technology has been applied in the tracking of radioactive materials shipments by the Department of Energy. This technology uses satellite communication technology, yet has not been used to provide much more than location-specific information. Additional information, such as cargo and materials characteristics, could be included but at significantly greater costs (TRB 1993).

The studies all identify similar problems with linking ITS solutions to hazardous materials transport. Primary among these is the cost of design and implementation of an integrated system that would provide information to regulators and responders. Further, the large number of participants involved in hazardous materials regulation and emergency response magnifies the number of institutions that would require access to the data on a regular basis, thus increasing the overall costs. The studies also show how the variety of technology — phone versus satellite communications, for example — can be applied in various situations. Other problems that are identified include the proprietary nature of the shipping data, the freedom of movement of trucks versus rail, and cooperation problems between fleet owner and traffic management centers.

2.4 SUMMARY

This chapter, and the previous one, paint a fairly complete picture of how ITS technology has been considered for applying to hazardous materials transport. Several observations can be made at this point:

- ITS, for hazardous materials transport applications, is most often associated with CVO applications of ITS technology, with some integration into incident management and safety applications. This assumes that a considerable amount of the responsibility for technology integration will be borne by the private sector.
- Most of the studies focus on post-incident applications for ITS, such as for providing responders with information regarding hazardous contents. Applying ITS technologies for incident preparedness is rarely considered.
- Route optimization applications of ITS technology is typically seen as determining the function of risk versus cost to the transport operator. In these cases, the cost to the operator is seen as a greater burden than the risk to a community.
- While the review presented here is not a definitive comparison between European and American approaches to integrating ITS into hazardous materials transport, the observation can be made that, in general, the European projects take a more systematic approach, in that they focus on tracking and monitoring hazardous shipments through a system. These have considerable applications for local preparedness and response.

These issues raise questions for further consideration and when linked to the significant impact that hazardous materials transport has on the state of Texas, suggest that there is potential for ITS applications in this state.

CHAPTER 3. RESPONSIBILITIES

Transporting hazardous cargoes of all kinds presents significant potential danger to transportation system users and residents in the immediate area. In general, a lack of training, materials, and compliance can all impact the local ability for incident response. The responsibilities for hazardous materials transport are delegated to a wide and diverse range of agencies and institutions. This chapter briefly outlines the institutional responsibilities for hazardous materials response, which will be further elaborated upon through our case studies of community preparedness in the following chapter.

From the local perspective, in the event of a hazardous materials incident, one of the first agencies contacted, beyond local authorities, is CHEMTREC, a public service organization of the Chemical Manufacturers Association. This organization maintains a 1-800 Hotline for local responders to call in order to confirm or identify the material and to locate the responsible party. CHEMTREC maintains a large database of shipping companies and their manifests, but there is no mandate for all companies to provide information to CHEMTREC. In the event that the responsible party is not a client of CHEMTREC, this company is still a valuable resource in aiding local teams on identifying the material and appropriate responses. CHEMTREC can also provide on-site assistance if the situation calls for it (Donahue 1994).

The local first responder will also be required to notify certain state agencies. The primary agency that requests this notification is the Texas Natural Resource Conservation Commission (TNRCC). Even if the spill poses no threat to humans and very minimum to the environment, they ask to be kept informed of the material involved and location. Notification becomes mandatory if the spill involves an injured person and/or poses a threat to the environment such that samples must be taken to assess the damage. The TNRCC is the lead agency of all inland oil or other hazardous material spills. This agency provides general contingency plans which cities may refer to when creating their own and it provides technical advice and resources when the situation is recognized to be advanced beyond the means of local resources. Additionally, if the spill is of such magnitude that federal or additional state agency assistance is needed the TNRCC serves as a dispatch that will contact each of these organizations.

Other state agencies are contacted based upon the location of the spill. For instance, if the spill occurs in coastal waters, the General Land Office serves as the lead state agency and the United States Coast is the lead federal agency. Additional criteria for determining the lead agency is the type material that is spilled. In general, the lead agency tends to be the TNRCC. The TNRCC is one of four of natural resource trustees the state has created. The others include the General Land Office, the Texas Water Commission, and the Texas Parks and Wildlife Department. Each of these agencies are responsible for maintaining the integrity of the state of Texas' natural resources, thus explaining their position in regard to hazardous material spills.

The federal programs primarily serve as the highest level of advice and support possible for a locality in the event of a transport incident. In general, the U.S. Department of Transportation has the authority to:

- determine hazardous material subject to regulation,
- regulate traffic affecting interstate commerce,
- regulate shipper handling, labeling, and packaging of hazardous materials, and
- conduct inspections and issue citations for violators (TRB 1993).

These agencies and their respective responsibilities are listed on Table 3.

Table 3. Responsibilities of State and Federal Haz Mat Response Agencies

ROLE	DESCRIPTION
Texas Natural Resource Conservation Commission (TNRCC)	Lead agency in spill response for certain inland oil spills, all hazardous substance spills, serves in an advisory role to federal on-scene coordinator, determines the adequacy of containment & clean-up operations
General Land Office (GLO)	Serves as primary agency for oil spills in coastal waters, advisory role to federal on-scene coordinator, monitors all removal operations & coordinates state activities for oil spills

Table 3. Responsibilities of State and Federal Haz Mat Response Agencies, continued

ROLE	DESCRIPTION
Railroad Commission of Texas (RCC)	Determines adequacy of containment & clean-up operations for spills involving crude oil from a rig or platform operating in coastal waters or a crude oil pipeline or truck spill
Texas Department of Public Safety (TxDPS)	Responsible for on-site coordination of hazardous materials transportation emergencies for all un-incorporated areas, may assume on-site coordination role within cities when requested
Texas Department of Transportation (TxDOT)	Provide personnel, equipment, and materials for state-funded clean-up activities
Governor's Division of Emergency Management (DEM)	If the spill threatens to become a disaster, the DEM makes available all resources within the state to prevent or lessen such an incident, advises and assists the governor in all matters regarding disaster preparedness, responsible for the coordination and utilization of all state resources during a disaster
Texas Water Commission (TWC)	Primary state lead agency for hazardous materials and inland oil spills, serves in an advisory role to federal on-scene coordinator for hazardous materials and inland oil spills, monitors all removal operations, and coordinates all state activities for hazardous materials and spills
Texas Air Control Board (TACB)	Provides trained personnel and dedicated equipment to sample suspected airborne toxic compounds, provides clearance for incineration of waste
Texas Parks and Wildlife Department (TxWD)	Provides information on marine resources, the fish and game industry and recreational facilities concerning restoration as a result of a major natural disaster
United States Coast Guard	Federal agency designated as non-scene coordinator for coastal oil spills, provides technical expertise and resources during a coastal oil spill that is under the jurisdiction of the federal government
Federal Emergency Management Agency (FEMA)	Provides training and emergency planning related to accidents involving transport, manufacture, storage and disposal of hazardous material, coordinates federal HAZMAT training programs, participates in the National Response Team, provides assistance and resources to state and local government for HAZMAT program development

