U.S. Department of Transportation

Research and Special Programs Administration

A Study of Hazards and Risks to Public Health and Safety, the Environment, and the Economy Associated with the Transportation of Hazardous Materials

As Required Under Section 352(b) of the Department of Transportation and Related Agencies Appropriations Act, Fiscal Year 2002

U.S. Department of Transportation
Research and Special Programs Administration
Office of Hazardous Materials Safety
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FINAL REPORT

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INTRODUCTION

Section 352(b) of the Department of Transportation and Related Agencies Appropriations Act, Fiscal Year 2002, directs the Secretary of Transportation, in consultation with the Comptroller General of the United States, to conduct a study of the effects on public health and safety, the environment, and the economy associated with the transportation of hazardous and radioactive materials. Section 352(c) states that the following matters are to be addressed in the study:

> (1) Whether the Federal Government conducts or reviews individualized and detailed evaluations and inspections of the condition and suitability of specific transportation routes for the current, and any anticipated or proposed, transport of hazardous and radioactive material, including whether resources and information are adequate to conduct such evaluations and inspections.
>
> (2) The costs and time required to ensure adequate inspection of specific transportation routes and related infrastructure and to complete the infrastructure improvements necessary to ensure the safety of current, and any anticipated or proposed, hazardous and radioactive material transport.
>
> (3) Whether emergency preparedness personnel, emergency response personnel, and medical personnel are adequately trained and equipped to promptly respond

to incidents along specific transportation routes for current, anticipated, or proposed hazardous and radioactive material transport.

(4) The costs and time required to ensure that emergency preparedness personnel, emergency response personnel, and medical personnel are adequately trained and equipped to promptly respond to incidents along specific transportation routes for current, anticipated, or proposed hazardous and radioactive material transport.

(5) The availability of, or requirements to, establish governmental and commercial information collection and dissemination systems adequate to provide public and emergency responders in an accessible manner, with timely, complete, specific, and accurate information (including databases) concerning actual, proposed, or anticipated shipments by highway, railway, or waterway of hazardous and radioactive materials, including incidents involving the transportation of such materials by those means and the public safety implications of such dissemination.

This study, prepared in response to the legislative requirements, first provides a brief overview of the Department=s role in assuring the safety of hazardous materials transported in commerce. Included in this overview is an explanation of the risk management and risk assessment philosophy that is the underpinning of the DOT regulatory program. The first two matters raised

in the statutory requirement for the study are discussed in the sections entitled “Routing of Hazardous Materials” and “Condition of the U.S. Transportation System Infrastructure.” The third and fourth matters are addressed in the section entitled “Emergency Response Planning and Training”. The final matter is discussed in the section entitled “Information Collection and Dissemination Systems.”

To address the specific issues highlighted by ' 352(b) of the Department of Transportation and Related Agencies Appropriations Act of Fiscal Year 2002, this study reviews Federal requirements for routing hazardous materials, including radioactive materials, and provides an assessment of the overall condition of highway, rail, and vessel transportation infrastructure. In addition, this study examines emergency response planning and training programs. Finally, the study summarizes information collection and dissemination activities related to hazardous materials transportation.

OVERVIEW

Federal Role in Hazardous Materials Transportation

Hazardous materials are essential to the economy of the United States and the well being of its people. The United States is a modern, industrial society that relies on the movement of large quantities of a wide assortment of materials. These materials are used to fuel vehicles, purify water, heat homes, provide medical care, grow crops, build roads, mine ore, produce electricity, and manufacture products. Much good comes from the movement of these materials. However, many of the materials present inherent hazards that can harm life, destroy property, and damage the environment.

Hazardous materials can explode, poison, burn, corrode, radiate, and infect. They are moved in vehicles subject to extreme forces in accidents and collisions and can encounter harsh environmental conditions. Equipment and packaging meant to contain the materials can malfunction, abrade, corrode, wear out, or otherwise fail. Human factors and the potential for operator errors are ever present. The nation must account for these possibilities and ensure that the movement of hazardous materials is accomplished safely, with minimal risk to the public and the environment.

The purpose of the Hazardous Materials Transportation Safety Program, first mandated specifically by statute in 1975, is to identify and manage risks presented by the transportation of hazardous materials in commerce. Federal hazardous materials transportation law (Federal hazmat law), codified at 49 U.S.C. 5101 *et seq*., directs the Secretary of Transportation to designate a material or a group or class of material as hazardous when the Secretary determines that transporting the material in commerce in a particular amount or form may pose an unreasonable risk to health and to safety or property. The Secretary is directed to prescribe regulations for the safe transportation of hazardous materials in commerce. The regulations apply to shippers, carriers, and those who manufacture, mark, test, certify, or sell packaging or containers represented as qualified for use in transporting hazardous materials. [1]

The Department=s hazardous materials program responsibilities are shared among the Research and Special Programs Administration (RSPA) and other Department of Transportation (DOT) operating administrations. RSPA develops hazardous materials transportation regulations, in cooperation with the Federal Aviation Administration (FAA), Federal Motor Carrier Safety Administration (FMCSA), Federal Railroad Administration (FRA), and the U.S. Coast Guard. Enforcement authority is split among the operating administrations. Enforcement activities applicable to a single mode of transportation generally are handled by the appropriate operating administration. For example, FMCSA generally handles enforcement issues involving the transportation of hazardous materials by motor carriers. However, the operating administrations

[1] Hazardous materials shipped by pipeline and bulk package shipments by vessel are not covered by the Hazardous Materials Transportation Program.

are not limited to issues involving a single transportation mode. A change in the Secretarial Delegations in August of 2000 allowed each operating administration to use its resources to address any hazardous materials transportation issue as necessary to assure the continued safety of the transportation system. Other Federal agencies, such as the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), and the Occupational Safety and Health Administration, also have substantial roles in regulating the transportation or handling of hazardous materials.

As required by hazardous materials transportation law, DOT participates in meetings of international organizations to ensure consistency between domestic and international requirements for hazardous materials transportation. RSPA represents the United States in meetings of the United Nations (UN) Economic and Social Council Committee of Experts on the Transport of Dangerous Goods which is responsible for developing requirements to enable international transportation. RSPA also represents the United States in meetings of the International Atomic Energy Agency responsible for regulations enabling international transportation of radioactive materials. RSPA also participates in meetings of the International Maritime Organization and International Civil Aviation Organization where the UN and IAEA requirements are incorporated into international regulations for sea and air transport. Under the North American Free Trade Agreement RSPA works with its Canadian and Mexican counterparts to achieve regulatory consistency among our NAFTA partners. In accordance with

hazardous materials transportation law, the regulations issued by RSPA are consistent with internationally agreed requirements to the greatest extent possible.

Types and Quantities of Hazardous Materials Transported and Related Packagings

The Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) govern the transportation of tens of thousands of materials, such as explosives, poisons, infectious substances, flammable and nonflammable gases, flammable liquids and solids, oxidizers, radioactive materials, and corrosives. The HMR include the defining criteria for each hazard class, packaging requirements for each material, requirements for communicating hazards to emergency responders and transport workers, training requirements for transport workers, requirements for emergency response information relevant to individual materials, and operational requirements, including mode-specific requirements. The regulations are keyed to the degree of risk associated with the transportation of specific hazardous materials or types of materials. The HMR establish a classification system that places these materials in nine hazard classes to assist in the establishment of consistent, risk-based requirements. The classes are: Class 1, Explosives; Class 2, Gases; Class 3, Flammable Liquids; Class 4, Flammable and Reactive Solids; Class 5, Oxidizing Substances and Organic Peroxides; Class 6, Poisonous and Infectious Substances; Class 7, Radioactive Materials; Class 8, Corrosives; and Class 9, Miscellaneous Materials. Certain classes are further subdivided into divisions to denote different hazards. For example, the Class 2 hazard class is subdivided into Division 2.1, flammable gases; Division 2.2, non-flammable, non-poisonous compressed gases; and Division 2.3, poison gases. DOT also works

through international organizations to ensure that the HMR are in harmony with worldwide standards.

We estimate that there are over 800,000 shipments of hazardous materials daily. Hazardous materials move by plane, train, truck, or vessel in quantities ranging from several ounces to many thousands of gallons. The 1997 Commodity Flow Survey (CFS), conducted jointly by DOT and the Department of Commerce every five years, captures data on shipments originating from selected business establishments located in the 50 States and the District of Columbia. Certain industry areas, such as government, are not included. Imports are not included until after they have left the importer's domestic location for shipment to another location. Despite these limitations, the CFS provides an excellent overall picture of hazardous materials transportation that occurred in 1997. Table 1 summarizes breakout by class and mode. These data are graphically depicted in Appendix A.

Table 1
Hazardous Material Shipments

	Truck		Rail		Water *	
Hazard Class	**Tons**	**Ton-Miles**	**Tons**	**Ton-Miles**	**Tons**	**Ton-Miles**
Class 1	1,089,000	385,000,000	**			
Class 2	54,393,000	6,448,000,000	15,203,000	11,447,000,000	5,135,000	1,909,000,000
Class 3	714,713,000	45,003,000,000	26,642,000	19,548,000,000	114,987,000	53,632,000,000
Class 4	4,763,000	819,000,000	6,477,000	8,639,000,000		
Class 5	5,839,000	1,568,000,000	3,182,000	2,820,000,000		
Class 6	2,840,000	967,000,000	1,949,000	1,446,000,000		
Class 7	56,000	17,000,000				
Class 8	44,512,000	11,964,000,000	24,427,000	16,998,000,000	17,822,000	11,061,000,000
Class 9	41,592,000	7,766,000,000	18,334,000	13,064,000,000		
TOTAL	**869,797,000**	**74,937,000,000**	**96,214,000**	**73,962,000,000**	**137,944,000**	**66,602,000,000**

Source: 1997 Commodity Flow Survey

* Shipments by water include both bulk and non-bulk shipments.
** Blanks indicate insufficient data to be statistically significant.

Gasoline and other flammable liquids dominate truck shipments of hazardous materials in terms of quantities of material transported. The distribution of large quantity shipments of hazardous materials by rail varies more widely. The Association of American Railroads (AAR) collects waybill data under contract to the Surface Transportation Board. The Waybill Sample for the 10-year period 1986-1995 shows the following top 10 materials shipped, with the average number of carloads shipped annually during this period:

Material	**Carloads**
Sodium Hydroxide	71,409
Sulfuric Acid	57,664
LP Gases	56,413
Molten Sulfur	52,990
Ammonia	45,022
Chlorine	44,571
Phosphoric Acid	31,637
Fuel Oil	20,334
Ammonium Nitrate	20,186
Methanol	17,480

Typical hazardous material packagings include bulk packagings, such as cargo tank motor vehicles, rail tank cars, portable tanks, and intermediate bulk containers, and non-bulk packagings, such as drums, boxes, pails, and cylinders. The HMR requirements for packaging specific materials are based on the hazard of the material to be transported. Shippers must use

more robust packagings when the properties of the materials or quantities of materials justify such packagings.

There are well over three million shipments of radioactive material (RAM) per year. Over ninety percent of these shipments are radiopharmaceuticals or shipments of small quantities (Type A or below) of industrial radioactive material. Although the nuclear power industry is a significant shipper of radioactive material, a vast majority of its transport activity is associated with the manufacture and delivery of new fuel to power plants-- that is, transportation on the front end of the fuel cycle. Currently, there are only 15 to 20 shipments of spent nuclear fuel annually -- that is, transportation on the back end of the fuel cycle. Shippers of spent nuclear fuel include utilities, academic institutions, and foreign operators of research reactors whose fuel is being returned to the United States. Upon licensing of a permanent repository for spent nuclear fuel, the number of such shipments will increase. Current estimates for future shipments of spent fuel to a permanent repository call for 45 truck and 130 rail cask shipments annually.

RAM packagings come in a wide range of sizes and strengths. Common package types include: (1) excepted packaging for very small amounts of radioactive material; (2) industrial packaging for low concentrations of radioactive material and articles whose surfaces are contaminated with radioactive material; (3) Type A packaging for small amounts of radioactive material; and (4)

Type B packaging for large activity shipments. All packagings must meet basic requirements to assure containment of the material and minimize radiation exposure of transport workers and the general public. Type A packagings are designed and performance-tested to ensure they will withstand normal conditions of transport and handling. Type B packagings are designed to survive hypothetical accident conditions. They must satisfy specific performance criteria under prescribed test conditions. To prove their survivability, Type B packagings, such as spent fuel casks, must be able to survive a series of performance tests that include a 30-foot drop onto an unyielding surface, a puncture test, a crush test, a 30-minute all-engulfing fire test, and an immersion in water test. Finally, Type B packagings must be certified by the NRC for domestic use or by DOT for international use.

Hazardous Materials Incidents

The HMR require a carrier to submit a written report when an incident involving a hazardous materials shipment occurs during transportation. (DOT defines a hazardous materials incident in the event of any unintentional release of a hazardous material during transportation.) RSPA receives approximately 17,000 such reports each year. About 400 of these incidents are considered serious. Serious incidents are those that result in:

(1) A fatality or major injury caused by the release of a hazardous material;

(2) An evacuation of the general public;

(3) Closure of a major transportation artery;

(4) Altering and aircraft flight plan or operation;

(5) Release of RAM from Type B packaging;

(6) Release of more than 11.9 gallons or 88.2 pounds of a severe marine pollutant; or

(7) Release of a bulk quantity (over 119 gallons or 882 pounds) of a hazardous material.

Incident data for the 10-year period 1991 through 2000 are summarized in Appendix B. During the 10-year period from 1992 to 2001, there were 223 fatalities attributable to hazardous materials transportation, including 110 resulting from the Valujet incident in 1996. Of the remaining 113 fatalities, all of which occurred in surface modes of transportation, 93 were due to the transportation of flammable/combustible liquids—predominantly gasoline-- by highway. A large fraction of these involve actions of the driver of the vehicle.

