Chapter 2

Data and Information Systems for Hazardous Materials Transportation

Source: National Transportation Safety Board

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Chapter 2

Data and Information Systems for Hazardous Materials Transportation

Government agencies responsible for the transportation of hazardous materials need data about manufacturers, shippers, carriers, commodity flow, and accidents to help them set regulations, plan for accident prevention and emergency response, and target enforcement efforts. The U.S. Department of Transportation (DOT) has lead Federal responsibility for the transportation of hazardous materials, and many related databases are kept by the various administrations within DOT.

Over the last 10 to 15 years the public has become increasingly aware of the special environmental and public health damage that hazardous materials transportation accidents can cause. With this awareness has come an understanding by State and local officials that, while they have responsibility for public safety in their jurisdictions, they do not fully understand the local risk from the transportation of hazardous materials. Moreover, there is a pervasive feeling that Federal regulations and programs do not take special local circumstances into account and, in any case, may not provide an appropriate and acceptable level of safety. These jurisdictions require data about hazardous materials transportation in their areas to help them establish regulatory, enforcement, and emergency response programs that meet their needs.

The level of public knowledge about the amount and destinations of hazardous materials traveling in or near a jurisdiction is generally low, so it is difficult for policymakers to assess risks for their area. * Once officials realize this, often after a severe hazardous materials emergency for which the jurisdiction found itself ill-prepared, they begin to look for information. For example, a 1979 chemical plant fire in downtown Memphis prompted the mayor to initiate a planning and data-collection effort.

*For example, hazardous wastes and radioactive materials represent only about 1 and 2 percent respectively of the hazardous materials shipped annually. The health and environmental risks they present may be matched or exceeded by those of many other commodities shipped routinely, yet these two substances are most frequently the subject of State and local restrictions.

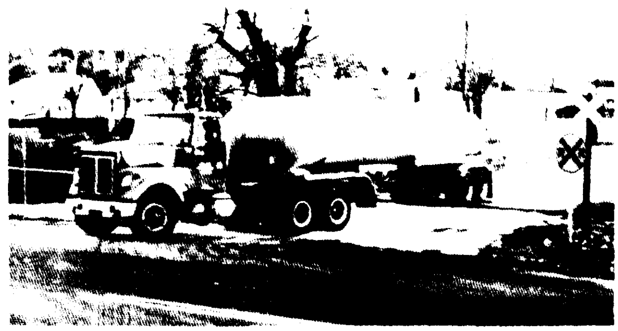


Photo credit: National Transportation Safety Board

Information gathered by State and local officials about commodity movements has been helpful in assessing risks and developing routing requirements.

However, acquiring necessary data is not easy. Such data as exist about facilities housing hazardous materials usually reside in fire departments or building permit files and are local in nature. For information on through shipments, the first step taken by a State or local jurisdiction is usually to seek assistance from Federal data sources. Yet, data and information pertaining to different aspects of hazardous materials transportation are kept by eight Federal agencies (see tables 2-1 and 2-10). The data systems are not interactive and do not use common commodity codes to identify the different hazardous materials. Furthermore, no Federal agency has a mandate to compare all the data or to analyze them for a comprehensive look at hazardous materials transportation patterns, although such information would be useful to Federal agencies in establishing program priorities.

Once they have determined that Federal resources are not helpful, some States and local jurisdictions have undertaken their own studies. After deciding what types of information will be most useful, they can tailor their efforts to meet specific needs. In many cases, demands for better Federal data have been voiced.[1] The increasing interest in better in-

[1]The National League of Cities requested formulation of a Federal database on hazardous materials commodity flow as part of its 1985 transportation policy position.