Table 3. Responsibilities of State and Federal Haz Mat Response Agencies, continued

ROLE	DESCRIPTION
Federal Environmental Protection Agency (EPA)	Enforces toxic air chemical release notification and ensures appropriate fixed hazardous material facility record keeping of reportable quantity requirements, coordinates Federal funding, equipment, personnel and expertise during major incidents, provides toxic air HAZMAT team guidance and training, provides technical assistance for developing site specific risk assessments
National Response Center (NRC)	Receives notification of spills and relays the reports to the pre-designated on-scene coordinator; single point of contact for responsible parties, government agencies, and private citizens to report spills
National Response Team (NRT)	Consists of 16 federal agencies with responsibilities and expertise in various aspects of emergency response, EPA serves as chair, Coast Guard as co-chair, provides policy guidance prior to an incident and assists the on-scene coordinator via a Regional Response Team
Regional Response Team (RRT)	Consists of 13 regional teams, maintains a Regional Contingency Plan, provides assistance as requested by the on-scene coordinator, may provide assistance to state and local governments in planning and training for emergency response
On-Scene Coordinators	A federal official pre-designated by the EPA for inland areas and by the Coast Guard for coastal areas, coordinates all containment, removal, and disposal efforts and resources during an incident
Departments of Health, Defense, and Energy	All ensure safety for citizens and investigate scene, cause, and effects on the environment
CHEMTREC	Private agency which maintains records of over 20,000 companies who deal with hazardous materials, maintains database of chemical and materials and containment and clean-up methods, also provide contact information of responsible parties
CHLOREP (for chlorine related incidents) NACA (pesticides safety team network) Chemical Referral Center	All give information on responsible parties, aid in identifying material, containing it, and cleaning it up

CHAPTER 4. CASE STUDIES

This study focuses on three communities within Texas: El Paso, College Station, and Sonora. Three case studies were developed in an effort to understand the processes communities take prior to and in the event of a hazardous material spill. The cities chosen are of three different population sizes—large, medium, and small, respectively—and were chosen based upon availability of information and resources, experience with hazardous material incidences, and complexity. The case studies, and subsequent flowcharts, show the steps of response taken by these communities when a spill occurs, and the differences between the three approaches. The objective of the comparative case study methodology is to identify weak points within the overall systems as designed. These weak points may be caused by unnecessary repetitive actions, lack of information, communication failures, or lack of participation or preparedness among key participants. Once identified, these problems can be evaluated to determine the applicability of ITS technologies in these situations.

4.1 CASE STUDY METHODOLOGY AND CONTINGENCY PLAN CHARACTERISTICS

Information was gathered for each community via telephone interviews and content analysis of the contingency plans developed by each county. The case study cities, as well as the other communities within the county, follow the guidelines and procedures outlined in the county-wide plan. The following information is a summarization of common terms and roles used which each of the three cities. Additionally, there will be a brief discussion on the generalized process in which the cities apply in the event of a spill The three communities were very similar in their practices, contingency plans, and how the plans came to fruition.

Each of the three plans reviewed for this study result from a statewide request for each county to develop an Emergency Plan. This request was issued by the passage of the State Disaster Act of 1975. The disasters included in this act were any natural or unnatural hazards that may effect the citizens of any area. The act required that each political subdivision have a hazardous material plan and that they elect an official of the county to serve as the director of emergency management.

Outlined within these contingency plans are the different disaster category levels. The following are the most commonly defined levels:

- Level 1: Potential Emergency Condition. An incident which can be controlled by first response agencies and does not require evacuation of other than the involved structure or the immediate outdoor area. The incident is confined to a small area and does not pose an immediate threat to life or property.
- Level 2: Limited Emergency Condition. An incident involving a greater hazard or larger area and poses a potential threat to life or property which may require a limited evacuation of the surrounding area.
- Level 3: Full Emergency Condition. An incident involving a severe hazard or large area which poses an extreme threat to life and property and will probably require a large scale evacuation; or an incident requiring the expertise or resources of county, state, federal, or private agencies and organizations.

Additionally, each contingency plan requires that all emergency response personnel should always operate under the following guidelines:

- All parties must operate as a team;
- All parties must operate under the Incident Command System (ICS);
- All parties are to report to the Incident Commander; and
- All parties operate within safe working limits and with proper protective equipment.

The incident commander (IC) is the individual who is in charge of the spill site. He or she controls who needs to be involved and whether or not state or federal agencies need to be included in the containment process. If the spill is too large for the local fire department, and the Incident Commander deems it necessary, they may forfeit their position to either the emergency coordinator for the Texas Natural Resource Conservation Commission or the Environmental

Protection Agency. In the event of a hazardous material spill, the site is initially inspected by what is known as the "first responder." This first responder may report the type of hazardous material is spilled, or contact CHEMTREC, to determine the material and the responsible party. Depending upon the location of the spill, there may be one of two emergency response teams. If the spill occurs in other un-incorporated areas the county or on a state or interstate highway, the county sheriff will be the first respondent and/or incident commander. If the spill occurs within the city limits of community, then the local fire department will serve this role. The objective of the first respondent is to make the initial calls to dispatch on the magnitude of the spill and possibly the substance in question. The magnitude of the spill is the sole criteria of how many levels of government will be involved. Magnitude is based upon the amount of chemical that is discharged, the number of people possibly effected, any injuries that resulted from the accident, what aspects of the environment are effected, and other factors such as wind direction or proximity to water. Once the first call is made to the dispatcher, the fire department determines what level of expertise is needed at the site. Regardless of the magnitude, it is recommended that the incident be reported to the Texas Natural Resource Conservation Commission.

The IC determines which city departments and other agencies must be involved. The IC attempts to identify both the substance and the responsible party through private agencies such as CHEMTREC. The next decisions are: does the state need to be involved, if so then the TNRCC is to be contacted via their Emergency Hotline; and, do federal agencies need to be involved, then the National Response Center 1 (800) number is called. Each contingency plan explains that all requests for state and/or federal assistance must be made by the mayor of the city, the county judge, or another official who is given the authority to do so by the mayor or the judge. Also, if the spill is of a large scale, then the Emergency Management Coordinator (EMC) is contacted. The jurisdictional EMC is then in charge of determining the need for a Emergency Operating Center. This center is the coordination point of the numerous representatives and officers that needed in the event of a large spill. The center acts as a "headquarters" for the different departmental representatives.