The current incident reporting system yields useful information on the causes and frequency of hazardous material accidents. However, there is room for improvement. On July 3, 2001, RSPA proposed revisions to improve Form DOT F 5800.1 -- Hazardous Materials Incident Report -- to obtain better, more detailed information on events with potentially greater consequences, to provide more descriptive information to help determine root causes of events, to offer better linkages so that data can be coupled, and to better structure the form to facilitate complete and accurate responses. Reporting of undeclared shipments that are discovered during transportation and reporting of certain non-release events involving bulk packagings are among the major changes proposed. The revisions are intended to increase the usefulness of data collected for risk

analysis and management by government and industry. RSPA is currently evaluating comments and expects to issue a final rule on changes to the incident reporting form by the end of the year.

Risk Management and Risk Assessment

Use of Risk Management. The structure of the hazardous materials transportation safety program is based on risk management principles. Elements of the multi-faceted program that constitute basic risk management include the classification system, hazard communication (shipping papers, package labeling and marking, and placarding), packaging, testing, training, registration, compliance and outreach, a grants program to assist emergency responders' training and planning activities for hazardous materials incidents, and the Emergency Response Guidebook, which serves as a guide for first responders.

The regulations continue to evolve to take into account new technology developments and DOT's commitment to reducing hazardous materials transportation risk. Changes to the regulations include requirements for head shield and thermal protection for railcars, rollover protection for tank trucks, additional shipping paper requirements to assist emergency responders, and emergency discharge control equipment for vehicles transporting liquefied compressed gases. As an example of safety improvements in a particular mode, a more complete discussion of those applicable to tank cars (which carry upwards of 75 percent of the hazardous materials moved by railroad) is included in Appendix C.

National Risk Assessment for Selected Hazardous Materials in Transportation. Although the overall safety record of hazardous materials in transportation has been good, one of the most difficult judgments to be made relates to system risks involving high consequence, low probability events. In order to better understand the contribution of such events to overall risk, RSPA sponsored a multi-year research effort conducted by the Argonne National Laboratory. The assessment modeled the hazardous materials transportation system to define the national risk associated with rail and highway transportation of selected hazardous materials. The study found that the long-term rate of fatalities due to the inherent dangers of hazardous materials is about 18 per year. The results support a conclusion that, overall, the hazardous material transportation system is functioning well, although there is a need for improvement. Appendix D provides additional information on the results of this risk assessment.

Spent Fuel Transportation Risk. Assessment of risk relating to proposed spent fuel transportation risk is the subject of great scrutiny because of recent decisions concerning a central repository for permanent storage of spent fuel. In 1977, the Nuclear Regulatory Commission (NRC) completed a *Final Environmental Statement on the Transport of Radioactive Materials by Air and Other Modes* (NUREG-0170). It is considered to be the baseline study on radioactive material transportation risk, including spent fuel transportation risks.

In March 2000, the NRC again looked at the issue in its *Reexamination of Spent Fuel Shipment Risk Estimates* (NUREG-CR-6672). This reexamination concluded that the risks from accident-

free shipments and from shipment where accidents occur are very low--even lower than previously estimated. The study confirmed that safety standards for spent nuclear fuel remain valid and require no changes. In addition, in February 1987, the NRC published "Shipping Container Response to Severe Highway and Railway Accident Conditions" NUREG/CR-4829. Among other things, that study reaffirmed validity of earlier risk assessments and included an analysis of the predicted response of a representative spent fuel cask to historically severe transportation accidents. (One example was the Livingston, Louisiana train fire in September 1982 that was allowed to burn for several days because of the toxic chemicals involved). Similarly, the NRC is currently assessing how a rail cask would have performed in the July 2001 Howard Street Tunnel fire in Baltimore, Maryland.

Security

RSPA's hazardous materials transportation safety program has historically focused on reducing risks related to the unintentional release of hazardous materials. The HMR are designed to ensure that hazardous materials are packaged and handled safely during transportation, thus minimizing the possibility of their release should an incident occur. Communication requirements in the HMR ensure safe and appropriate handling during transportation and facilitate effective emergency response in the event of an accidental release.

In the wrong hands, hazardous materials can pose a significant security threat. Hazardous materials in transportation are particularly vulnerable to sabotage or misuse. Security of hazardous materials in the transportation environment poses unique challenges as compared to

security at fixed facilities. Hazardous materials are frequently transported in substantial quantities. Such materials are already mobile and are frequently transported in proximity to large population centers. While the HMR provide for a high degree of safety with respect to avoiding and mitigating unintentional releases of hazardous materials during transportation, the HMR do not specifically address security threats.

Gauging the dimension of the security risk posed by hazardous materials transported in commerce will not be easy. The Department has initiated rulemaking action to propose revisions to current shipping documentation, training, and planning requirements to enhance the security of hazardous materials shipments (see *Federal Register* 67 FR 22028). In addition, the Department
is considering a number of technological and operational means to enhance hazardous materials transportation security.

Since September 11, DOT has taken a number of steps to protect our Nation=s transportation infrastructure from possible terrorist attacks or disruptions:

< The U.S. Coast Guard has enhanced its presence to protect critical bridges, port facilities, and other infrastructure. In addition, the Coast Guard and the Customs Service now require 96-hour advance notice of arrival for ships entering U.S. ports. Moreover, the Coast Guard has deployed sea marshals and small boat escorts to accompany vessels containing critical cargoes and those traveling through sensitive areas. Also, the St.

Lawrence Seaway Development Corporation has been working closely with its Canadian counterpart and the Coast Guard to heighten security on the St. Lawrence River and ensure the protection of ocean access to Great Lakes ports.

< The Coast Guard is currently working nationally, and internationally through the International Maritime Organization (IMO), to develop and implement mandatory requirements for all vessels, facilities, and ports to implement and maintain security plans and programs. Once national programs have been developed, and if adopted by the International community, this initiative will enhance security at ports throughout the world, by raising awareness of the vessels, personnel and cargo operating in the ports, and by placing greater restrictions on access to sensitive areas within the ports.

< The Coast Guard, along with the U.S. Customs Service, other government agencies, and our industry partners, are also pursuing a number of initiatives to improve the security of cargo being shipped through the ports and facilities of the United States. Current initiatives include:

--The development of national and international programs and procedures that will ensure a secure chain of custody for hazardous materials cargo and containers from their point of origin to their destination;

--Identifying and pursuing technologies to track cargoes and containers as they move throughout the transportation system, that will enable authorities to determine when there has been unauthorized access to a container, and detect Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) materials in containers;

--Identifying "Trusted Agents,"(i.e. shippers who have robust security program efforts can be targeted for their container shipments), so that inspection authorities could concentrate

on those containers determined to be a higher risk due to a lack of or minimal security procedures; and

--Developing and supporting enhanced computerized shipping manifest systems, and increasing the time frames of the currently required Advance Notice of Arrival of hazardous cargoes, to capture more information on containers and other cargoes offered for shipment and to identify anomalies in those shipments.

< The Federal Highway Administration (FHWA) has increased efforts to heighten security and surveillance of critical highway infrastructure, including vital connectors to ports, railroads, and military bases. The FHWA works with State departments of transportation and local transportation officials to conduct vulnerability assessments and establish protection strategies.

< The Federal Railroad Administration (FRA) is assisting the rail industry to conduct security assessments of the freight rail system. The security of hazardous materials (including radioactive materials) and defense related shipments have received special emphasis.

< The Federal Motor Carrier Safety Administration and State motor carrier safety officials made on-site visits to tens of thousands of hazardous materials carriers and businesses to identify potential vulnerabilities in carrier security programs and report potentially

serious security issues to appropriate authorities. With the International Association of Chiefs of Police and the Commercial Vehicle Safety Alliance, FMCSA developed outreach material and a training course to raise the awareness of law enforcement officers across the country to the potential threat commercial vehicles can pose if they are used as a weapon.

In most cases security and safety interests are compatible. There may be tensions in particular aspects, however. A quick and easy ability to identify the contents of hazardous materials transportation vehicles is essential for safety reasons, providing rapid notice to transportation workers and emergency responders. However, easy identification of hazardous materials may present concerns from a security standpoint. Avoiding particular routes for transportation security reasons may make sense. However, such actions may have the opposite effect on safety risks for society as a whole. The challenge is to understand and reconcile these conflicts in a way that is balanced and rational.

ROUTING OF HAZARDOUS MATERIALS

The study requirement in § 352(c) of the Department of Transportation and Related Agencies Appropriations Act of Fiscal Year 2002 directs DOT to address the question of whether the Federal Government reviews the condition and suitability of specific transportation routes currently used or proposed to be used for transporting hazardous materials. Generally, the Federal government does not conduct reviews or individualized, detailed evaluations or inspections of specific transportation routes for current or anticipated hazardous materials shipments. This approach is based on the reasoning that a route that is considered safe for passenger and commercial traffic will be safe for hazardous materials shipments, as well.

The study requirement also directs DOT to address the costs and time that would be required to inspect specific transportation routes. Because we do not believe that detailed evaluations of individual hazardous materials routes are necessary to assure safe transportation, this study does not address the costs and time that would be required to ensure adequate inspection of specific transportation routes.

However, the DOT hazardous materials transportation safety program, through the HMR, is designed to ensure that, whatever mode of transportation or transport route is selected, hazardous materials are packaged and handled safely, thus minimizing the possibility of their release should

an incident occur. This regulatory approach allows the integration of hazardous materials into the general transportation system with minimal risk. Shippers and carriers make decisions concerning the appropriate mode of transportation for a specific shipment and the appropriate route by which a specific shipment should travel. For the most part, mode and routing decisions are based on the nature and amount of the material to be transported, the time-sensitivity of the shipment, and cost.

Routing decisions illustrate one of the more obvious choices for hazardous materials transportation risk management -- and some of the complexities. A simple solution would be to avoid routes near population centers. Indeed, recent RSPA security alerts and advisories suggest altering routes to minimize product exposures to communities or populated areas, where practicable.

There are limits to what can be done with routing, however. The greatest use of hazardous materials is near population centers where industrial centers and people are located. Such populated areas have tended to develop around transportation links. Commercial transporters tend to choose routes that minimize the distance and the time between points. Choosing routes through less-populated areas may increase the distance and time in transportation, thus increasing the statistical probability of a hazardous materials incident. Further, in avoiding population centers, shippers and carriers may also be routing shipments through locations where the emergency response capabilities are less sophisticated, or not as well-prepared and -

equipped. Total transportation risk (general transportation risk plus hazardous materials transportation risk) may actually rise due to the increased distances traveled.

The Federal Motor Carrier Safety Regulations (FMCSR; 49 CFR Parts 390-397) include general requirements for routing hazardous materials that are transported by highway. Generally, motor carriers are required to operate their vehicles over routes that do not go through or near heavily populated areas, tunnels, or narrow streets or alleys. Deviations are permitted when there is no practical alternative; to reach terminals, delivery points, or food, fuel, rest, and repair facilities; or in emergency conditions. (See 49 CFR 397.67.)

States, Indian tribes, and local communities may establish, maintain, and enforce routing designations for hazardous materials in quantities that require placarding when transported by motor vehicle. These routing designations are subject to the restrictions of regulations established by FMCSA in 49 CFR Part 397. Part 397 includes specific risk factors that must be considered when designating a route and procedures to be followed by entities that wish to designate or restrict hazardous materials on a specific route. Regulations pertaining to routing designations of non-radioactive hazardous materials are found in Subpart C of Part 397. Regulations relating to designation of preferred routes for transportation of Highway Route Controlled Quantities of radioactive materials (HRCQ, i.e., shipments with high levels of radioactivity such as high level waste, cesium, cobalt sources, spent nuclear fuel) are found in Subpart D of Part 397. FMCSA maintains a National Hazardous Materials Route Registry that

provides the most current listing of the national network of designated hazardous materials routes at http://hazmat.fmcsa.dot.gov.

Within the routing designations established by States, Indian tribes, and local communities and general routing requirements in 49 CFR Part 397, shippers and carriers are responsible for choosing the specific route for each highway shipment of hazardous materials. Factors considered in these decisions include average accident rates on specific highways, construction zones, and delivery schedules.

In accordance with Subpart D of Part 397, highway carriers of HRCQ shipments must use Apreferred routing.@ Preferred routing restricts transportation to specific Interstate highways that reduce time-in-transit. A preferred route is an Interstate System highway or alternative route selected by State or Tribal authorities in accordance with DOT guidelines. The offeror or carrier, as appropriate, must select the preferred route to be used and prepare a written route plan for the motor vehicle driver and shipper showing origin and destination of shipment, scheduled route, all planned stops, estimated time of departure and arrival, and emergency telephone numbers.

The DOT regulations do not contain specific routing requirements for rail or vessel shipments of hazardous materials. Rail routes for hazardous materials, including radioactive materials, are determined by the shipper and the railroad based on safety, best available trackage, schedule

efficiency, and cost effectiveness. Similarly, for HRCQ shipments of radioactive materials in the water mode, transportation routes used, including ports and facilities, are established primarily by the shipper and carrier, but in consultation with the U.S. Coast Guard. With respect to physical protection of spent nuclear fuel, the NRC requires advance approval of routes used for road and rail shipments and of any U.S. ports where vessels carrying such cargo are scheduled to stop.

The FRA has a program that encompasses safety compliance oversight for high-level radioactive waste and spent nuclear fuel transported by rail. The agency=s *Safety Compliance and Oversight Plan for Rail Transportation of High-Level Radioactive Waste and Spent Nuclear Fuel* (SCOP) focuses on safe and secure transportation of high-level radioactive waste and spent nuclear fuel through enhanced inspections, liaison with shipper route planners, training of railroad employees and emergency responders, and enhancing FRA safety inspection practices and overall safety oversight policies.

Under the SCOP, FRA also prepares an accident prediction model for the highway-rail grade crossings along the intended route and uses this model to assist DOE in coordinating with appropriate State, local, and tribal agencies in route planning activities. In addition, the agency works with DOT=s Office of Intelligence and Security in coordinating security precautions, such as the identification of "safe havens," with the offeror, law enforcement officers, and intelligence communities. Finally, FRA reviews the emergency response plans of the offeror, rail carrier,

and

DOE to ensure that they adequately address the actions to be taken in the unlikely event of an accident or incident involving the train.