Table 2=1.—Commodity Flow Databases

Databases	Kept by	Years	Modes	Commodity codes	Conversion table	Strengths	Weakness/drawbacks
Federal:							
Commodity Transportation Survey (CTS)	Bureau of the Census	1977	All	5-digit STCC	Yes	• Multimodal . Consistent selection procedure for all sample data points for all modes • Cross-checked against the census of manufacturers	• Only 5-digit level of commodities • No hazardous materials flags • Only shipments from manufac. turing sites to first destinations • Only "principal" mode is reported
Truck Inventory and Use Survey	Bureau of the Census	1977, 1982	Highway	Simple classes	No	• Covers all trucks used in the United States . Contains hazardous materials-related data items . Sample biased toward heavy trucks	• No flow data Only rudimentary commodity information . Tractor database, not a trailer database—reflects tractor use, not trailer use
Motor Carrier Census	Bureau of Motor Carrier Safety, FHWA	Most recent 5 years	Highway	Hazard classes	No	• Comprehensive listing of carriers and truck fleet operators	. No flow data . Mileage and fleet size data are sparse
Radioactive Materials Routing Report	Office of Hazardous 3 Materials Transportation	1982 to present	Highway	Not applicable		• Almost complete flow data for highway route controlled quantities of radioactive materials • Gives highway route data	• Data is often not recorded for months after shipment • Material description not always complete
Waybill File	Interstate Commerce Commission	At least past 12 years	Rail, TOFC/ COFC	7-digit STCC	Yes	• Well-organized sample (1 '/0) of all rail flows . Database is consistent enough to allow trend analyses • Contains some routing information	• Not all hazardous material flows use the special hazardous materials STCC
Waterborne Commodity Statistics	Army Corps of Engineers	At least 12 years	Water, domestic and international	4-digit WCSC code	Only to a limited extent	• ** "100%" sample of all vessel movements • Complete routing information	Only 163 commodity codes in all, so level of detail is weak . Conversion table has some incorrect cross-references
States:							
Hazardous Waste Shipment Data	States, for the EPA	Varies	Primarily highway	Either EPA codes or OHMT	No	• "100%" sample of all hazardous waste shipments . Actual flow data	Many States do not computerize the data • No consistency to commodity code usage • No routing information
Private:							
TRANSEARCH, FREIGHTSCAN, etc.	Consulting firms	Varies	All	Varies, up to 7-digit for rail	Yes	. Cross-checked against other production/consumption data . Melding of the best available for each mode	• Truck flows predominantly based on the CTS data (see above)
TRAIN II	Association of American Railroads	Current	Rail, TOFC/COFC	7-digit STCC	Yes	• "100°/0" data on all movements for participating railroads . Routing information	Not specifically designed to record car movement histories Not in the public domain
National Motor Truck Data Base	Consulting firms	1977 to present	Highway	Varies, up to 7-digit STCC	Yes, where commodity code is provided	• Focuses on long-distance highway flows • True flow data . Describes the vehicle used to carry the commodity	. Purposely excludes short-haul truck movements, especially in the Northeast • Not in the public domain

ACRONYMS: EPA = Environmental Protection Agency; FHWA = Federal Highway Administration; OHMT = Office of Hazardous Materials Transportation, Research and Special Programs Administration; STCC = Standard Transportation Commodity Code; TOFC/COFC = trailer on flatcar (piggy back)/container on flatcar; WCSC = Waterborne Commerce Statistics Center (Army Corps of Engineers).

SOURCE: Office of Technology Assessment.

formation on movements of hazardous materials and more complete and reliable data on accidents and releases led Congress to identify an analysis of available Federal data and information resources as a specific focus for this Office of Technology Assessment (OTA) report.

By law, DOT is required to report annually on the safety of hazardous materials transportation, including:

1. a thorough statistical compilation of any accidents and casualties involving the transportation of hazardous materials, and
2. an evaluation of the effectiveness of enforcement activities and the degree of voluntary compliance with applicable regulations.[2]

To be responsive to this requirement and prepare an accurate report, DOT would need a comprehensive record of accidents and spills related to hazardous materials and some idea of how much hazardous material is transported annually by each mode. OTA research shows that, in fact, DOT has an incomplete record of accidents and spills and has no documentable idea of how much hazardous material is transported. Moreover, Research and Special Programs Administration (RSPA) officials told OTA that data collection was a secondary function, despite its importance to safety and risk analysis.

Furthermore, because DOT has made no ongoing effort to study hazardous commodity flow, it cannot reliably determine accident rates for various commodities or the containers in which they are carried, or pinpoint high-accident locations or special circumstances. Without sufficient data and accident analysis, DOT cannot plan adequately or set priorities for changing container and vehicle regulations to address risks and problems or evaluate technology advances. For a general discussion of the nature of risk assessment, see box 2A.

With OTA assistance, a contractor collected and studied relevant databases and other information currently kept by a number of Federal agencies. To check the Federal sources for accuracy and completeness, OTA looked for outside resources; States, local jurisdictions, and industries provided helpful data.

This chapter includes the findings of the OTA contractor's exhaustive investigation of the current

[2]49 U.S.C. 1808(e) and 33 U.S.C. 173(C) (173.51-59).