Each contingency plan also states that the responsible parties are to pay for the cleanup and/or damages incurred as a result of the spill. If they are unable to, or they cannot be reached, funding is then requested by the TNRCC from the Superfund. The amount should be reimbursed by the responsible party if possible. A representative from the TNRCC explains that there are two types of parties: responsible and irresponsible. The responsible parties keep updated manifests of freight, maintains their shipping vehicles, and have a pre-determined "clean-up crew." The irresponsible parties often do not have many restrictions on their operators or their vehicles, nor do they require detailed documentation of their cargo and destinations. The representative from the TNRCC explained that the majority of spills are paid for by the Superfund due to the fact that the irresponsible parties are bankrupt or cannot by located.

4.2 HAZARDOUS MATERIAL ROUTES

One important element of the contingency plans that are relevant for ITS technology is the hazardous materials routing information. All three counties involved in the case studies do have some form of a hazardous material route planned. The community that did not have a route defined explicitly for the area within the city limits was College Station. The hazardous cargo maps for the cities of Sonora and El Paso include routes that go into the central areas of the city. The only hazardous cargo mapped area for Brazos county is near the city of Brenham. This route specifies that vehicles carrying these materials completely bypass the city altogether.

The city of Sonora, as well as the county of Sutton, has outlined not only a transportation route, but has mapped all industries that could contribute to a hazardous materials incident. For example, Sonora has identified and mapped all bulk fuel, storage, and oil field service companies and has included this information within the Hazardous Material Response Plan (Sutton County, Texas 1995).

The city of El Paso also has a prepared route for transporting hazardous material within the city. The map is not included in the Hazardous Materials and Oil Spill Response plan as it is with the Sonora/Sutton County plan. The creation of these routes, in contrast to the city of Sonora and Brazos County, involved an additional factor of working directly with another country which also has a prominent stake in the transportation of hazardous material.

As mentioned above, the city of College Station does not have a hazardous cargo map established and included in the Brazos County plan. Therefore, vehicles carrying hazardous cargo may drive down any road equipped to handle the size of truck hauling the material. This includes streets lined with schools, parks, residences, and major shopping areas.

4.3 CASE STUDY COMMUNITY: SONORA, TEXAS

The city of Sonora created their first *Hazardous Material Response Plan* in 1982 as a result of the state of Texas' request for county-wide response plans. Sonora reviews its plan annually, however, and updates are made every four years. The county judge of Sutton County and the mayor of Sonora have the overall responsibility for response direction and control for the county and city. These two individuals take their positions at the Emergency Operating Center along with the other departmental representatives and work together with the on-scene command post. The on-scene command post is occupied by those departments with the knowledge and authority to be in closer contact with the spill site.

In the event of a hazardous material spill, the first contact made with the site is by the "first responder." This person is responsible for notifying the Sutton County/Sonora Communications Center and, if necessary, evacuate nearby residents or building occupants. Once the notification is received via an incident report, then the level of impact is determined. This decision is the basis for which departments and organizations to involve. If the spill is a Level 1, then the local Sonora Volunteer Fire Department is equipped to handle the situation. The incident commander is the ranking officer of the volunteer fire department. If the spill requires a larger workforce, technical expertise, and resources, then the San Angelo Fire Department is called. San Angelo is approximately 65 miles north from Sonora. The position of incident commander may be replaced by the ranking San Angelo battalion chief if it is deemed necessary. The IC then makes requests for local support via the Sutton County/Sonora Communication Center. This is the means in which all local departments are notified. If the spill is large enough, then the District Disaster Committee is called. The committee works in conjunction with the IC to ensure that all parties are working in coordination with each other. If state and/or federal assistance is needed, then the request for assistance is made by the mayor/county judge or another official authorized by the Mayor/County Judge.

Once the state agencies arrive, the Texas Water Commission takes the lead role of the state and/or federal agencies while supporting the requests of the IC. The local, county, state, and federal agencies work together to contain the material, while the responsible party is notified. The responsible party is then in charge of cleanup of the material.

Sutton County has a very detailed plan that includes quite a bit of useful information. The appendix hold maps, not only of the Sutton County and city of Sonora transportation routes, but of the locations of all draws, streams, and river bends in Sonora; locations of all auto repair, body work, part stores, in Sonora; location of all retail fuel suppliers; location of all bulk fuel and oil field service companies; as well as contact information of each of these companies.

Table 4. Responsibilities and Description of Incident Responders: Sonora, Texas

ROLE	DESCRIPTION
First Respondent	Usually a local fire or police official, notifies the Sutton County dispatcher, cordons off area or evacuate occupants, takes immediate steps to identify material, initiates appropriate action to control and eliminate hazard, applies appropriate fire fighting or policing techniques, ensures no material is being flushed into the storm drain system, determines a safe route into area.
Sutton County Sheriff's Dept./Police Department	Keeps one radio-equipped officer at the on-scene command post, evacuates citizens, cordons off incident scene, provides assistance for identification of bodies, reports on number of fatalities to Office of Emergency Management, protects sensitive and critical installations and prevents looting, enforces traffic control.
Sonora Fire Department	Volunteer fire department, first responder, ranking officer is the initial Incident Commander.
San Angelo Fire Department	Responds as needed and applies appropriate fire fighting techniques under the direction of the ranking fire official or incident commander.
Fire Chief/Ranking On-scene Fire Dept. Officer	Ensures Communications Center is notified, confirms appropriate fire officials have been notified, serves as incident commander, establishes an integrated on-scene common post, determines when the zone is safe for reentry
Incident Commander	Determines response level, determines public action to be taken, establishes hazardous area line and staging areas upwind in a safe location, designates an evacuation zone, initiates public notification, requests appropriate resources and support, rescues any injured persons, maintains overall command of scene until containment is verified.
On-scene Command Post	Identifies material and disseminates information to appropriate emergency agencies and citizens in area of site, obtains assistance from the public health representatives to determine the hazards involved and limits of an evacuation zone, ensures all department representatives at the command post are informed of evacuation zone and need, assists police by providing protective clothing and breathing apparatus.