Training is an important element of the SCOP. It is FRA=s policy to assist DOE, and the offeror or agent, in the development of emergency response training and safety briefings and to monitor the industry to verify that requisite training and briefings have been performed. FRA also conducts reviews to ensure that train crews who operate the trains in which nuclear materials are transported are properly certified, trained, and experienced in running over the designated routes. FRA also checks to see that these crews have received specific training concerning the nature of the shipments. FRA also coordinates with Operation Lifesaver to increase grade crossing safety awareness and education in communities along designated routes.

CONDITION OF THE U.S. TRANSPORTATION SYSTEM INFRASTRUCTURE

The study requirement in § 352(c) of the Department of Transportation and Related Agencies Appropriations Act of Fiscal Year 2002 asks DOT to assess the costs necessary to make infrastructure improvements that will ensure the safety of current or planned hazardous materials shipments. There is a need for overall improvements to the Nation=s surface transportation infrastructure. However, such improvements are necessitated by increased capacity demand or normal wear-and-tear, not because of any specific risk related to the transportation of radioactive or other hazardous materials. For this reason, this study does not address the costs and time required to complete infrastructure improvements necessary to ensure the safety of current or anticipated hazardous materials and radioactive materials shipments.

HIGHWAY INFRASTRUCTURE

The Nation=s highway transportation infrastructure consists of Federal, State, and locally owned roads and bridges. There are about 4 million miles of public roads in the United States. This mileage is overwhelmingly local and rural. About 3.11 million miles B79 percent of total mileageB are located in rural areas.

About 3 million miles, or 75 percent of the national road system, is locally owned. Federally owned roads make up about 170,000 miles, or 4.3 percent, of the national road system. State-owned roads make up over 800,000 miles, or 20 percent, of the national road system.

The national road system includes 582,976 bridges. About 47 percent of these are State-owned, while 51 percent are locally owned. The remaining 2 percent are Federally owned, privately owned, or their ownership is unclassified.

Current Road Conditions

Roads are evaluated based on pavement conditions, roadway alignment, and lane width.

Pavement condition. Pavement condition affects travel costs, including costs related to vehicle operation, delays, and accidents. Poor road surfaces cause additional wear or damage to vehicle suspensions, wheels, and tires. Delays result from the necessity for vehicles to slow for potholes or very rough pavement. Unexpected changes in surface conditions can lead to accidents. Further, inadequate road surfaces may reduce road friction, which can affect the stopping ability and maneuverability of vehicles.

Pavement condition is measured using the International Roughness Index (IRI) and the Present Serviceability Rating (PSR). The IRI measures the effects of pavement profile on a simulated car model in inches per mile. Pavements with over 170 inches per mile are considered to have unacceptable ride quality. The PSR is a subjective rating system based on a scale of 1 to 5. Only new, or nearly new, superior pavements are likely to be smooth enough and sufficiently distress free to qualify for a rating of 5. Pavement in extremely deteriorated condition, passable only at reduced speeds and considerable ride discomfort, is rated 1 or below. States report IRI

data for the Interstate system, other principal arterials, and rural minor arterials. The majority of data reported for other roads is based on PSR ratings.

Based on the IRI and PSR data reported by the States, 16 percent of the national road system is in very good condition, while an additional 25.3 percent is in good condition. About 40.5 percent of the national road system is in fair condition, 11.6 percent is considered mediocre, and 6.6 percent is in poor condition. Pavement conditions have generally been improving over time. Since 1993, the percentage of road miles in poor condition has decreased from 8.6 to 6.6 percent. The Interstate system supports the largest share of vehicle travel. Interstate pavement conditions continue to improve. The percentage of all Interstate mileage with acceptable ride quality has increased from 91.2 percent to 92.4 percent.

Roadway Alignment. Alignment adequacy affects the level of service and safety of the highway system. Horizontal alignment affects speed and sight distance, while vertical alignment principally affects sight distance. Inadequate alignment can result in speed reductions, especially for trucks, and impaired sight distance. Alignment adequacy is evaluated on a scale from Code 1 (best) to Code 4 (worst). Alignments rated Code 1 meet all appropriate design standards. Alignments rated Code 4 have frequent grades that impair sight distance or severely affect truck speeds, and severely restricted speed limits due to the design of the curves. Adequate alignment is more important on roads with higher travel speeds and/or higher traffic volumes, such as Interstates. More than 90 percent of rural Interstate miles are classified as

Code 1 for both vertical and horizontal alignment. Roadway alignment continues to improve gradually as sections with poor alignment are reconstructed.

Lane Width. Lane width affects safety and capacity. Narrow lanes prevent a road from operating at full capacity. As with roadway alignment, lane width is more crucial on roads and highways with higher travel volumes. High-standard roads are expected to have at least 12-foot lanes. Currently, over 99 percent of all Interstate miles meet the 12-foot standard. Lanes have been widening over time through new construction, reconstruction, and widening projects. Since 1993, rural mileage with lane widths of at least 12 feet increased from 51.8 percent to 53 percent; urban mileage with lane widths of at least 12 feet increased from 64.1 percent to 66.2 percent.

Current Bridge Conditions

The most common indicator used to evaluate the condition of bridges is the number of deficient bridges. There are two types of deficient bridges B structurally deficient and functionally obsolete. Bridges are structurally deficient if they are restricted to light vehicles, require immediate rehabilitation to remain open, or are closed. Bridges are functionally obsolete if they have deck geometry, load carrying capacity, clearance, or approach roadway alignment that no longer meet the criteria for the system of which the bridge is a part. A deficient bridge is not necessarily unsafe or one that requires special posting for speed or weight limitations. A deficient bridge does require significant maintenance, rehabilitation, or, perhaps, replacement.

Some deficient bridges are posted for speed or weight limitations, and may prohibit trucks over a certain weight.

In 1998, 29.6 percent of all bridges were deficient; 16 percent were structurally deficient, and 13.6 percent were functionally obsolete. There are significant differences in bridge deficiencies by level of government ownership. Of the 289,222 bridges owned by local governments, 99,503 (33.4 percent) are deficient. This represents 57.7 percent of the total number of deficient bridges. The majority of these deficiencies are structural. Of Federally owned bridges such as those located in national parks and in national forests, only 23.8 are deficient. The majority of deficiencies on Federally owned bridges are functional. The number of deficient bridges on the highway system has been steadily declining. Since 1995, the percentage of deficient bridges decreased from 31.4 percent to 29.6 percent.

Highway System Management

Management of the highway transportation system is shared among the Federal, State, and local government owners of highways and related infrastructure. Fiscal responsibility for maintaining highways and bridges is also shared. Taken together, all levels of government spent $101.3 billion for highways in 1997. The Federal government funded $21.1 billion, or 20.8 percent; States funded $52.7 billion, or 52.1 percent; and counties, cities, and other local government entities funded $27.5 billion, or 27.1 percent.

Federal Responsibility for Highway Infrastructure

Primary Federal responsibility for overseeing the Nation=s highway infrastructure rests with FHWA, which performs the following functions:

< Funds and supports projects to improve the design, operation, and maintenance of roads and bridges throughout the country. The FHWA provides funds for projects chosen by States and local governments, focusing on the contracting process and compliance with Federal requirements.

< Promotes improved highway planning, design, construction, operation, and maintenance through development of standards and deployment of new strategies and advanced technologies.

< Manages the Federal Lands Highway Program, providing funding and design and construction expertise to build and improve more than 90,000 miles of public roads.

RAIL INFRASTRUCTURE

Rail tracks and associated infrastructure are owned and maintained by the railroads. Track must meet the minimum safety requirements of the *Federal Track Safety Standards*, 49 CFR Part 213. The FRA most recently revised the *Track Safety Standards* in a final rule published on June 22, 1998 (63 FR 33991), which was based on the consensus recommendation of an industry safety advisory group comprised of representatives from railroads, rail labor, States, and FRA. The

standards establish minimum track safety requirements for each of nine track classes, 1-9. Most railroads have maintenance standards that are well above the minimum regulatory requirements.

Each railroad determines the class of track that it will maintain over a particular route or segment, based upon operating requirements and available resources. By publishing a railroad timetable speed that governs train operations, the railroad becomes obligated to maintain the track to the applicable standards and to inspect the track at the frequency required for that track class. For example, if a railroad decides to maintain track to operate freight trains at 60 mph and passenger trains at 80 mph, the railroad would be required to conduct inspections and meet the safety requirements for Class 4 track. The safety standards are more stringent at the higher classes.

The *Track Safety Standards* address the condition of the track roadbed (vegetation, drainage, etc.), geometry (gage, cross level, etc.), appliances (derails, etc.), track structure (rail, cross-ties, switches, etc.), and track inspection. If the track does not meet the requirements of its intended track class, the railroad must initiate immediate remedial action to bring the track in compliance. This involves repairing the track before the operation of trains at the maximum speed, removing the track from service, or placing a speed restriction on that segment of track until the repairs are made. By placing an appropriate speed restriction, the railroad is reducing the track to a lower track class for which the track does meet the standards.

Required Inspections

The *Track Safety Standards* require visual inspections of the track by qualified railroad inspectors. In addition, the standards require continuous automated inspections for internal rail flaws in the higher track classes. Other automated inspections are mandated for Classes 6 - 9. The frequency of inspection for visual inspections is based on the type of track (e.g. main, siding, or yard), the track class, the amount of accumulated tonnage, and the type of traffic (e.g. passenger). For example, if a main track or siding carries passenger trains or more than 10 million gross tons of traffic during the preceding calendar year in Class 1 through 3 track, the railroad must visually inspect the track by walking or riding over the track in a vehicle at an appropriate speed at a frequency of at least once per week. Class 4 and 5 track must be inspected visually at least twice each week. Most railroads have policies to inspect track more often than required by the minimum standards.

A railroad must conduct inspections for internal rail flaws using equipment known as Adetector cars@ in all class 3 and above track. The frequency of inspections is based on the type of traffic and the tonnage on the line. For example, Class 3 track without passenger trains must be inspected at least once every 30 million gross tons or once a year, whichever is longer. Many railroads conduct inspections several times each year on heavy tonnage routes. However, despite the improvements in detection technology and the quality of rail steel, broken rail derailments continue to be the leading category of track-caused derailments in highly utilized

track.

When the railroad discovers conditions that do not meet the applicable track safety standards, the railroad is obligated to take immediate action. The railroad must also keep records of the deviations found by the railroad inspectors and the remedial action taken. These records must be kept by the railroad for one year and must be available for FRA review. The most recent revision of the track safety standards permits the railroads to maintain the inspection records electronically. Two major railroads have already realized the benefits of reduced paperwork and improved communication resulting from the new electronic systems.

On August 30, 2000, FRA published a policy statement on the structural safety of railroad bridges that provides guidelines for bridge inspection and maintenance programs. The policy Statement affirms FRA's readiness to address any immediate safety issues posed by operations over bridges. The policy statement is founded on a field survey that determined that the major railroads maintain active and appropriate bridge inspection and maintenance programs, but that smaller railroads vary widely in their bridge management capabilities.

Condition of Track and Associated Infrastructure

The condition of track on major freight and passenger routes is good to excellent and is well above the minimum safety standards. Railroads generally exceed the minimum safety standards to avoid accidents and expedite train movements. Through such options as continuous welded

rail, concrete ties, improved rail quality, and other technologies, the railroads have found ways to support heavier axle loads. Improved railroad car designs enabled railroads to reduce the forces on the rail, despite the increased axle loads. Railroad bridges and tunnels on the major railroads are in suitable condition to safely handle the present levels of railroad traffic. The bridges on many smaller railroads, however, do not have the capacity to sustain traffic with the heavier cars that are becoming more common. Lacking the capital resources for major bridge upgrades, these smaller railroads will be unable to handle these heavier cars, with a resulting diversion of the traffic to highways for the entire movement.

Mergers in the last few years have produced improvements in some lines. However, the railroads continue to reduce their workforces, and in some cases the local track forces responsible for inspection and routine spot maintenance have been challenged with larger territories. FRA work under Safety Assurance and Compliance Programs on the individual railroads has indicated that, in notable instances (such as documented in a joint labor/management/FRA manpower pilot project on an eastern railroad) this lack of adequate local forces has contributed to the presence of undetected or unremedied defective conditions. Accumulated tonnages that are greater than experienced in previous years have also accelerated rail fatigue (with the potential for broken rails) and have necessitated increased attention to program maintenance.

FRA continues to work aggressively with the railroads to identify and address these concerns.

Nevertheless, the general trend line of reductions in track-caused accidents leveled off in the late 1990's, despite the improved technologies and better understanding about vehicle/track interaction and analyses of derailments. In fact, in the years, 1999, 2000, and 2001, FRA has noted a small increase in track-caused accidents. While this increase resulted primarily from more numerous yard derailments, and while a small increase in yard derailments does not constitute a major concern with respect to the release of hazardous materials, it does indicate the need to be vigilant with respect to future main line track conditions. Over the past several years, the rate of track-caused derailments on main tracks *per million ton-miles* has continued to decline (indicating that the railroads are making progress in delivering freight safely) but the rate *per million train-miles* has risen slightly.

Ongoing/Planned Improvements to Rail Infrastructure

Increased traffic and axle loadings place more demands on the nation=s rail infrastructure. To address these concerns, major railroads are planning to expand the capacity of their networks by Adouble-tracking@ large segments. This reverses a trend a few decades ago when railroads were removing some tracks to reduce costs. Regional and short line railroads face the challenges of dealing with an aging infrastructure.

The rail industry is capital-intensive and requires a significant infusion of capital on a regular basis to maintain operations. In the case of costs related to track and structures, it is necessary to include expenditures treated as both capital and maintenance items to understand the magnitude

of the railroads' investments. The amount of investment depends on the service level, traffic mix, and miles of track, among other factors. According to the most recent information available from the Association of American Railroads, these expenditures translate in the following physical features: about 5,400 miles of rail laid (including both new and relay), down from 6,000 in 1999; and about 11.5 million ties laid (including both replacement and addition), down from 12.1 million in 1999.

Railroads are installing premium materials such as new continuous welded rail, concrete ties, elastic fasteners, and improved switches. Railroads are placing a high degree of emphasis on roadway worker safety. However, with the challenges presented by the increased traffic and higher car loadings, it is imperative that the railroad industry and FRA remain vigilant to maintain the safety of the track and structures.