Box 2A.—Risk Assessment

Risk assessment involves estimating the frequencies and consequences of undesirable events, then evaluating the associated risk in quantitative terms. 'The process of risk assessment serves to organize thinking about risks, permitting the judgments of interdisciplinary teams of experts to be integrated in a systematic way. It also helps identify risks that might not have been thought of otherwise and it motivates improvements in data collection by pointing out database deficiencies. The results of risk assessment provide knowledge essential to informed decisionmaking.

Public concern is greatest about risks that are involuntary, uncontrolled, unfamiliar, immediate manmade, and catastrophic.[1] Hazardous materials transportation possesses many and sometimes all of these attributes. Risk assessments can help to address two fundamental questions, one quantitative and objective and *one* qualitative and subjective: What is the level of risk? and What levels of risk are acceptable to the parties concerned? The first question is relatively readily addressed with adequate data and proper methodology, whereas the second question involves numerous judgments and often a great deal of discussion and negotiation, especially when large numbers of people and several governmental jurisdictions are involved. Professional risk assessment places heavy emphasis on quantitative results. Where policy issues are involved, however, and involuntary risks exist, such as those associated with the transportation of hazardous materials, qualitative judgments are important.

The question of risk acceptability is complicated further by the fact that some of the concerned parties may have risk perceptions that differ substantially from the actual risks. Risk equity, the appropriate distribution of risks among different members of society, is another complicating factor.

NC. Rasmussen, "The Application of Probabilistic Risk Assessment Techniques to Energy Technologies," *Annual Review of Energy, vol. 6, 1981,* pp. *123-138.*

Federal collection and analysis of information on commodity flows, accidents, and spills associated with the transportation of hazardous materials.[3] In addition, State and local data-collection efforts were

[3]Mark Abkowitz and George List, "Hazardous Materials Transportation: Commodity Flow and Information System s," OTA contractor report, January 1986. This report is available from OTA on request.

reviewed to determine what information was deemed useful and whether Federal data could provide a resource. An OTA workshop and numerous personal interviews also provided information. Part I of the chapter deals with commodity flow data and Part 11 with incidents or releases.* Part I focuses on the quantity and quality of commodity flow (movement) data currently available to:

- identify existing Federal hazardous materials-related databases that provide information on hazardous materials movements, and investigate their potential use to develop geographic flow trends and to understand the relative importance of all modes of transport for different regions; and
- identify State and local data-collection efforts and evaluate the need for a standardized database on hazardous materials transportation movement.

*The Research and Special Programs Administration refers to a release of a hazardous material during transportation as an incident. There is no agreement on the definition of an incident among the other groups collecting data. OTA will hereafter refer to releases rather than incidents.

Part II explores hazardous materials transport release and accident reporting requirements, information systems, and release and accident trends. Among the issues addressed are:

- the institutional background of release reporting and data collection;
- the completeness and adequacy of the present reporting systems, and ways to make them more useful; and
- statistical analyses of the frequency of releases and related causes and consequences.

PART 1: HAZARDOUS MATERIALS FLOW DATABASES

Identifying hazardous material flow-related databases is a complex task. Flow, vehicle and vessel fleets, and travel network data must be considered for all four major freight modes–truck, rail, marine, and air.** Moreover, many diverse organizations maintain different pieces of relevant information; these organizations include Federal agencies, State and local governments, trade associations, carriers, shippers, and consulting firms.

National Data Resources

Several databases are needed to describe the flows for the hazardous materials transportation network. Table 2-1 shows the major sources of hazardous materials flow data and indicates the commodities and modes covered by each one. For example, the 1977 Commodity Transportation Survey (CTS), collected by the U.S. Bureau of the Census, provides ways to estimate market shares and shipment trends. However, it lacks shipment data on major hazardous cargoes—waste materials, agricultural products, and raw materials, such as crude petroleum and natural fertilizers. Moreover, it reflects only shipments from the point of manufacture to the first destination, often a warehouse, missing all subsequent movements in the distribution chain. There is no specific focus on hazardous materials, meaning analysis is limited by the data contained in the commodity flows themselves, and it is not always possible to determine what percentage of the shipments are hazardous. Data submission is voluntary, creating unknown biases due to nonreporting. The scope of the survey is heavily dependent on Federal budget priorities, and the questions asked are not consistent, making trend analyses difficult. Moreover, the Bureau collects data at 5-year intervals and typically takes 2 years to release the data. Recently, budget constraints have made heavy inroads on many of the Bureau's activities. Data from the 1983 CTS was scheduled to be released late in 1985; however, the Bureau decided not to release the results, because the data was faulty and inadequate for analysis. Because the transportation industries have changed dramatically since 1977, not having more recent data is a severe handicap.