Table 4. Responsibilities and Description of Incident Responders: Sonora, Texas, continued

ROLE	DESCRIPTION
Mayor and County Judge	Responsible for the control and direction of the Sutton County and the city of Sonora response, requests for state and federal assistance if necessary.
Sutton County Sheriff's Office Dispatcher	Initiates staff activation and public warning, responsible for preparing report detailing the communications between the county/city and the fixed site.
Sutton County/Sonora Emergency Operations Officer	Responsible for preparing summary incident report, cause of incident, incident critique, damage assessment, expenditures, and conclusions.
Sutton County or City of Sonora Attorney	Responsible for preparing investigative report that includes who, what, why, when, where, how, witness statements, photographs, etc.
Office of Emergency Management	Reports to on-scene command post, initiates the request for Emergency Operating Center (EOC) activation, coordinates evacuation operations through the EOC, ensures that the Sutton County/city of Sonora Attorney is notified.
Public Works Department	Assists with appropriate heavy equipment, provides barricades and material for building containment dikes, coordinates with police to establish a detour with signage, assists public utilities, assists in removal, transportation, and disposal of liquid or solid contaminants by either private or public means.
Health Department	(A city /county physician) Reports to on-scene command post, makes medical estimate of situation based upon magnitude, directs injured to proper medical facilities, works with Texas Water Commission.
Water Department	Reports to on-scene command post, assists in matters pertaining to effluent, provides and deploys Water Department heavy or specialized equipment, ensures water supply for fire suppression and restore services, reacts to entry of any pollutant into water supply, cooperates with the Health Department.
Transportation Department	Dispatches and directs evacuee transport to holding areas or shelter facilities via private vehicles, church and/or school buses, and various government-owned vehicles, coordinates with law enforcement agencies.
Shelter Officer	Responsible for providing shelters/mass care for evacuees, provides care, lodging, food, and clothing, usually through the Salvation Army and/or Red Cross.
Human Services	Red Cross or Salvation Army provides sleeping equipment and food service for evacuees.
Fixed Site Hazardous Material Facility Role	Designates facility emergency coordinator, develops on-sight contingency plan that specifies responsibilities and procedures, provides technical support for development of off-site risk assessment, provides planning support for off-site release contingency planning to include vulnerable zone identification, provides emergency response liaison to Sutton County/Sonora EOC, provides emergency service representative to on-scene command post, provides public information representative to Joint Information Center, provides public alert system, coordinates on-sight emergency plans with emergency management director, initiates emergency notification and written follow-up, provides initial incident assessment.
Emergency Operating Center	Focal point for coordinating resource requirements in support of on-scene activities and off-site protective action decisions, operated and maintained by the Sutton County/Sonora Office of Emergency Management, staffed with representatives from each department and private sector organization.

4.4 CASE STUDY COMMUNITY: EL PASO, TEXAS

The city of El Paso follows the same general outline for their contingency plan as does the previous two communities. El Paso is similar to the city of College Station in that it also serves as the primary response team for the county of El Paso. As such, the steps of action are very similar.

The city and county of El Paso are unique, in regard to hazardous materials transport, in that directly across the border are industries called *maquiladoras* that contribute significantly to the daily transportation of goods and materials across the border between Mexico to the United States. The city of El Paso is a primary hub of international trade between the two countries. In order to address the issue of a hazardous material spill, the contingency plan for the city and county of El Paso works in conjunction with the *Joint Contingency Plan for Accidental Release of Hazardous Substances Along the Border*. This document outlines coordinated efforts between the United States and Mexico in regard to large scale spills within 100 km of the border.

In the event of a spill, the first responder contacts the El Paso City/County dispatcher who then contacts the fire, police, and EMS to handle initial critical situations. Then the incident commander is established, as well as the departments that are needed and any and all supplies that may be needed. The dispatch then contacts the Office of Emergency Management official who will then determine if the EOC is needed to be activated. Following this, the IC determines the extent of the incident and makes the effort to identify the substance and the responsible party. From here, the county judge, mayor or appointed official will contact the appropriate state agency if the incident is beyond the capabilities of the city/county.

Table 5. Responsibilities and Description of Incident Responders: El Paso, Texas

ROLE	DESCRIPTION
First Respondent	Usually a local fire or police official; notifies El Paso 911 Emergency Communications Center to provide information of location, materials release and FD, PD, and EMS; cordons area and/or evacuate occupants.
EL Paso City/County Sheriff's Dept./Police Department	Keeps one radio-equipped officer at the on-scene command post, evacuates citizens, cordons off incident scene, provides assistance for identification of bodies, and reports on number of fatalities to Office of Emergency Management, protects sensitive and critical installations and prevents looting, enforces traffic control.

Table 5. Responsibilities and Description of Incident Responders: El Paso, Texas, continued

ROLE	DESCRIPTION
El Paso Fire Department	Applies appropriate fire fighting techniques under the direction of the ranking fire official or incident commander; initiates appropriate action to control and eliminate hazard, takes appropriate steps to control and contain contamination, ensures no action is made to flush material into storm drain, determines safe routes.
Fire Chief/Ranking On-scene Fire Department Officer	Ensures Communications Center is notified, confirms appropriate fire officials have been notified, serves as incident commander, establishes an integrated on-scene common post, determines when the zone is safe for reentry.
Incident Commander	Determines response level, determines which public action should be taken, establishes hazardous area line, establishes staging areas upwind in a safe location, designates an evacuation zone, initiates public notification, requests appropriate resources and support, rescues any injured persons, maintains overall command of scene until containment is verified.
On-scene Command Post	Identifies material and disseminates information to appropriate emergency agencies and citizens; obtains assistance from the public health representatives to determine the hazards involved and limits of an evacuation zone, ensures all department representatives at the command post are informed of evacuation zone and need, assists police by providing protective clothing and breathing apparatus.
Mayor and County Judge	Responsible for the control and direction of the EL Paso City-County incident response and makes requests for state and federal assistance as necessary.
El Paso County/City Sheriff's Office Dispatcher	Initiates staff activation and public warning, prepares a report detailing the communications between the county/city and the fixed site, notifies the following agencies: PD and/or sheriff's department, EMS, El Paso City-County Health District, Texas Water Commission, DH&PT, Office of Emergency Management, DDC at DPS.
El Paso City-County Emergency Management Director/Coordinator Officer	Responsible for preparing report summarizing the incident, cause of incident, incident critique, damage assessment, expenditures, and conclusions; coordinates all response activities.
El Paso City-County Attorney	Responsible for preparing an investigative report that includes who, what, why, when, where, how, witness statements, photographs, etc.
Office of Emergency Management	Reports to on-scene command post, initiates the request for Emergency Operating Center (EOC) activation, coordinates evacuation operations through the EOC, ensures that the El Paso County-City attorney is notified.
Public Works Department	Assists with appropriate heavy equipment, provides barricades and material for building containment dikes; coordinates with police to establish a detour with signage, provides assistance to public utilities, assists in removal, transportation, and disposal of liquid or solid contaminants by either private or public means.
Health Department	(A city /county physician) Reports to on-scene command post, makes medical estimate of situation based upon magnitude, directs injured to proper medical facilities, works with Texas Water Commission; assists in identifying material, provides assistance or advice on actions, determines appropriate method for neutralizing, containing, or removing material.