Approximately 100 FRA and State Track Safety Inspectors monitor the safety of the track and structures across the Nation. To assist in identifying track segments that may present a concern, FRA operates a technologically advanced track geometry car as part of FRA=s Automated Track Inspection Program (ATIP). By establishing Safety Assurance and Compliance Programs on many of the railroads, FRA is able to work with the industry to identify and correct systemic problems on the railroads. These partnerships with railroads and their employees enable FRA to leverage its small inspector force. For example, FRA recently began a Rail Integrity Audit to determine the best practices present in the industry for the management of rail flaw detection

surveys, rail relays, grinding, and other issues related to rail management.

MARINE INFRASTRUCTURE

The U.S. Marine Transportation System (MTS) consists of waterways, ports and their intermodal connections, vessels, vehicles, and system users. The MTS is primarily an aggregation of State, local, or privately owned facilities and private companies. As with the U.S. economy as a whole, decision-making and investment are driven primarily by the marketplace. In addition, the Federal government cooperates with State and local governments to manage, finance, and operate the MTS.

The MTS includes more than 1,000 harbor channels and 25,000 miles of inland, intracoastal, and coastal waterways. The system also includes over 300 ports and upwards of 3,700 terminals that handle passenger and cargo movements. Annually, the MTS moves more than 2 billion tons of domestic and international freight, including more than 3.3 billion barrels of oil. The MTS also transports 134 million passengers by ferry, serves 78 million recreational boaters, and hosts more than 5 million cruise ship passengers. In addition, the MTS supports 110,000 commercial fishing vessels.

Ships and barges have the fewest accidental spills or collisions of all forms of transportation.

They routinely load and discharge millions of barrels of petroleum, and tons of coal, grain, chemicals, and other essential products throughout the United States without incident.

Waterways

The principal components of the MTS waterway infrastructure are harbor channels, inland and intra-coastal waterways, and locks and dams.

Harbor channels. There are 926 Federal harbor channel projects, both deep draft and shallow draft, that support the U.S. port system. In addition, non-Federal interests maintain and improve a network of channels, connecting channels, and berths.

The U.S. deep-water port system includes more than 300 Federal harbor channel projects. There are 51 ports with depths of 40 feet or more. Although some ports have natural deep water, most Federal harbor channels are deepened channels. Deepening projects may include breakwaters, seawalls, channel control structures, dredged material disposal sites, drift removal components, and related features. There is no one-to-one relationship between ports and Federal channels. Some U.S. ports include several Federal harbor channel projects with varying depths. A few ports have no Federal channels. In addition, a single Federal harbor channel may provide access to more than one port.

Inland and intracoastal waterways. There about 25,000 miles of inland, intracoastal, and

coastal channels and waterways in the United States. Of this total, nearly 12,000 miles of network make up the commercially active inland and intracoastal waterway system. This network includes 10,867 miles of inland waterways maintained with fuel tax revenues. Fuel-taxed waterways comprise nearly all of the commercially significant inland and intracoastal waterways in the United States.

The Mississippi River and its tributaries and the Gulf Intracoastal Waterway connect Gulf Coast ports with major inland ports. The controlling depth of 45 feet in the section of the Mississippi River from Baton Rouge to the Gulf of Mexico allows ocean shipping to connect with barge traffic. On the Great Lakes, seven key waterways must be kept navigable during average or severe winters when ice formation would otherwise restrict or prohibit ship movements. The U.S. Coast Guard conducts icebreaking operations to keep harbors and channels open for commercial navigation during the winter.

The Atlantic Intracoastal Waterway is a combination of protected coastal waterways and connecting canal segments that parallel the Atlantic Coast between Norfolk, Virginia, and Jacksonville, Florida. Another section, known as the Intracoastal Waterway, continues from Jacksonville south to Miami. A shallower, partially protected stretch of the Intra-coastal Waterway extends along the Atlantic Ocean side of the Delmarva Peninsula in Virginia and along the coast of New Jersey and Long Island. The shallow-draft, inland waterways of the Pacific Coast include the Columbia-Snake Waterway and the Willamette River above Portland,

Oregon.

Locks and dams. Locks and dams allow vessels to move up or down when traveling navigable waterways with different water levels. There are 192 commercially active lock sites with 238 chambers in the Federal navigation system. Of these, 171 lock sites with 215 chambers are in segments designated as fuel-taxed waterways.

Ports

The U.S. port system consists of 326 coastal, Great Lakes, and shallow-draft ports. Within the individual ports, cargo is transferred between water and landside transportation modes at both publicly and privately owned marine terminals. Major ports on the Atlantic and Pacific coasts serve container trades, while the major Gulf Coast ports are involved primarily in tanker and dry bulk trades. Deep-draft seaport and Great Lakes port facilities include over 1,900 terminals that contain over 3,000 berths. In addition, the MTS includes more than 1,800 river terminals with shallow water depths.

Support Infrastructure

Information systems help support the MTS. Information systems include Intelligent Transportation Systems (ITS) and navigation systems. Information technology has the potential to transform the MTS and the intermodal freight industry by enabling it to integrate operations across the supply chain. Advanced communication and information systems can provide real-time information on intermodal freight operations and congestion within the physical

transportation system. Increasing our ability to share information about congestion and operations across intermodal freight systems is critical to increasing capacity and improving reliability.

Navigation systems. Navigation systems are key to safe operations within the MTS. Vessels, both large and small, rely upon existing public and private navigation systems to transit the Nation=s waterways and ports. These vessels, possibly carrying large numbers of passengers or environmentally harmful cargoes, have the potential to cause significant accidental injury and damage. The National Oceanic and Atmospheric Administration (NOAA), U.S. Coast Guard, U.S. Army Corps of Engineers (USACE), and the National Imagery and Mapping Agency (NIMA) cooperate to provide navigation warning information to mariners. These are used to update nautical charts and publications issued by NOAA and NIMA. The Coast Guard issues the Local Notices to Mariners, the USACE issues Notices to Navigation Interests, and NIMA issues worldwide Notices to Mariners, including U.S. notices of interest to international shipping. U.S.
notices must be coordinated with the national charting authority, NOAA, and with other information providers such as the port authorities.

Short-range aids to navigation help mariners operate safely and efficiently. Used in conjunction with nautical charts, these aids to navigation provide mariners with visual directions that guide them away from dangers by marking channels, shoals, and hazards, and help them to avoid groundings, obstructions to navigation, and collisions with other vessels. Among the many

factors considered when establishing aids to navigation are depth of water, bottom composition, tides and currents, width of the waterway, and size and types of vessels (naval, commercial, recreational) using a waterway. Additionally, the requirements of all mariners using a waterway are considered when establishing aids to navigation. The Coast Guard maintains approximately 50,000 Federal aids to navigation and oversees an additional 50,000 private aids to navigation. Many of the 50,000 Federal aids mark channels to and from commercial or military ports used by deep-draft vessels. However, the largest percentage of aids is located in shallow waters frequented primarily by shallow-draft commercial operators and recreational boaters.

Although not currently available as an integrated information suite, mariners require real-time access to integrated hydrographic services, including bathymetry, shoreline, detailed large-scale digital vector charts, precise positioning information, and real-time and predicted oceanographic and meteorological data. Integrating this information into a data suite is essential to providing the mariner with a three-dimensional view of the significant hazards to navigation. Accurate bathymetric information implies recent acquisition of full bottom surveys. Accurate shoreline information implies recent data from aerial surveys or satellite remote sensing. Detailed large-scale digital vector charts, coupled with precise positioning, enable precision docking and undocking and waterway transit. Real-time and predicted information provide the reliable safety margins and competitive advantage necessary to conduct modern just-in-time intermodal commerce. In the event of hazardous materials accidents, they facilitate accurate containment, cleanup, and restoration response. The nautical chart, whether paper or electronic, is the

background on which this information suite is integrated and displayed. A chart update service will refresh this most fundamental tool of safe navigation on a weekly basis. These navigational system components and their integration are offered through various programs supported by the Hydrographic Services Act of 1998. One such element is NOAA=s Physical Oceanographic Real-Time System, which provides real-time tide and current information. Positioning technologies are centered on the Differential Global Positioning System.

Vessel Traffic Services (VTS) promote the safe and orderly flow of traffic through a port or waterway. The USCG operates nine VTSs. In the Port of Los Angeles-Long Beach, a tenth VTS is operated jointly by the USCG and the local Marine Exchange. The USACE operates a VTS in the Cape Cod Canal. Port authorities and pilots= associations operate VTS advisory services in Tampa Bay and Delaware River. VTSs increase safety and efficiency by providing navigational information, traffic organization, and navigation assistance services. Ninety-nine percent of all communication between the VTS and participating vessels is information in nature.

MTS Management

The MTS is managed by a combination of public and private sector organizations at the national, regional, and local levels. Federal, State, and local governments, as well as private sector entities, share fiscal responsibility within the system. The MTS is highly decentralized. Investment decisions are currently made by many users and service providers, both public and private, often in partnerships that are intended to take advantage of competitive opportunities in

the marketplace. However, overlying this complex investment environment is a general framework, established in the U.S. Constitution and through long-standing practice, that places responsibility for the development and operation of landside infrastructure with State and local governments and the private sector. Responsibility for construction and maintenance of common waterways rests with the Federal government, while responsibility for private channels, approaches, and berths rests with non-Federal stakeholders.

Federal Responsibility for Marine Infrastructure

The Federal government plays an integral role in managing the MTS. This responsibility is spread across a number of Federal agencies that provide leadership, expertise, technical assistance, advice, resources, and information, and promote system mobility, safety, environmental protection, and security. Following is a list of the relevant agencies and a brief description of their roles.

< The U.S. Coast Guard is responsible for providing a safe, secure, efficient, and navigable waterway system to support domestic commerce, international trade, and the military sealift requirements for national defense. Coast Guard responsibilities include: (1) long- and short-range aides to navigation; (2) charting, tide/current/pilotage information through notices to mariners; (3) vessel traffic services; (4) domestic and international icebreaking and patrol services; (5) technical assistance and advice; (6) vessel safety standards and inspections; and (7) facilitation of regional and local stakeholder groups to enhance the safe, secure, efficient, and environmentally safe movement of goods and

people through the HTS. The Coast Guard is also responsible for approving the location and plans of bridges and causeways constructed across navigable waters of the United States, approving the location and plans of international bridges, and alteration of bridges found to be unreasonable obstructions to navigation. In addition, the Coast Guard plays a lead role in coordinating the complex responsibilities for management of the MTS by chairing the Interagency Committee on the MTS (ICMTS). ICMTS consists of 18 Federal agencies with jurisdiction over portions of the MTS. The agencies work through ICMTS to assure effective management of the system.

< The Maritime Administration (MARAD) provides technical assistance in port, intermodal, and advanced cargo handling technologies to government and private entities and assists in environmental compliance, planning, management, and operations. MARAD is the Federal sponsor for the Marine Transportation System National Advisory Council (MTSNAC). MTSNAC is an organization of 30 commercial transportation firms, trade associations, State and local public entities, recreational boating interests, academics, and environmental groups. MTSNAC was established in 2000 to advise the Secretary of Transportation on the conditions and needs of the MTS. MARAD also operates the United States Merchant Marine Academy (USMMA) at Kings Point, New York. The USMMA provides a four-year undergraduate program, which leads to a Bachelor of Science degree and U.S. Coast Guard license as a Third Mate or Third Assistant Engineer. The Global Maritime and Transportation School (GMATS) also operates on the USMMA campus. The GMATS offers extensive maritime and

transportation professional education program.

< The U.S. Army Corps of Engineers (USACE) plans, designs, builds, and operates water resources and other civil works projects, including navigation and flood control projects. The USACE is responsible for maintaining and improving more than 12,000 miles of inland waterways and for operating 235 locks. The USACE also maintains 300 commercial harbors and more than 600 smaller harbors.

Outlook for the Future

The total volume of domestic and international marine trade is expected to more than double over the next 20 years. The number of recreational users of the MTS is expected to grow by over 65 percent. Vessel types are also changing, with larger freight ships, higher speed ferries, and small, high-speed personal watercraft. The increased use, coupled with vessel size and speed will place additional demands on the aged and obsolete infrastructure of many of our ports and waterways and will add stress to the safety and mobility mechanisms used to manage the MTS. Key infrastructure issues include:

< *Dredging and marking the harbor channels that connect U.S. ports to the world.* Larger vessels, while more cost-efficient, require deeper waterways. Overall, the Nation=s future dredging requirements can be expected to grow. One of the challenges associated with dredging projects is managing the dredging and disposal of dredged material in an environmentally sound manner.

< *Modernizing locks and dams to regulate water flow and facilitate commerce.* More than

40 percent of inland waterway locks and dams are at least 50 years old. Many locks are undersized for modern commercial barge movements. A large number of tows have to break down and reassemble their barges at each lock because of inadequate lock size.

This lengthens transit times and produces queues at locks, thereby increasing operating costs and, ultimately, the price consumers pay for the goods being transported.

< *Advancing computer, communications, and navigation technologies to increase the productivity, safety, and security of the MTS.* Such technologies include Intelligent Transportation Systems, such as Differential Global Positioning Systems, Vessel Traffic Services, Automated Identification Systems, Physical Oceanographic Real-Time Systems, and Electronic Navigational Charts. The Coast Guard is embracing an emerging technology, the Automatic Identification Systems (AIS), as the principal technology for VTS information exchange systems and to improve navigation safety in non-VTS areas. (AIS) is based on shipborne radio transponders that repeatedly broadcast vital information about the vessel. This information includes data such as: vessel identification, type, position, course, speed, dimensions, and type of cargo. When coupled with an appropriate display capability, the AIS transponder approach gives real time navigation and vessel traffic information to the mariner in the wheelhouse. An important aspect of AIS is that it electronically exchanges digital information between all AIS equipped vessels and thereby reduces the intrusive voice radio traffic associated with congested ports. Within a Vessel Traffic Service Area, AIS transponders will manage the

exchange of data between vessels and the shore-based Vessel Traffic Center. The VTS could enhance the information by including up to the minute water depths, weather, current speed and direction or other safety related information. The mariner may then consult the display to make better decisions on collision avoidance and navigation. Outside a VTS area, AIS

would work in ship-to-ship mode. The transponders would broadcast information, and would in turn receive information from transponder-equipped ships nearby.

Recruiting and retaining a qualified MTS workforce. There is a critical shortage, both nationally and internationally of qualified MTS workers to operate the various components of the system, in particular the waterside. Because we depend on the MTS not only to feed and clothe our nation, but also to support our security objectives, it is vital that we address this problem.

EMERGENCY RESPONSE PLANNING AND TRAINING

Overview

The study requirement in § 352(c) of the Fiscal Year 2002 Department of Transportation and Related Agencies Appropriations Act directs DOT to assess whether emergency response personnel are adequately trained and equipped and, if not, to estimate the costs and time required to ensure that they are adequately trained and equipped. In a recent report to Congress [2], FEMA noted that no formal standards exist to evaluate the Nation's overall emergency readiness. The central conclusion of this report is that the States have the basic capabilities in place to effectively respond to disasters that normally confront them. States facing specific risks, such as being located in areas prone to hurricanes or earthquakes, near chemical stockpile disposal sites or nuclear power facilities, assessed themselves as having a greater capability to handle those risks than other States. Where there is a need to improve emergency response capabilities, the Federal government provides financial support as requested by States and local jurisdictions to address needs specific to each jurisdiction. Further, equipment and training provided to local agencies for one purpose can be used for other purposes. For instance, some breathing apparatus used in firefighting can also be used in responding to a hazardous material incident. Similarly, someone trained in hazardous materials response would also be prepared to assist in a flammable gas threat resulting from a national disaster. This synergy allows localities to leverage Federal resources and tailor their investments to their unique risk profiles. For these reasons, it is

2 Federal Emergency Management Agency: "State Capability Assessment for Readiness: A Report to the United States Senate Committee on Appropriations, December 10, 1997.

difficult to quantify the costs and time required to assure that all emergency response personnel are adequately trained and equipped, and this study does not attempt to do so.

Because of the events of September 11, State and local governments are more aware of the risks associated with terrorism. In response to these concerns, President George W. Bush has created the Office of Homeland Security, whose mission is to strengthen the safety and security of the American people. This office will coordinate the executive branch's efforts to respond and recover from terrorist attacks at home. The President's Budget for FY 2003 includes an increase of 1,000 percent for first responders. All aspects of first response—including building fires, hazardous materials incidents and automobile accidents—will benefit from the increased funding.

The overall record of hazardous materials transportation is good. Despite dramatic increases in the number of shipments and the volume of hazardous materials being shipped over the past decade, the rate of reported hazardous materials incidents, and the consequences of those incidents, have been declining. Most hazardous materials incidents involve a small quantity of hazardous material released with little or no consequence. A small percentage of incidents -- about 400 per year -- are considered serious, and require a more sophisticated, informed response.

Numerous offices within multiple Federal, State, and local agencies and departments are

responsible for hazardous materials accident prevention, preparedness, and response. The current emergency preparedness and response system addresses all phases in the life of a hazardous material -- from design, production, storage, transportation and use, to disposal. Historically, the primary responsibility for emergency preparedness and response has been with State and local governments. Local government agencies are responsible for contingency planning and response to hazardous material emergencies -- an outgrowth of their responsibilities to respond to fires, natural disasters, or other non-hazardous materials emergencies. State and local agencies work with hazardous materials shippers and carriers to respond to and clean-up hazardous materials releases.

There are currently almost 2 million people responsible for emergency preparedness and response. These include 250,000 professional firefighters, 750,000 volunteer firefighters, 556,000 police officers, 291,000 sheriffs= personnel, and 155,000 emergency response technicians.

With respect to radioactive materials transportation, NRC has surveyed State and Tribal emergency response capabilities for transportation incidents (NUREG/CR-5399, 1990). Such capabilities support adequate safety for current shipment levels. As envisioned by the Nuclear Waste Policy Act, the current level of Federal, state, local and tribal training, preparedness and

equipment can be expanded, as necessary, in the years leading up to a larger-scale spent nuclear

fuel shipment campaign.

Federal Agencies Responsible for Emergency Response

The primary Federal agencies with a role in emergency preparedness for hazardous materials incidents or emergencies are FEMA, DOT, DOE, EPA, and NRC. Other Federal agencies provide funding for equipment procurement and planning and training activities to prepare for other kinds of incidents -- such as non-hazardous materials vehicle accidents, natural disasters, and security threats.

The National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan or NCP, is the Federal government's blueprint for responding to both oil spills and hazardous substance releases. The National Contingency Plan is the result of our country's efforts to develop a national response capability and promote overall coordination among the hierarchy of responders and contingency plans.

The first National Contingency Plan was developed and published in 1968 in response to a massive oil spill from the oil tanker Torrey Canyon off the coast of England the year before. More than 37 million gallons of crude oil spilled into the water, causing massive environmental damage. To avoid the problems faced by response officials involved in this incident, U.S. officials developed a coordinated approach to cope with potential spills in U.S. waters. The 1968 plan provided the first comprehensive system of accident reporting, spill containment, and

cleanup, and established a response headquarters, a national reaction team, and regional reaction teams (precursors to the current National Response Team (NRT) and Regional Response Teams (RRT)).

Congress has broadened the scope of the National Contingency Plan over the years. As required by the Clean Water Act of 1972, the NCP was revised the following year to include a framework for responding to hazardous substance spills as well as oil discharges. Following the passage of Superfund legislation in 1980, the NCP was broadened to cover releases at hazardous waste sites requiring emergency removal actions. Over the years, additional revisions have been made to the NCP to keep pace with the enactment of legislation. The latest revisions to the NCP were finalized in 1994 to reflect the oil spill provisions of the Oil Pollution Act of 1990.

The National Contingency Plan provides the institutional framework that: (1) defines responsibilities of Federal, State and local governments; (2) describes resources available for response; (3) establishes a hierarchy of response teams; (4) specifies a command structure to oversee spill response; (5) requires Federal, regional and area contingency plans; (6) summarizes State and local emergency planning requirements, as well as response priorities, phases and procedures; and (7) provides procedures for the use of chemicals (e.g., dispersants, shoreline cleaning agents) in removing spilled hazardous materials. This general framework has been retained throughout periodic revisions over the past 30 years.

The NRT is made up of 16 Federal agencies, each with responsibilities and expertise in various

aspects of emergency preparedness and response. With nationwide responsibility for interagency planning, policy, and coordination, the NRT assures that the most valuable tool for an emergency B readiness B is available for incidents of all sizes and kinds. Prior to an incident, the NRT provides policy guidance and assistance. During an incident, the NRT provides technical advice and access to resources and equipment. EPA is the NRT chair. The U.S. Coast Guard is the vice chair. This interagency and coordination network is replicated at the regional, sub-regional, and local levels.

Federal On-Scene Coordinators (FOSCs) coordinate or direct response resources and efforts during an incident. The FOSC oversees area planning, provides access to the expertise of the 16 NRT agencies, and is a valuable source of support and information to the local response community. The FOSC has immediate access to funding through the Oil Spill Liability Trust Fund for petroleum releases and the Superfund Trust Fund for hazardous substance releases. There are more than 250 EPA and Coast Guard FOSCs located throughout the United States. The Department of Defense and DOE provide FOSCs for incidents that occur at their facilities or under their jurisdiction.

The National Response Center, located at U.S. Coast Guard headquarters and staffed by Coast Guard personnel, is the communications core of the NCP. It is staffed 24 hours a day and receives more than 30,000 incident notifications each year. From these notifications, the National Response Center generates reports and relays them to appropriate FOSCs and to State

emergency response centers. Federal law requires the responsible party to report oil spills, gas and hazardous liquid pipeline releases, chemical releases, and radiological releases to the National Response Center.

Federal Emergency Management Agency (FEMA)

FEMA, under Executive Order 12148, is the lead Federal agency for establishing policies and coordinating the emergency planning, response and assistance functions of the Federal government for all types of threats and emergencies, including hazardous materials incidents, except those involving marine oil spills. FEMA has the lead role in assessing national-level emergency management capabilities and the capabilities of State and local communities to respond to disasters, and in providing Federal assistance to improve these capabilities. Within FEMA:

< The ***Office of National Preparedness*** has been designated lead agency for the President's First Responder Initiative. A total of $3.5 billion is being proposed in FY 2003 to assist with equipment, training, exercises and planning. The First Responder Grant Program consolidates several existing grant programs, including the $220 million Counter-Terrorism program previously administered by the Department of Justice.

< The ***Directorate of Readiness, Response and Recovery*** is currently implementing the Comprehensive HAZMAT Emergency Response-Capability Assessment Program (CHER-CAP) to assist local communities and tribal governments to obtain a greater understanding of hazardous materials risks, identify planning deficiencies, update plans,

train first responders, and stimulate and test the system for strengths and needed improvements. As a voluntary program, CHER-CAP uses the skills and resources of Federal, State, tribal, and local governments, and industry partners, to identify and address local jurisdictions' hazardous materials preparedness needs. It also enhances the community's ability to operate within the National Response System, as described in the National Contingency Plan. EPA and DOT are key Federal partners in CHER-CAP.

< The ***U.S. Fire Administration (USFA)*** supports local fire authorities in four program areas: data collection, public education, training, and technology development. The National Fire Academy, the training arm of the USFA, is a school for fire officers and other allied professionals, providing them with the training they would require to improve fire protection at the local level.

< The ***Federal Radiological Emergency Response Plan (FRERP)*** addresses significant potential radiological emergencies. The Plan delineates coordination among 17 Federal agencies in responding to a peacetime radiological emergency.

< The ***Federal Response Plan (FRP)*** is based upon the authority of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The FRP assists State and local governments in dealing with any type of catastrophic disaster beyond their response capabilities. Under the FRP, the NCP is used to address hazardous materials problems caused by a disaster.

Department of Transportation (DOT)

< ***RSPA*** provides technical assistance to the emergency preparedness community. For example, for more than 25 years, RSPA has published and distributed more than 8 million copies of the Emergency Response Guidebook (ERG) to public response organizations nationwide. RSPA also manages the Hazardous Materials Emergency Preparedness (HMEP) Grants program. Funds provided under this program are allocated to States based on a formula that addresses relative risk among States. Under HMEP, $5 million is available annually to States for developing, improving and putting into effect emergency plans, determining the need for hazardous materials response, and studying the hazardous materials flow through communities. Another $7.8 million is available annually for training fire departments and other responders to handle accidents and incidents involving the transportation of hazardous materials.

< **The Coast Guard** maintains the National Strike Force (NSF), comprised of three Strike Teams (Atlantic, Gulf and Pacific Strike Teams) and the National Strike Force Coordination Center. The NSF provides highly trained responders and equipment to support Coast Guard and EPA Federal On Scene Coordinators in mitigation of oil discharges and hazardous substance releases.

Environmental Protection Agency (EPA)

The EPA coordinates preparedness and response for oil discharges and hazardous substances releases in the inland zone. The EPA also maintains the Environmental Response Team, a group of highly trained scientists, engineers, and responders who provide training and technical skills

in sampling and analysis, hazard assessment, and clean-up techniques.

The Emergency Planning and Community Right-to-Know Act, enacted by Congress in 1986 as Title III of the Superfund Amendments and Reauthorization Act (SARA; 42 U.S.C. 11011 et seq.) requires States to establish State and local emergency planning groups to develop chemical emergency response plans for each community. EPCRA also requires facilities to provide information regarding the hazardous materials they have on site to States, local planners, fire departments and, through them, the public. In addition, EPCRA requires notification of releases of certain hazardous substances. This information forms the foundation of both the community emergency response plans and the public-industry dialogue on risks and risk reduction. EPCRA emphasizes prevention, preparedness, and response as key factors in reducing the hazards associated with chemical releases.

Department of Energy (DOE)

The Nuclear Waste Policy Act (NWPA) (as amended) recognizes the need to prepare emergency response personnel for risks unique to radioactive materials. Under Section 180 (C) of the NWPA, DOE is required to plan and implement a program of technical and financial assistance to States for training public safety officials of local governments and Indian tribes, including first responders and inspectors, in jurisdictions where DOE plans to transport radioactive materials. According to DOE, funds will be made available to States and Indian tribes approximately five years before commercial shipments of spent nuclear fuel are planned to begin. An initial

planning grant of up to $150,000 will identify training needs. Up to 25% of the first year funds and 10% of future year funds can go toward the purchase of training equipment.

The DOE Transportation Emergency Preparedness Program (TEPP) addresses transportation and preparedness issues for radioactive materials shipments. DOE has provided funding and training for many of its radioactive materials shipments.

Nuclear Regulatory Commission (NRC)

The NRC regulates the use, possession and transfer of byproduct, source, and special nuclear materials to assure adequate protection of public health and safety, promote the common defense and security, and protect the environment. The NRC is the lead Federal agency for emergency response to radiological events involving NRC-licensed facilities and the transportation of licensed materials. NRC also provides expertise and advice for other radiological incidents.

Department of Labor

The Occupational Safety and Health Administration (OSHA) is the lead Federal agency for protecting the health and safety of workers on the job. As a member of the NRT, OSHA provides advice, assistance and other services necessary to ensure the safety and health of personnel deployed at emergency response sites. OSHA also protects emergency response

personnel from releases of hazardous substances through its Hazardous Waste Operations and

Emergency Response standard (29 CFR 1910.120).

Federal Training Programs

The responsibility to provide training to local public service and volunteer staff rests with State and local agencies, based on risks unique to each jurisdiction. Training emergency response personnel is a continuing process. The staff must be trained to respond to threats, and retrained to keep their capabilities current. Advanced training is required to ensure that staff is capable of assuming a higher command responsibility. Similarly, future resource requirements are determined locally based on economic activity, population and housing growth, new industry, and other evolutionary developments, tempered by practical and fiscal constraints.

Training programs are offered by a number of Federal agencies:

< FEMA offers extensive hazardous materials response training at the National Fire Academy (NFA). Classes are conducted at the NFA campus in Emmitsburg, Maryland. Off-campus courses are offered through relationships with States. In addition, the NFA distributes video, audio and multi-media versions of courses on CD-ROM and the Internet. The NFA trains approximately 7,800 firefighters and others per year. Approximately 30-40 courses are offered.