Table 5. Responsibilities and Description of Incident Responders: El Paso, Texas, continued

ROLE	DESCRIPTION
Water Department	Reports to on-scene command post, assists in matter pertaining to effluent, provide and deploy Water Department heavy or specialized equipment, ensures water supply for fire suppression and restore services, reacts to entry of any pollutant into water supply, cooperates with the Health Department.
Transportation Department	Dispatches buses and transports evacuees to holding areas or shelter facilities via private vehicles, church and/or school buses, and various government-owned vehicles; coordinates with law enforcement.
Shelter Officer	Responsible for providing shelters/mass care for evacuees, provides care, lodging, food, and clothing, usually through the Salvation Army and/or Red Cross.
Emergency Public Information Officer	Disseminates information to media and public.
Fixed Site Hazardous Material Facility Role	Designates facility emergency coordinator, develops on-sight contingency plan that specifies responsibilities and procedures, provides technical support for development of off-site risk assessment, provides planning support for off-site release contingency planning to include vulnerable zone identification, provides emergency response liaison to El Paso City-County EOC, provides emergency service representative to on-scene command post, provides public information representative to Joint Information Center, provides public alert system, coordinates on-sight emergency plans with Emergency Management Director, initiates emergency notification and written follow-up, provides initial incident assessment.
Emergency Operating Center	Focal point for coordinating resource requirements in support of on-scene activities and off-site protective action decisions, operated and maintained by the Sutton County/Sonora Office of Emergency Management, staffed with representatives from each department and private sector organization.

4.5 CASE STUDY COMMUNITY: COLLEGE STATION, TEXAS

The city of College Station created its *Annex Q - Hazardous Materials Emergency Plan* as a result of two factors. First was the Disaster Act of 1975. This required that each political subdivision have a hazardous materials plan and that the jurisdiction elect an official of the county to serve as the director of emergency management. This may be a county judge or mayor, who in turn appoints an Emergency Management Coordinator. The second factor was the development of a county-wide hazard mitigation plan, written in 1982. The plan was first written in the 1980s and is updated every three years and reviewed annually (Brazos County 1995).

The city of College Station is one of three jurisdictions in the Brazos County that has an organized emergency plan and a Fixed Site Hazardous Material Facility. This distinction makes the Brazos County plan unique. The other two jurisdictions are the city of Bryan and Texas A&M University. All three jurisdictions work in cooperation with each other in the event of spills and support one another with resources and supplies. Each has its own emergency management coordinator who is in charge of assisting the incident commander in notifying the proper authorities and departments, as well as aiding in the accumulation of resources or supplies. The city of College Station serves as the lead response team for the county. As such, if a smaller community in Brazos County has an incident and the local volunteer fire department is unable to properly tend to the situation, then the College Station Fire Department is called to assist.

The College Station Fire Department is the primary organization who has direct involvement with hazardous material spill sites. If a spill occurs in other areas of Brazos County, then the College Station Fire Department serves as the technical resource for the site, under the direction of the local incident commander.

If the spill is significantly larger than this, then the "C" shift is called out to the site. This particular fire department squadron has several certified hazardous material technicians on the team as well as a battalion commander who serves as the incident commander. If the spill is at an even larger scale, then the operations chief of the entire fire department is the incident commander. If a spill is larger than the city can handle, then one of the three controlling parties, the mayors of Bryan and College Station, the Brazos County judge, or the president of Texas A&M University may call or issue a request for authorized personnel to called the state emergency number (TNRCC) for further assistance. Table 6 describes the roles and responsibilities of the incident responders according to the College Station contingency plan.

Table 6. Responsibilities and Description of Incident Responders: College Station, Texas

ROLE	DESCRIPTION
First Respondent	Usually a local fire or police official; notifies the College Station 911 Emergency Communications Center to provide information of location, materials release and notify FD, PD, and EMS; cordons area or evacuate occupants.
Fire Department	Applies appropriate fire fighting techniques under the direction of the ranking fire official or incident commander; first on scene makes an effort to identify materials; initiates appropriate action to control and eliminate hazard; takes appropriate steps to control and contain contamination; ensures no action is made to flush material into storm drain; determines safe routes.
Fire Chief/Ranking On-scene Fire Dept. Officer	Ensures Communications Center is notified; confirms appropriate fire officials have been notified; serves as incident commander; establishes an integrated on-scene common post; determines when the zone is safe for reentry.
Incident Commander	Determines response level; determines which public action should be taken; establishes hazardous area line and staging areas upwind in a safe location; designates an evacuation zone; initiates public notification; requests appropriate resources and support; rescues injured persons; maintains overall command of scene until containment is verified; maintains a detailed log of all sampling results.
On-scene Command Post	Identifies material and disseminates information to appropriate emergency agencies and citizens in area of site, obtains assistance from the public health representatives to determine the hazards involved and limits of an evacuation zone, ensures all department representatives at the command post are informed of evacuation zone and need, assists police by providing protective clothing and breathing apparatus.
College Station Police Department	Keeps one radio-equipped officer at the on-scene command post, evacuates citizens, cordons off incident scene, provides assistance for identification of bodies and reports on number of fatalities to Office of Emergency Management, protects sensitive and critical installations and prevents looting, enforces traffic control.
Mayor, County Judge, President of TAMU	Responsible for the control and direction of the College Station incident response and makes requests for state and federal assistance as necessary.
Emergency Management Coordinator Officer	Responsible for preparing report summarizing the incident, cause of incident, incident critique, damage assessment, expenditures, and conclusions, coordinates all response activities, fulfills the resource requests made by the incident commander, determines if establishments of an Emergency Operations Center is necessary, to what extent the center should be put into effect.
College Station City Attorney	Responsible for preparing an investigative report that includes who, what, why, when, where, how, witness statements, photographs, etc.
Public Works Department	Assist with appropriate heavy equipment, provides barricades and material for building containment dikes; coordinates with police to establish a detour with signage, provides assistance to public utilities, assists in removal, transportation, and disposal of liquid or solid contaminants by either private or public means.
Environmental Health Department	Provided by the TNRCC; assists in determining the identity of the hazardous material and establishing the type and degree of the hazard involved.
Transportation Department	Dispatches buses and transports evacuees to holding areas or shelter facilities via College Station ISD, Texas A&M University Transportation, or Brazos Valley Transit.
Shelter Officer	Responsible for providing shelters/mass care for evacuees, provides care, lodging, food, and clothing, usually through the Salvation Army and/or Red Cross.

Table 6. Responsibilities and Description of Incident Responders: College Station, Texas, continued

ROLE	DESCRIPTION
Emergency Public Information Officer	Disseminates information to media and public, this is an appointed position, IC may serve as PIO.
Fixed Site Hazardous Material Facility Role	Designates facility emergency coordinator, develops on-sight contingency plan that specifies responsibilities and procedures, provides technical support for development of off-site risk assessment, provides planning support for off-site release contingency planning to include vulnerable zone identification, provides emergency response liaison to College Station EOC, provides emergency service representative to on-scene command post, provides public information representative to Joint Information Center, provides public alert system, coordinates on-sight emergency plans with emergency management director, initiates emergency notification and written follow-up, provides initial incident assessment.
Emergency Operating Center	Focal point for coordinating resource requirements in support of on-scene activities and off-site protective action; located in the College Station Fire Department.

CHAPTER 5. DISCUSSION AND CONCLUSIONS

This report presents a review of previous ITS/hazardous materials transport research, and a review of hazardous materials incident response processes from three local Texas communities. This final chapter includes a discussion of the findings, general recommendations for further consideration, and final conclusions.

5.1 DISCUSSION OF FINDINGS

The review of previous research on hazardous materials transport and ITS applications for hazardous materials transport suggests that we have only begun to scratch the surface of the potential applications of ITS for this type of transport. Compared to other potential applications of ITS, such as transit, the amount of available research on ITS and hazardous materials transport is slight, indeed. What has been conducted can be generally categorized into two divisions: those that focus on post incident applications, or those that focus on routing applications. What little has been done on pre-incident ITS applications suggests that this is not an area of interest or long-term concern for ITS stakeholders.

Costs of linking ITS and hazardous materials transport are assumed to be high. From a funding perspective, two assumptions drive the literature: that ITS/hazardous materials applications will be prohibitively expense, and that it is up to the CVO industry to assume this expense, if they feel it justified. The Transportation Research Board, in fact, maintains that it would not be cost effective to track hazardous materials shipments on a regular basis (TRB 1993). This attitude shows up in the ITS National Plan, as well, which would seem to rationalize the use of ITS for post-incident purposes only (ITS America 1995).

Finally, the literature is silent, for the most part, on what the potential benefits of linking ITS and hazardous materials transport might actually be. Nailer and Queree (1993), however, are explicit in this regard, as they provide the most inclusive list of benefits of information exchange for both regulatory authorities and trucking concerns. The benefits for authorities include:

- Improved emergency response,
- Improved monitoring of congestion and traffic flow, and
- More efficient customs procedures.

The benefits for the trucking industry include:

- Traffic information availability,
- Weather condition information,
- Route planning, and
- Access to third-party information, such as a chemical databases.

The survey of the three Texas communities and their hazardous materials incident response plans is also revealing in several ways. First, all three plans are similar in form, in that they are all developed with input and support from the same state and federal agencies. There is little unique in any of the plans that separates one from the others. There is nothing particularly wrong with this, until an attempt is made to integrate ITS technology into the plan at which time questions of technological capacity for implementation and financial capacity for funding such integration become important. If the focus of ITS/hazardous materials linkages were to shift from post-incident to pre-incident applications, this could create significant problems.

The case studies presented in the previous chapter reveal certain characteristics common to all the communities, in particular the large number of agencies and participants involved in responding to a hazardous materials incident. The large number of respondents to an incident presents logistical information problems as responsibilities overlap within the incident time frame of events. For example, the first responder assumes certain responsibilities that are subsequently assumed by a higher level of authority as the response situation develops. This situation suggests a need for consistent and reliable information that can be passed along during the response activities, a requirement in which ITS can certainly play a major role.

In spite of the large number of responders shown in these cases, several provide more potential applications for ITS technology than do others. While these are primarily post-incident responders, as suggested in the literature review, there are some potential applications for pre-incident applications. Post incident responders who represent potential ITS users include:

- First responders and incident commanders;
- Police and fire department personnel;
- Public works departments; and
- Transportation departments.

ITS technology, such as changeable message signs, already integrated into local and state transportation systems and agencies can also be activated and applied in the event of a hazardous spill. The Sonora incident on Interstate 10 is an illustration of this scenario.

Based on the information from Tables 4-6, the potential pre-incident list is shorter, as the number of participants that would benefit from ITS technology prior to an incident is smaller. This would include the local and county dispatchers, as they would be a logical clearinghouse for hazardous materials tracking information. Potentially, however, if a tracking system were integrated into a community, fire, police, and health and medical agencies could use the information for staffing information.

5.2 RECOMMENDATIONS

The findings from this report reveal several areas where ITS and hazardous materials transport have been linked, conceptually, and, in a small number of cases, where pilot projects have been developed and implemented. However, the small number of studies that show up in a literature review on this issue suggest that there might be many more applications that can be considered, particularly from a local perspective, as opposed to the top-down and economic perspectives. This section outlines recommendations for discussion purposes on further linkages between ITS technologies and the transport of hazardous materials. These recommendations take as their starting point, the emphasis placed on post-incident applications by previous research before considering pre-incident applications and non-economic based applications.

There appears to be a role for local participants in applying ITS technologies beyond that of incident response. In particular, as ITS focuses on the transfer of information between the vehicle and the roadway, this relationship can, and often does, include local agencies. This is most obvious in the Traffic Management Centers (TMCs) in Houston and San Antonio, for example. The question is how to extrapolate the benefit of large scale TMCs down to medium and small communities without the costs? It would seem that regular shipments of hazardous materials through a community would provide an opportunity to consider such an extrapolation. One means of integrating ITS into the community could be through larger projects such as the Federal Emergency Management Agency's "Project Impact" program, which seeks to reduce the costs of local disasters. The subtitle to this program is, "Building a Disaster Resistant Community," and is based on mitigation and reduction of the effects of disasters. The methodology for implementing this program is based on building community partnerships, identifying hazard vulnerability, and prioritizing risk reduction actions in the community. ITS could conceivably be one element of these risk reduction activities in a community particularly vulnerable to potential hazardous materials incidents, such as those along highly traveled interstate highways. The FEMA program has worked with seven communities to develop project impact plans, and has entered into memoranda of agreement with three other communities. FEMA is providing up to $1 million for community seed money for disaster resistant actions. As the goal of "Project Impact" is to "change the way America prepares for and prevents disasters," it would appear that ITS could be a viable component of such an effort (Witt 1998).

Although previous studies suggest that the tracking or monitoring of all hazardous shipments is not cost effective, two variables could be used to determine those shipments for which tracking and monitoring could, or should, be considered. The first variable is the in-state origin and destination of materials; the second variable is public perception of risk.