< The Transportation Safety Institute (TSI) develops and conducts worldwide safety, security, and environmental training, and provides training products, and services for both public and private sectors. TSI trains approximately 50,000 students annually. TSI's

Hazardous Materials Division trains Federal and State enforcement agencies, emergency response personnel and industry (shippers, carriers, manufacturers, etc.) in the complexities of the hazardous materials regulations. Students are instructed on the hazardous materials regulatory requirements for highway, rail, aircraft and vessel; the International Maritime Dangerous Goods Code for ocean vessel shipments; and the International Civil Aviation Organization Technical Instructions (along with the industry standards issued in the International Air Transport Association Dangerous Goods Regulations) for commercial air shipments. TSI also offers specialized classes on radioactive materials, infectious substances, explosives, hazardous wastes and substances, cargo tanks, portable tanks and intermediate bulk containers, cylinders, packaging, instructor training, and the military airlift of hazardous materials.

< The USCG's Container Inspection Training And Assistance Team (CITAT) provides deployable on-site packaged hazardous material inspection and familiarization training to CG units, U.S. Customs Service, and industry, including Hazardous Communications for Responders, Hazardous Awareness for Law Enforcement, Hazardous Materials Transportation, and Explosive Handling Supervisor courses. CITAT also helps coordinate joint inspections with other federal and state enforcement agencies, evaluates specialized inspection equipment (i.e. health and safety equipment, interior scanning equipment, etc.)

< The EPA offers first responder and advanced training through its Environmental Response Team and regional programs.

Other Non-HazMat Federal Resources

Weapons of Mass Destruction (WMD) Preparedness: The Department of Justice provides direct training and technical assistance to State and local jurisdictions to enhance their capacity and preparedness to respond to domestic incidents in the areas of WMD awareness, technical, operations, and terrorist incident command.

Bioterrorism Preparedness: The Department of Health and Human Services is offering $1.1 billion in grants to States in part to enhance the readiness of hospitals to deal with a large number of casualties, and to improve connectivity between hospitals and city, State and local health services. This is in addition to HHS' regular fiscal year 2002 budget request of $345 million for bioterrorism preparedness.

INFORMATION COLLECTION AND DISSEMINATION SYSTEMS

The study requirement in § 352(c) of the 2002 Department of Transportation and Related Agencies Appropriations Act directs DOT to examine the availability of government and commercial information collection and dissemination systems that include timely, complete, and accurate information on current and proposed hazardous materials shipments. There is currently no central data repository where an interested party can go to get precise or predictive information on the flow of hazardous materials in the various modes nor are there active plans to develop such a data repository.

A centralized data collection system is likely to be burdensome to those required to submit data on every shipment as it occurs or as it is anticipated. Moreover, a user at the local level may be overwhelmed with information concerning hazardous materials flow through the community. It is technically possible today to track hazardous materials shipments and provide notification when shipments have left prescribed or registered routes. From a security standpoint, this makes sense only if there is sufficient time to react if such a development occurs. False alarms would create problems and waste resources. Collecting data merely for the sake of collecting data makes little sense. Much remains to be done to determine if centralized information systems are practical, useable, and justifiable. The potential benefits of such systems, as well as their problems, will be reexamined as DOT revisits the concept and considers possible system architecture.

The use of micro-data from the CFS conducted by DOT's Bureau of Transportation Statistics (BTS) and the Department of Commerce would offer some insight into aggregate hazardous material flows through communities. The USCG has had some success in using the U.S. Customs Service's Automated Manifest System as a source of hazmat data for inspection targeting. Other sources might include local industry and industry associations or organizations such as the AAR. Data on rail transportation of hazardous materials are more developed and available than that of other modes. Specialized surveys or studies might offer further detail. Development of information of this type would require a considerable amount of resources.

Section 25 of the Hazardous Materials Transportation Uniform Safety Act of 1990 (HMTUSA), (Pub. L. 101-615, 104 Stat. 3273) required the Secretary of Transportation to conduct a rulemaking to evaluate methods for establishing and operating a central reporting system and computerized telecommunication data center. HMTUSA mandated that the Department contract with the National Academy of Sciences (NAS) to study the feasibility and necessity of establishing and operating a central reporting system and computerized telecommunication data center. Areas of study included: (1) receiving, storing, and retrieving data concerning all daily shipments of hazardous materials; (2) identifying hazardous materials being transported by any mode of transportation; and (3) providing information to facilitate responses to accidents and incidents involving the transportation of hazardous materials.

In conjunction with the NAS study, RSPA issued an ANPRM entitled AImprovements to Hazardous Materials Identification Systems@ on June 9, 1992 (Docket HM-206; 57 FR 24532). Among other hazard communication and emergency response issues, the ANPRM discussed the feasibility of establishing a central reporting system and requested comment from the industry on how such a system could be implemented.

The NAS submitted Special Report 239, *Hazardous Materials Shipment Information for Emergency Response*, to the Congress and the Secretary of Transportation on April 29, 1993. [A copy of the NAS report can be obtained from the Transportation Research Board at 2101 Constitution Avenue, NW, Washington, DC 20418.] The central recommendation of the report advises that the government not attempt to implement a national central reporting system. NAS found the existing hazardous material communication system to be effective, in most instances. Further, NAS determined that the information available at hazardous materials transportation incident sites meets the critical information needs of emergency responders. NAS concluded that a national reporting system would be extremely complicated, burdensome, expensive to implement, and of questionable benefit.

Although we believe this conclusion and the central recommendation of the NAS report are likely still valid, recent advances in technology (including satellite, cellular, and global positioning system technology), computer and internet-based application developments, reduction in information technology costs, and heightened security concerns are causing the

DOT to reconsider what is possible. Instances of customer management of routing and establishment of requirements for the use of such technology already exist for particular shipments of nuclear materials and DoD explosives. However, many obstacles remain to be overcome and, in the end, what might be done may not be justifiable except for the most highly hazardous materials.

Obtaining the type of information necessary to establish a central data repository and information center would require working with major shippers and carriers, some of whom may consider information at this level of detail as proprietary. It should also be noted that easy access to information on specific shipments may present security concerns. For example, information regarding certain shipments of radioactive materials (e.g., spent nuclear fuel) is protected for security reasons pursuant to NRC requirements in 10 CFR Part 73.

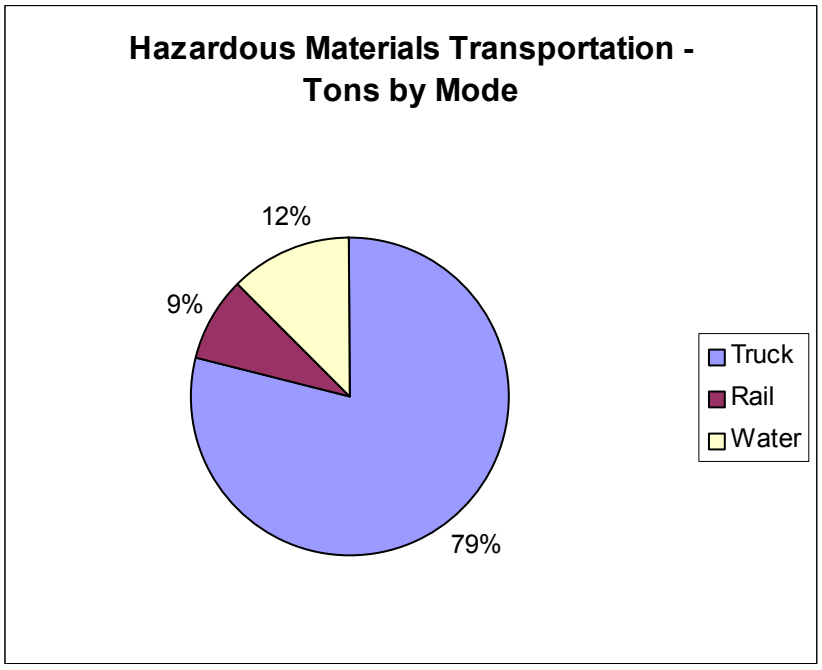
In the meantime, one of our highest priorities is development of more accurate basic data describing hazardous materials transportation. RSPA is working with the Bureau of Transportation Statistics, industry and industry associations, and others to improve the accuracy and availability of information on hazardous materials transportation. RSPA is also considering proposals to gather essential basic information on hazardous material flow as a condition of registration for hazardous materials transportation.

Accidents that result in releases of hazardous materials must be reported to RSPA and are

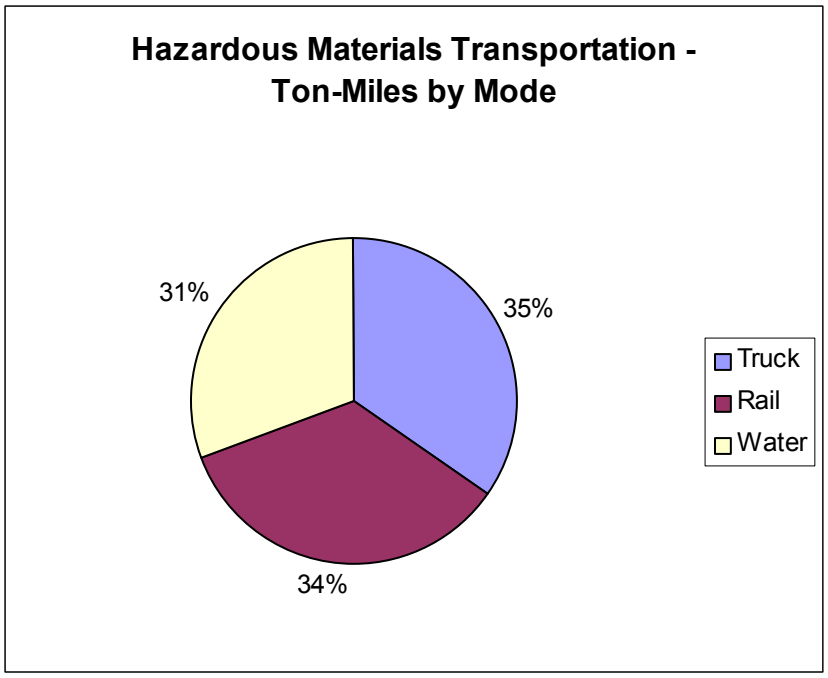
available in databases that can be accessed though the hazardous materials website, http://hazmat.dot.gov . There are currently limited requirements to report accidents involving hazardous materials that do not result in a release of the materials (e.g., those that result in evacuation or the closure of a major transportation artery), other than what may be required by the operating modes for basic accidents, crashes, or derailments. As part of changes to the incident reporting form as discussed earlier, RSPA is looking at establishing requirements for reporting on certain non-release incidents.

APPENDIX A

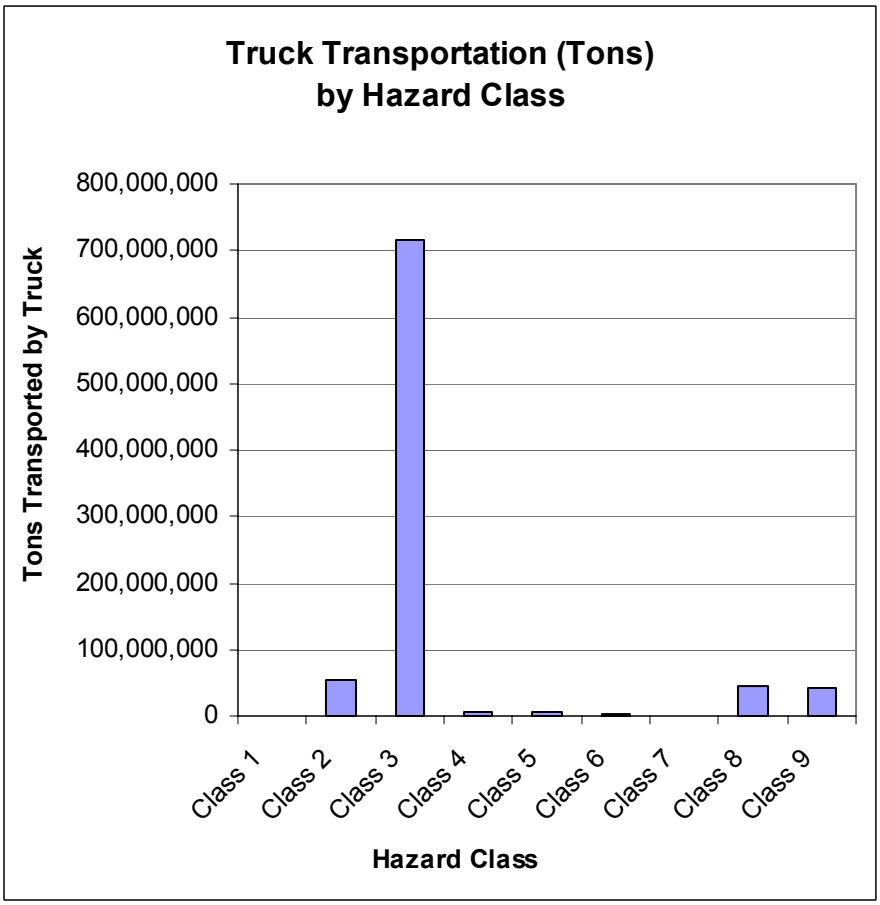
Hazardous Materials Shipments



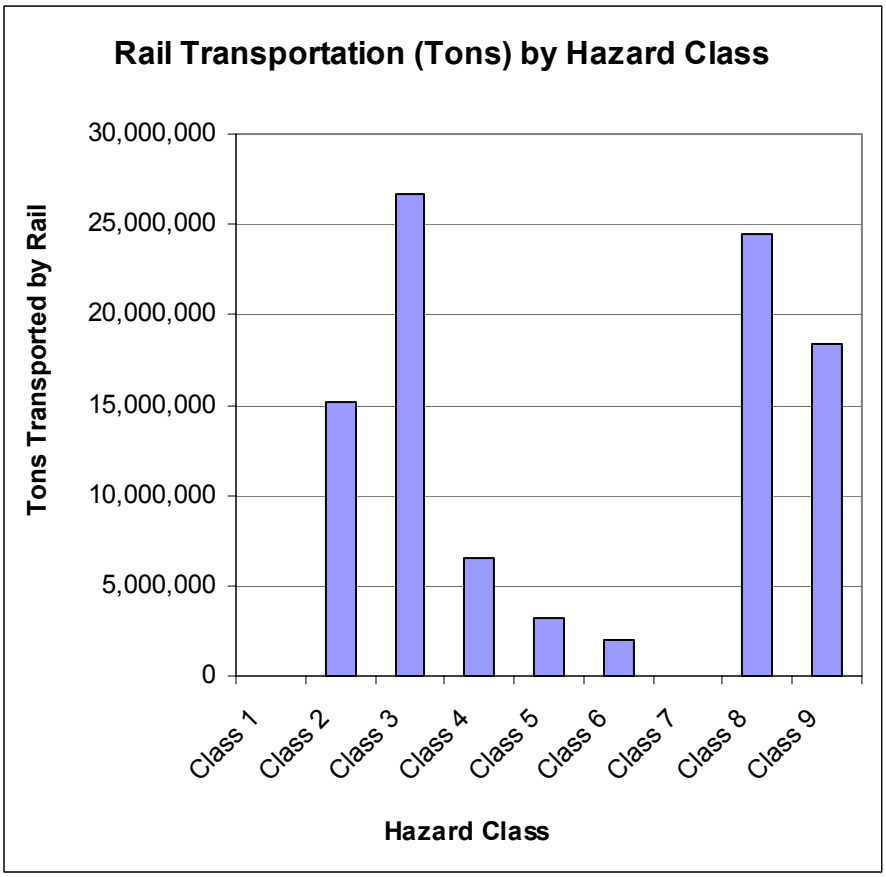
Source: 1997 Commodity Flow Survey; conducted by the Bureau of Transportation Statistics, U.S. Department of Transportation and the Census Bureau, U.S. Department of Commerce.



Source: 1997 Commodity Flow Survey; conducted by the Bureau of Transportation Statistics, U.S. Department of Transportation and the Census Bureau, U.S. Department of Commerce.



Source: 1997 Commodity Flow Survey; conducted by the Bureau of Transportation Statistics, U.S. Department of Transportation and the Census Bureau, U.S. Department of Commerce.



Source: 1997 Commodity Flow Survey; conducted by the Bureau of Transportation Statistics, U.S. Department of Transportation and the Census Bureau, U.S. Department of Commerce.

APPENDIX B

Hazardous Materials Incident Reporting System Data

04/24/2002

U.S. DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS SAFETY
HAZARDOUS MATERIALS INFORMATION SYSTEM
INCIDENTS BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	413	622	929	813	918	1029	1382	1583	1420	1074	10183
HIGHWAY	7831	11080	13995	12764	11916	11864	13017	14984	15087	15398	127936
RAILWAY	1128	1120	1157	1153	1112	1103	989	1074	1054	893	10783
WATER	8	8	6	12	6	5	11	8	17	4	85
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	9380	12830	16087	14742	13952	14001	15399	17649	17578	17369	148987

DEATHS BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	0	0	0	0	110	0	0	0	0	0	110
HIGHWAY	16	15	11	7	8	12	13	8	14	6	110
RAILWAY	0	0	0	0	2	0	0	0	1	0	3
WATER	0	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	16	15	11	7	120	12	13	8	15	6	223

INJURIES BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	23	50	57	33	33	24	20	12	5	13	270
HIGHWAY	465	511	425	296	216	152	151	217	160	92	2685
RAILWAY	116	66	95	71	926	45	22	35	82	29	1487
WATER	0	0	0	0	0	0	2	0	0	0	2
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	604	627	577	400	1175	221	195	264	247	134	4444

DAMAGES BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	98634	88480	177695	100582	87188	336178	266628	286082	271629	308126	2021222
HIGHWAY	23968161	19849049	25242713	22144029	29256831	24719802	28613957	32114394	49284081	60999336	316192353
RAILWAY	11857297	2650931	18673002	8485159	17385078	8355659	16363506	30606652	26520313	21017154	161914751
WATER	143115	213091	92003	173511	120146	38145	1014931	60500	283183	25119	2163744
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	36067207	22801551	44185413	30903281	46849243	33449784	46259022	63067628	76359206	82349735	482292070

04/24/2002

U.S. DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS SAFETY
HAZARDOUS MATERIALS INFORMATION SYSTEM
SERIOUS INCIDENTS*
INCIDENTS BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	10	9	15	11	13	12	23	15	12	11	131
HIGHWAY	308	283	335	329	376	344	340	378	391	334	3418
RAILWAY	57	66	76	68	77	66	69	71	95	66	711
WATER	1	0	1	1	0	0	0	0	2	0	5
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	376	358	427	409	466	422	432	464	500	411	4265

DEATHS BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	0	0	0	0	110	0	0	0	0	0	110
HIGHWAY	16	15	11	7	8	12	13	8	14	6	110
RAILWAY	0	0	0	0	2	0	0	0	1	0	3
WATER	0	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	16	15	11	7	120	12	13	8	15	6	223

INJURIES BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	7	7	33	22	21	4	4	4	0	3	105
HIGHWAY	189	242	188	88	85	66	52	109	40	24	1083
RAILWAY	78	11	45	20	892	6	9	3	57	8	1129
WATER	0	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	274	260	266	130	998	76	65	116	97	35	2317

DAMAGES BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	1500	23175	69871	6041	11410	6209	26168	6262	49134	68034	267804
HIGHWAY	19481769	13169100	14485766	16744937	23826872	18777697	22419418	24158832	41074271	52502466	246641128
RAILWAY	10356264	1935467	12385233	7492260	16619721	7399115	15506579	28777181	25498079	20062796	146032695
WATER	125000	0	0	71141	0	0	0	0	75000	0	271141
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	29964533	15127742	26940870	24314379	40458003	26183021	37952165	52942275	66696484	72633296	393212768

* RSPA defines serious incidents as incidents that involve: a fatality or major injury due to a hazardous material; closure of a major transportation artery or facility or evacuation of six or more persons due to the presence of a hazardous material; or a vehicle accident or derailment resulting in the release of a hazardous material.

U.S. DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS SAFETY
HAZARDOUS MATERIALS INFORMATION SYSTEM
INCIDENTS INVOLVING RADIOACTIVE MATERIALS
INCIDENTS BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	3	7	4	3	8	3	3	5	7	6	49
HIGHWAY	9	1	5	7	8	9	9	8	4	2	62
RAILWAY	0	0	0	0	1	6	18	2	2	0	29
WATER	0	0	1	0	0	0	0	0	0	0	1
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	12	8	10	10	17	18	30	15	13	8	141

DEATHS BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	0	0	0	0	0	0	0	0	0	0	0
HIGHWAY	0	0	0	0	0	0	0	0	0	0	0
RAILWAY	0	0	0	0	0	0	0	0	0	0	0
WATER	0	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0

INJURIES BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	0	4	0	0	0	0	0	0	0	0	4
HIGHWAY	0	0	0	0	0	0	0	0	0	0	0
RAILWAY	0	0	0	0	0	1	0	0	0	0	1
WATER	0	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	4	0	0	0	1	0	0	0	0	5

DAMAGES BY MODE AND INCIDENT YEAR

MODE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
AIR	2000	75	0	50	1500	1853	685	0	0	0	6163
HIGHWAY	65428	15000	28000	26695	50	8000	6485	36400	83000	24694	293752
RAILWAY	0	0	0	0	0	90000	0	0	0	0	90000
WATER	0	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0	0	0	0	0
TOTAL	67428	15075	28000	26745	1550	99853	7170	36400	83000	24694	389915

HAZARDOUS MATERIALS SAFETY
HAZARDOUS MATERIALS INFORMATION SYSTEM

HAZMAT SUMMARY BY CAUSE FOR CALENDAR YEAR 2001

CAUSE	INCIDENTS	MAJ-INJ-MIN		DEATHS	$ DAMAGES
HUMAN ERROR	14980	12	83	1	8563288
PACKAGE FAILURE	2027	2	23	0	2282239
VEHICULAR ACCIDENT/DERAILMENT	329	4	4	5	71406282
OTHER	33	0	6	0	97926
TOTAL - 2001	17369	18	116	6	82349735

NOTE: Due to multiple causes being involved in a single incident, the total above may not correspond to the total in other reports.

NOTE: Cause "other" includes incidents with unreported causes.

HAZARDOUS MATERIALS SAFETY
HAZARDOUS MATERIALS INFORMATION SYSTEM
HAZMAT SUMMARY BY CLASS FOR CALENDAR YEAR 2001

CLASS	INCIDENTS	MAJ-INJ-MIN	DEATHS	$ DAMAGES
CORROSIVE MATERIAL	6989	6	63	0	34447820
FLAMMABLE - COMBUSTIBLE LIQUID	6752	4	18	6	31485734
POISONOUS MATERIALS	1139	1	3	0	4191536
MISCELLANEOUS HAZARDOUS MATERIAL	575	1	6	0	6106486
OXIDIZER	453	0	3	0	1067674
NONFLAMMABLE COMPRESSED GAS	420	1	7	0	1334796
COMBUSTIBLE LIQUID	294	0	2	0	2592201
FLAMMABLE GAS	203	4	4	0	718142
ORGANIC PEROXIDE	175	1	0	0	104389
INFECTIOUS SUBSTANCE (ETIOLOGIC)	139	0	6	0	2329
FLAMMABLE SOLID	117	0	0	0	58743
OTHER REGULATED MATERIAL,CLASS D	47	0	0	0	28504
POISONOUS GAS	37	0	3	0	47547
SPONTANEOUSLY COMBUSTIBLE	16	0	0	0	10320
DANGEROUS WHEN WET MATERIAL	14	0	0	0	24100
EXPLOSIVE NO BLAST HAZARD	8	0	1	0	61025
RADIOACTIVE MATERIAL	8	0	0	0	24694
EXPLOSIVE MASS EXPLOSION HAZARD	3	0	0	0	25120
EXPLOSIVE FIRE HAZARD	2	0	0	0	18075
VERY INSENSITIVE EXPLOSIVE	1	0	0	0	500
TOTAL - 2001	17392	18	116	6	82349735

NOTE: Due to multiple classes being involved in a single incident, the total above may not correspond to the total in other reports.

APPENDIX C

Ensuring Tank Car Safety

Background: Based on research and on the FRA's continuing review of serious accidents involving the transportation of hazardous materials in tank cars in the United States and Canada, the Department issued a number of regulations to improve the survivability of these cars in accidents. The new regulations include a requirement for the installation of a tank-head puncture-resistance system (head protection), a coupler vertical restraint system (shelf couplers), insulation, and a thermal protection system for certain high-risk hazardous material ladings.

The difference between a ''thermal protection system'' and ''insulation'' is that a ''thermal protection system'' protects a tank from a pool or torch-fire environment. In contrast, ''insulation'' protects the lading inside the tank from ambient, temperature differentials, much like home insulation. The record shows that these systems, working in combination, have greatly reduced the potential harm to human health and the environment when tank cars are involved in accidents. Below is a summary of these safety improvements, followed by recent approaches to ensuring the fitness-for-service of cars in service.

Coupler Vertical Restraint System (Shelf Couplers): Research on accidents showed that a frequent cause of hazardous materials releases was couplers that vertically disengaged in

derailments or due to over speed switching and acted as a battering ram to puncture an adjacent tank car. Top and bottom shelf couplers were found to be effective at keeping couplers engaged during switching and in derailments, thereby preventing this type of release. The Department required a coupler vertical restraint system on certain DOT 112/114 tank cars beginning in 1978, DOT 105 cars by 1982, and all cars transporting a hazardous material by 1992. Currently all tank cars, regardless of commodity, require coupler vertical restraint systems.

Tank Head Protection: The Department first introduced tank-head protection requirements after a series of railroad accidents in the late 1960s and early 1970s involving head punctures of tank cars (39 FR 27572 and 41 FR 21475). The requirements of, and criteria for, head protection were based on tests performed by FRA, the AAR, and the Railway Progress Institute (RPI) Tank Car Safety Research and Test Project in the early 1970s. In summary, these tests showed that head punctures, caused by over-speed impacts in railroad classification yards, generally occurred at speeds above 12 mph and often happened when a loaded tank car struck a standing empty tank car, causing the empty car to ''jump'' and ram its coupler into the head of the oncoming tank. FRA research on puncture resistance, which shows that puncture resistance is strongly influenced by impact location, head and jacket thickness, and insulation thickness. Stated differently, research demonstrates that puncture resistance is an inter-related function of head thickness, insulation thickness, and jacket thickness, and that the concept of ''head protection'' must include more than just traditional ''head shields.'' The current Federal regulations require full-scale testing to ensure puncture resistance. A car passes a test when there is no evidence of

leaking after an 18 mph impact of a coupler into a tank head protection system.

Currently, the following commodities require the use of a tank car with head protection:

- X Class 2 materials (flammable, non-flammable, and poisonous gases)
- X Materials poisonous by inhalation
- X Certain hazardous substances that pose a potential risk to human health and the environment (halogenated-organic compounds banned from land disposal.)
- X Any hazardous material transported in a tank car constructed from aluminum or nickel plate.

Thermal Protection: RSPA began to require the application of a thermal protection system (fire resistance system) on tank cars transporting Division 2.1 materials (flammable gases) or ‘‘ethylene oxide’’ (Division 2.3) after a series of major railroad accidents involving fires and ruptures of non-insulated pressure tank cars. The design of and criteria for thermal protection systems were based on tests performed by FRA at the U.S. Army Ballistics Research Laboratory in White Sands, New Mexico, and at the Transportation Test Center in Pueblo, Colorado. These tests revealed that a 127.2 kl (33,600 gallon) non-protected tank car filled with propane (Division 2.1) would rupture, with 40 percent of the lading remaining in the tank car, within 24 minutes after exposure to a pool-fire. Rupture occurs when the residual strength of the tank shell falls below the force generated by the vapor pressure the lading exerted on the inside surface of

the tank shell. Further testing by FRA demonstrated that a tank car filled with propane and equipped with a thermal protection system delayed the thermal rupture of the tank car for 94.5 minutes, by maintaining the shell temperature low enough to vent 98 percent of the lading through the safety relief valve. The current performance standard, requiring exposure to a 100-minute pool fire and a 30-minute torch fire, was chosen because it provides emergency response personnel time to assess the accident and to initiate remedial actions, such as evacuating an area.