As the number of hazardous materials shipments are increasing in Texas, and tracking all shipments would be prohibitively expensive, certain shipments can lend themselves to ITS technologies more than others. This is particularly the case of in-state generated materials or waste with in-state destinations. For example, if a plant or facility regularly ships hazardous materials in state, this situation could integrate ITS technology for tracking, monitoring, and both pre- and post-incident information transfer along the shipment route. ITS technologies could be applied at the origin, destination, and along the route through cooperation with traffic management centers and local agencies that are placed at risk from the shipments. From a regulatory perspective, ITS technologies can be integrated into hazardous materials transport requirements. It is conceivable that a state could require certain shippers and facilities to implement ITS tracking and monitoring technologies as part of the licensing requirements for these companies. This requirement could also connect to communities along planned routes in order to provide shipment information to incident response agencies.

The second variable, public perception of risk, can be used to determine the level of tolerance and expectations the public has for being placed at risk from the transport of hazardous materials. Previous studies have shown that this public perception is a complex and dynamic issue which has not been addressed in Texas, yet can be used to inform the planning process for ITS applications. This report recommends that the state of Texas develop a statewide survey of public perception of risk associated with hazardous materials, such as those conducted in New Mexico and Nevada. The results of this survey can be far reaching, and relate to more than just ITS applications, too. The potential risk associated with various types of materials, as perceived by regulatory agencies and experts, can then be balanced with the public perception and understanding of these risks in informing the planning process ITS technologies. If perceptions of risk vary with material, as they have in other surveys, this information can be used to inform a regulatory selection process for those materials that have to be monitored through inhabited areas by using ITS technologies.

In a related issue, perception of key hazardous materials transport issues by ITS researchers and developers, and state and local regulatory agencies, also needs to be changed. The economic-based cost-benefit analysis conducted by ITS research suggests that the costs of hazards materials tracking before an incident is too costly, particularly to the shipping industry. The ITS plans and programs in place relegate the applications of ITS technologies for these shipments primarily to the commercial vehicle operations category, which again focuses on the economics of shipping. It is easier, of course, to study and quantify the costs of developing and implementing ITS applications for shippers, who rely on economics to justify their expenditures, than it is to study and quantify the risks and costs to a community or corridor that is placed at risk from hazardous materials shipments.

Recent reports in the press underscore how transport issues are perceived at the state and local levels. First, the Texas Department of Public Safety admits that less than one in every 1,000 commercial trucks on the road are inspected (Houston Chronicle 1998). Second, the Houston Police Department claims that, "There are better things that we can do with our manpower [than inspect trucks]. We do not see this as a real public safety issue. This is regulatory as opposed to law enforcement" (Feldstein 1998). Perceiving the issue as a public safety issue, however, rather than an economic issue for shippers, places the application of ITS technology in a completely different light.

The findings from this report underscore the lack of local involvement in local hazardous materials transport planning. State agencies provide general guidelines for preparing city and county plans, yet this results in plans that are strikingly similar and void of local conditions or situations that might make a community less or more vulnerable to hazardous materials transport incidents. In conjunction with statewide surveys, community and corridor level studies should be conducted to determine at-risk communities. This approach is similar to the FEMA program previously cited.

The issue of how hazardous materials transport has been considered in state ITS plans needs to be addressed and modified, too. The ITS deployment strategy for Texas does little to include hazardous materials transport applications. As in the national plans and research studies, this issue is most obvious in the commercial vehicle applications section, rather than the public safety sections. Again, perceiving this issue primarily for potential CVO applications not only constrains the potential of ITS, it also limits the responsibility of ITS planners and developers by insulating them from their ethical responsibilities to the general public. Recent events in Texas, such as the Sonora/I-10 spill, the Sierra Blanca dispute, and the press attention on the lack of truck inspections in the state should be seen as events which can focus attention, and therefore opportunity, to expand the applicability of ITS beyond the CVO area of interest.

An additional recommendation needs to be made for pre-incident research into ITS applications for hazardous materials transport. As perceptions are changed regarding possible

ITS benefits for hazardous materials transport, we will see more interest in local-level involvement from at-risk communities. One of the primary concerns will be funding issues, which may be addressed through local level partnerships along at-risk corridors for the benefit of spreading costs. Attempts at interagency cooperation can result in conflict, particularly concerning costs of technology. A previous study of local cooperative efforts for implementing geographic information systems shows that although these systems require large investments and commitments, sharing the costs can reduce costs for the participants, among other benefits from technology sharing (Brown, O'Toole, and Brundey 1998). Rural communities, in particular, could benefit from such a cooperative effort for both pre- and post-incident ITS applications.

In summary, this report offers the following recommendations:

- Consider integrating ITS/haz mat applications into larger programs for community safety, such as the FEMA Project Action program.
- Certain types of hazardous cargo can be tracked on an ongoing basis in order to reduce the risk to communities through which these shipments go on a recurring basis. Determining which shipments to monitor should be based on public input, as well as expert assessments of risk.
- A statewide survey should be conducted focusing on public perception of risk from the transport of hazardous materials. This information can inform ITS planning efforts as well as public policy.
- Research should be encouraged and supported that goes beyond both traditional cost-benefit analyses and the CVO perspective of linking ITS technologies with the transport of hazardous materials. The argument of excessive cost to the CVO community should be reconsidered from other local- and community-based perspectives.
- The difficult issue of shifting the perspective of the ITS community from an economic focus to a public safety focus regarding the transport of hazardous materials needs to be addressed within state and local agencies. The rationale for this shift is that it will open up additional avenues for ITS applications, as well as focus attention on an important ethical issue.

- Local hazard incident response plans need to reflect unique characteristics and vulnerabilities of these communities. ITS applications can be integrated into existing plans, most readily for post-incident response and management.
- State-level ITS plans need to reflect the importance of, and potential risk to the public from, transporting hazardous materials on Texas roadways.

5.3 CONCLUSIONS

This report provides an introduction to the dynamic issue of hazardous materials transport and ITS technology. In addition, it summarizes the local contingency plans from three Texas communities and identified potential linkages for ITS applications. The recommendations in this report direct research toward several areas for consideration. This section offers some concluding remarks on these issues.

There are many potential uses for ITS in the area of hazardous materials transport: regulation, incident response, hazard mitigation, and risk reduction. The research reviewed in this report reveals significant gaps in our efforts, however, particularly as they are limited to post-incident response and primarily linked to CVO applications. This situation suggests that there exists a wide gulf between how the ITS community perceives the potential for these technologies, and how the public may perceive the potential risk of these types of shipments. The public relies on a transport safety system that is maintained by the shippers, yet studies show vast numbers of non-compliant trucks carrying hazardous materials on the roadway. There is even movement in Congress to shift this perception of the hazardous materials transport issue. Representative Frank Wolf, R-Va, is attempting to move the Office of Motor Carriers (OMC) from the Federal Highway Administration to the National Highway Traffic Safety Administration, as a result of concerns over incompetence and influence in the OMC (Wilner 1998).

Finally, environmental justice and equity issues are becoming important concerns for transportation planning and programming. ITS technologies represent a potential component for dealing with these important concerns, yet little has been mentioned in the ITS/hazardous materials transport literature. This raises broader, more complex issues of how and when should advanced technologies, such as ITS, be applied for the protection of the general public, rather than merely relegating and limiting its use to the private sector, such as the CVO industry.

ITS technologies represent potential solutions for real and perceived risks associated with the transport of hazardous materials. This report shows that much more work can and should be conducted on this connection of technology and risk.

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APPENDIX

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The author describes the additional services available through CHEMTREC. Additionally, he explains CHEMTREC, current Hazmat regulations, emergency response mutual aid network, a non-emergency network, and emergency response training programs.

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This section of the program plan discusses hazardous materials incident response. It focuses on needs, operational concepts, technologies, cost/benefits, and party roles regarding improvement opportunities to improve the safety of emergency response personnel and public in the event of a Hazmat incident.

FRAME Consortium. 1994. The Integration of Hazardous Goods Monitoring and Control Systems for Overall Logistical Control and Quality Management of Chemical Substances. *Towards an Intelligent Transport System. Proceedings of the First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems, Vol. 3.* Artech House: London.

The Consortium considers the complex issue of total quality management within the context of hazardous goods shipment and monitoring. Preliminary conclusions suggest that considerable payoffs may be available on short haulage routes for participants in an integrated information and logistics system.

Gorys, Julius. 1990. Transportation of Dangerous Goods in the Province of Ontario. *Transportation Research Record 1264.* Transportation Research Board: Washington, D.C.

The amount of dangerous goods transported in the Province of Ontario, Canada, is assessed in this paper. In addition, the author looks at the modal distribution, issues associated with the transport of dangerous goods, and the degree of societal risk.

Goulias, K. G., and S. B. Alam. 1997. *TransitXpress: Hazardous Material Fleet Management and Monitoring System.* Mid-Atlantic Universities Transportation Center: University Park, PA.

Tranzit Xpress is comprised on a traffic/safety control center, motor vehicle instrumentation, and off vehicle tolls which communicate with each other for purposes of monitoring and managing hazardous materials fleets. This report presents preliminary findings from the first phase of the project.

Gurcan, M. K., and N. H. Lewis. 1994. Performance Evaluation of a Vehicle Position Reporting System for Hazardous Goods Monitoring. *Towards an Intelligent Transport System. Proceedings of the First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems, Vol. 3.* Artech House: London.

This paper evaluates a shared-satellite based system for tracking the positions of a large number of hazardous materials vehicles. The project is one component of the EC DRIVE II FRAME project.

Lo, Hong K. 1996. Organizing for Intelligent Transportation Systems: Case Study of Emergency Operations in San Francisco Bay Area. *Transportation Research Record.* 1603: 34-40.

The author examines the coordination between transportation management centers (TMC) and emergency operations (EOs) and whether or not an appropriate level between the two may be established.

Nailer, Christopher, and Dr. Christopher Queree. 1993. Traffic Message Exchange for Hazardous Goods Control Systems: Project Portico. *IEEE IE Vehicle Navigation and Information Systems Conference*. Ottawa Congress Centre: Ottawa, Ontario.

These authors describe the model for applying the needs of European shippers and the authorities via the PORTICO and DRIVE II projects. Additionally, it describes how this experiment will be evaluated.

Percival, Mark, and A. Monteiro. 1994. Hazardous Goods Fleet Management and Traffic Control: Co-operative Data Exchange: Project PORTICO. *Towards an Intelligent Transport System. Proceedings of the First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems, Vol. 3*. Artech House: London.

This paper reports on a pilot hazardous materials transport project within the European Project PORTICO. The authors find that excessive costs may keep technologies from being applied for hazardous materials shipment monitoring, even if these are socially desirable.

Poveda, J. et al. 1994. ARTIS-7: First Results of a Hazardous Goods Transport Monitoring System from a Field Trial. *Towards an Intelligent Transport System. Proceedings of the First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems, Vol. 3*. Artech House: London.

This paper reports on the first results of a field trial for ARTIS-7, an advanced road traffic informatics project being conducted in Spain. The objective of the field trial was to evaluate the monitoring system for future development. Results of the trial suggest the need to consider a global system for hazardous goods monitoring and control, which would consider the economic aspects of the system, and intermodal aspects of this transport environment.

Saccomano, Ann. 1994. Information Technology Takes the Lead in Improving Hazmat Emergency Response. *Traffic World,* 12 December, 42-43.

This article reports on the use of information technology for first responders to rail accidents involving hazardous materials. Using similar technology for trucks will be difficult, as they are not as standardized as rail shipments, and there are many more companies involved.

Schulz, John D. 1993. Critical TRB Report Prompts Applegate to Withdraw Costly Hazmat Tracking Plan. *Traffic World*, 27-28.

The article explains the conclusions of the Transportation Research Board's (TRB) feasibility study of Rep. Douglas Applegate's (D-Ohio) proposal of a costly hazmat tracking plan. TRB found the proposed system to be too expensive and recommended a thorough investigation of the present needs of emergency responders' weaknesses in the system and focus on more cost-effective programs that work in coordination with current systems.

Jenkins-Smith, Hank, A. Fromer, and C. L. Silva. 1996. *Transporting Radioactive Materials: Risks, Issues and Public Perceptions*. UNM Institute for Public Policy, University of New Mexico: Albuquerque, NM.

Public perceptions of the risks of transporting radioactive materials can vary considerably. This report attempts to understand how and why the public responds to these types of shipments in different ways and in different parts of the country.

Titus, Matthew J. 1993. Benefits of electronic clearance for enforcement of motor carrier regulations. *Transportation Research Board* 1522: 64-68.

This article is advocating the Federal Highway Administration's ITS for Commercial Vehicle Operations. The author focuses on the inadequacies of the current strategies and the industry and social benefits of applying the ITS-CVO systems.

Turnquist, Mark S. 1991. Using Real-Time Location Information for Hazardous Materials Shipments. *Applications of Advanced Technologies in Transportation Engineering.* American Society of Civil Engineers: New York, New York.

This paper discusses using real-time location information for transporting hazardous materials as a means of updating routing decisions. A hypothetical network is applied in this paper in order to recognized problems and to discover ways in which to remedy the situation.