With the exception of a regulatory phase-in period for certain "older" tank cars, the regulations now require the use of a tank car with a thermal protection system for all Class 2 materials.

Pressure Relief Devices: In the 1980's, the FRA and the tank car industry developed an analytical program for calculating the effects of fire on railroad tank cars for the purpose of selecting pressure relief device type, sizing, capacity, and pressure settings. These procedures were used to predict various parameters, such as the start-to-discharge time to failure, the residual amount of lading and pressure in the tank at time of failure, the time to reach this pressure level, etc. Further work to enhance the program was made in 1992. Additional work is being conducted to further refine and expand the software. This research should be completed in FY 2002.

Flow capacity and rating of tank car pressure relief devices, especially non-pressure or general-purpose cars, requires an understanding of the thermodynamic behavior of the product in fire

conditions and the performance of the car. This also is the case for cars carrying "poison by inhalation" material. This project will identify parameters and rules to apply in the formulation of proper relief properties for this type of lading, similar to what has been done for pressure tank cars.

Currently, the regulations require a flow rate greater than a calculated value based on a flow capacity formula or that obtained by the thermal model for all Class 2 materials. For other than Class 2 materials, the regulations require calculation of the flow rate solely on the calculated value.

Bottom-Discontinuity Protection: The Department requires bottom-outlet protection on any tank car transporting a hazardous material. This protection must conform to paragraphs E9.00 and E10.00 of the AAR Specifications for Tank Cars, M– 1002, for all new tank cars equipped with bottom unloading services. Existing tank cars, without bottom-discontinuity protection, used for the transportation of hazardous materials must conform to the above paragraphs no later July 1, 2006.

Improved Steels for Tank Cars: The RPI/AAR accident database was studied in an effort to determine whether the steels used for tank car tank construction could be improved for better performance in accidents. It was known that low temperatures negatively affected the steels that were in use, and even though the study indicated that a relatively few releases were preventable by use of improved steels, the builders voluntarily agreed starting in 1987 to use steels with

improved low-temperature properties. FRA continues to c0-fund research into improved steels for tank cars, so that such cars have improved puncture and fatigue-crack growth resistance, and weldability.

Quality Assurance Programs: Starting in the 1980s, AAR imposed a rigorous Quality Assurance certification and auditing program on certain railcar components and, in particular, on the tank car building and repair industries. The program provides a disciplined approach for the examination of contractors' quality management programs and the effectiveness of their implementation. The goal is to ensure that materials, products and services conform to specified requirements. For tank cars, the AAR quality assurance requirements were embodied into Federal law in 1996 to include manufacture, inspection, and repair.

Damage Tolerance Analysis of Tank Car Stub Sills: A follow-up to the stub sill inspection program is Damage Tolerance Analysis (DTA). This investigation has been underway for several years to develop an improved understanding of the structural design requirements for tank cars based on the forces they actually experience in normal operation. The results of this investigation have helped tank car manufacturers improve the designs of their cars so that they are better able to withstand the railroad operating environment. DTA is ultimately intended to develop inspection intervals for each car design to ensure the safe operation of these cars.

Reliability-Centered Maintenance: Accidents, tank car structural failures, and the existence of defects in structural components of railroad tank cars, lead the FRA to believe that measures of

reliability for tank car components must be defined and detailed reliability assessments on a variety of components should be performed. This type of assessment should be performed for each unique component design to define and document boundaries for the reliable use of each tank car. This R&D project is planned to continue through FY 2003.

The reliability of the tank car may be defined as the probability that, when operating under Stated environmental conditions, the tank car will perform its intended function adequately for a specified interval of time. To assess tank car reliability, different modes of tank car failure must be defined and categorized. Although complete and catastrophic failure is easily recognized, tank car performance as a safe packaging of hazardous materials can deteriorate and elements contributing to this deterioration (e.g., corrosion, cracks, pitting, fatigue, changes in material properties) need to be documented. Reliability functions, expected life, hazard functions, and failure rates must to be defined for tank cars. Since the reliability of the tank car will be a function of several design variables and parameters, developing a methodology for combining these random variables into a tank car "strength" function is necessary. The results of this assessment can provide tank car owners with quantitative information to define and document boundaries for the reliable use for each tank car, enabling them to implement guidelines for the maintenance and use of tank cars.

APPENDIX D

Summary of Results of the National Risk Assessment for Selected Hazardous Materials in Transportation and a Comparison of Risks with Other Transportation-Related Risks in the United States*

Risk Type	10-yr Period Fatalities	10-yr Period Injuries	Annual Fatalities	Annual Injuries
Risks primarily due to trauma				
Motor vehicles, including large trucks[a]	416,160	22,500,000	41,616	2,250,000
Large Trucks[b]	50,877	1,327,000	5087	132,700
Large trucks carrying HAZMAT[c]	2,500	66,000	250	6,600
Rail accidents (grade crossing)[d]	5,439	16,905	544	1,691
Rail accidents (nongrade crossing)[d]	5,860	163,377	586	16,338
Risks due to hazardous materials releases only				
Gasoline transportation[e]	108	205	11	21
Highway LP gas transportation[f]	42	154	4.2	15
Explosives transportation[f]	4.9	14	0.49	1.4
TIH highway accidents[f]	3.8	149	0.38	15
TIH highway en route/nonaccidents[f]	0.70	36	0.07	3.6
TIH rail derailments[f]	16	559	1.6	56
TIH rail en route/nonaccidents[f]	2.0	103	0.20	10
Total TIH materials transportation[f]	23	846	2.3	85
Total highway risk for HAZMAT releases[g]	160	558	16	56
Total rail risk for TIH material releases	18	662	1.8	66
Total risk for HAZMAT releases considered in study[g]	178	1,219	18	122

[a] 1994-1998, Injury Facts, National Safety Council, Itasca, Ill. (1996-1999).

[b] 1989-1998, MCSAFE Newsletter, Federal Motor Carrier Safety Administration (May 2000); available at http://www.fmcsa.dot.gov/factsfigs/Mcsafe51.htm.

[c] Taken as 5% of all large truck injuries and fatalities following Harwood, D.W., and E.R. Russell, Present Practices of Highway Transportation of Hazardous Materials, FHWA/RD-89/013, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. (1990).

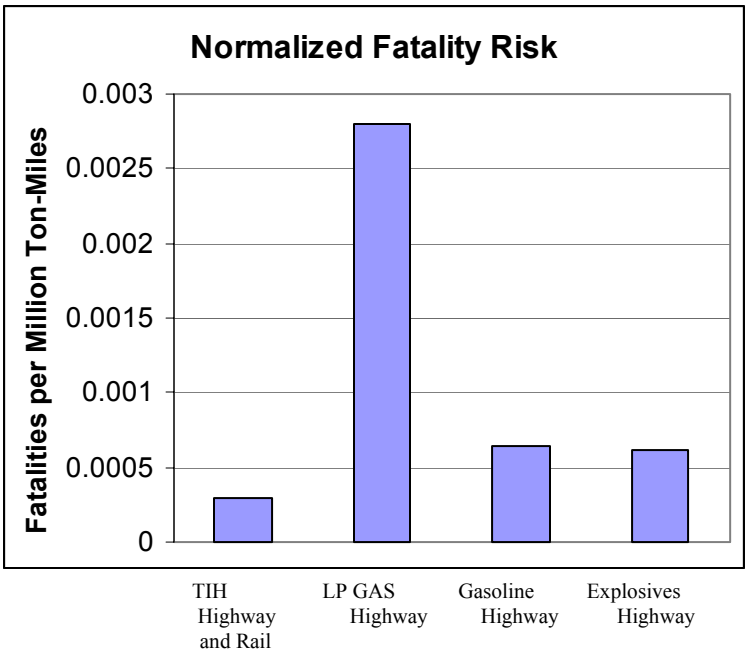
[d] 1989-1998, *Injury Facts*, National Safety Council, Itasca, Ill. (1999).

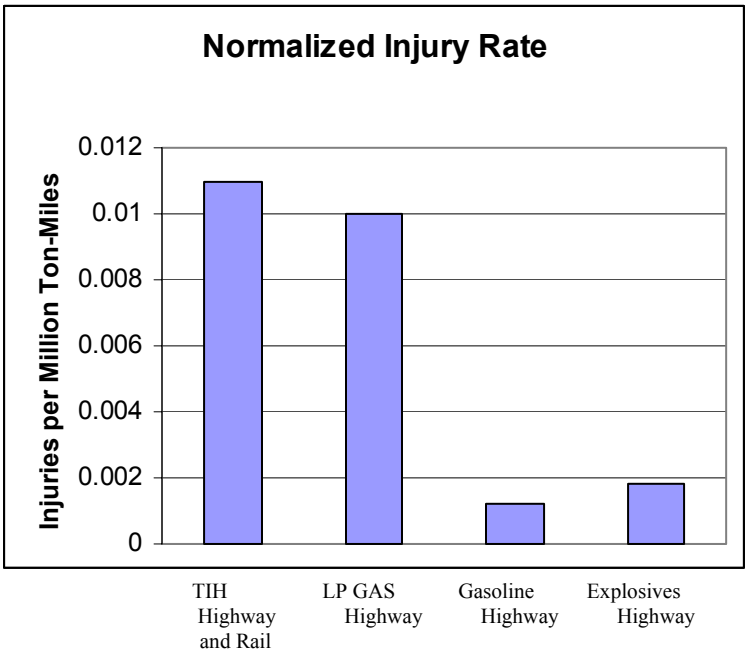
[e] Estimated from the HMIS on the basis of the statistical analysis developed in this report. A factor of 1.5 was applied to estimate total intrastate plus interstate fatalities and injuries and to account for under-reporting.

[f] As estimated in the risk assessment phase of this study. Results for TIH materials include exposure reductions due to sheltering

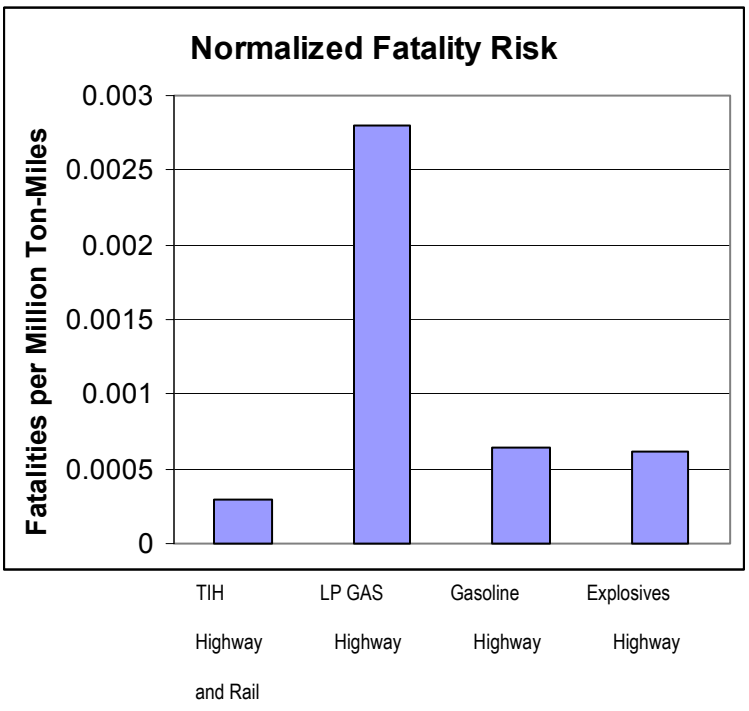
[g] TIH materials, gasoline, LP gas, and explosives.

* In this study, a Monte Carlo simulation was used to model roughly a million to 100 million year sample of accident scenarios and consequences. The study represents the first comprehensive application of techniques in this arena for this purpose. While the model employed is sophisticated, the accuracy of data used is often less precise. Estimates, assumptions, and aggregate number have been used in many cases. ***Specific quantitative results are subject to the limitations previously described and citation and use should be done with care.***





(Results for TIH materials include exposure reductions due to sheltering.)


Normalized Fatality Risk
Fatalities per Million Ton-Miles
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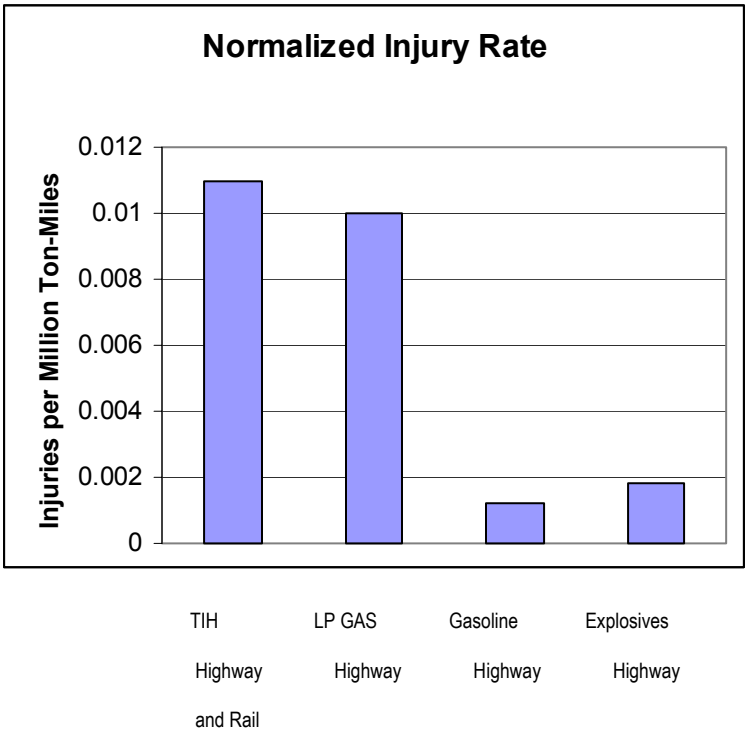
0.0025
0.002
0.0015
0.001
0.0005
0
TIH Highway and Rail
LP GAS Highway
Gasoline Highway
Explosives Highway



(Results for TIH materials include exposure reductions due to sheltering.)