Despite these problems, the CTS is the only national multimodal database available. Other organizations, such as State and local governments, do not collect similar information. They rely either on the CTS directly or on its interpretation and enhancement by consulting firms for their multimodal

**This report does not consider pipelines which transport somewhat more than half of all hazardous materials.

flow information.* Consulting firms use the CTS, supplemented heavily with other modal sources, to improve the quality of the data.[4]

Separate, relatively complete databases are available for rail and marine transport. Because the sample waybill data collected by the Interstate Commerce Commission (ICC) has recently been increased to include about 6 percent of all shipments, it is adequate for determining rail flows. Additionally, although costly and difficult to obtain, the proprietary TRAIN II data, kept by the Association of American Railroads (AAR), provides much more complete information representing 100 percent data on at least 80 percent of the rail shipments.

The data for marine vessel movements are essentially complete, although the marine commodity classifications are very broad, making it difficult to determine what specific commodities are being transported. Only 163 identifying codes are provided, of which only 30 pertain to hazardous materials. Additionally, no computer indicator is provided to show that a specific flow involved a hazardous material.

The available data for truck and air shipments are much less helpful. The absence of better truck data is an enormous gap, since trucks carry the most hazardous materials tonnage in the largest number of vehicles, giving the highway mode the most widespread public impact. The CTS is helpful for truck movements, but in addition to the shortcomings mentioned earlier, it misses some major flows. Data from the Truck Inventory and Use Survey (TI&U), which is also collected by the Bureau of the Census; and the Motor Carrier Census, which is collected by the Federal Highway Administration's Bureau of Motor Carrier Safety (BMCS), provide some useful information. However, these sources give only truck and truck-mile data for hazardous materials movements, not graphic flow information. The only other independent resource is the National Motor Truck Database, a private sector initiative, which is limited by an intentional bias toward long-haul shipments and does not cover the Northeast.

*TWO examples are FREIGHTSCAN, marketed by Data Resources, Inc., Lexington, MA, and TRANSEARCH, marketed by Reebie Associates, Greenwich, CT.

[4]Data Resources, Inc., "FREIGHTSCAN Technical Documentation," prepared by the Transportation and Logistics Service, Lexington, MA, no date.

The CTS is the only public database for air shipments, and its air flow data is incomplete, as OTA learned from checking other data, Using a hybrid developed from all data available, OTA estimated aggregate modal commodity flows as shown in table 2-2.

Specialized Databases

Hazardous Wastes.—U.S. Environmental Protection Agency (EPA) regulations require every hazardous waste shipment to have a manifest,[5] copies of which are submitted to the State and eventually to the EPA regional office. Thus, in theory, a complete hazardous waste flow database exists. In practice, however, the extent of computerization varies widely from one EPA region to another, and OTA did not find any complete flow records. Nevertheless, an outgrowth of the manifest requirement is that States generally have good information on waste movements and carriers. In some cases, the States are collecting and computerizing the data for EPA. Carriers also have fairly complete data, even though they are not actually responsible for preparing the manifests.

Radioactive Materials.–The data on radioactive shipments are also relatively complete. The U.S. Department of Energy (DOE) maintains a list of all high-level radioactive shipments, and it conducts surveys of the low-level radioactive shipments. One such survey was conducted in 1975,[6] and a second was recently completed. ? DOT compiles data on completed highway shipments of radioactive materials. More than 1,000 shipments have been recorded since January 1982 in the Radioactive Materials Routing Report (RAMRT) from DOE, the U.S. Nuclear Regulatory Commission (NRC), and NRC-licensed shippers. However, the RAMRT data may not be recorded for as long as 1 year after a shipment is made, because regulations do not allow release of routing information until after the entire

[5]US. Environmental Protection Agency, "Identification and Listing of Hazardous Waste," 40 CFR, Part 261, November 1984, pp. 345.378.

[6]J.L. Simmons, et al., Battelle Pacific Northwest Laboratories, *Survey of Radioactive Materials Shipments in the U. S.*, NUREG-0073 (Richland, WA: Sandia National Laboratories, 1976).

'Harold S. Javits, et al., *Transport of Radioactive Material in the United States*, SAND 84-7174 (Albuquerque, NM: Sandia National Laboratories, April 1985).

Table 2-2.–Estimated Transportation of Hazardous Materials by Mode in 1982

Mode	Number of vehicles/vessels used for hazardous materials	Tons transported	Ton-miles
Truck	337,000 dry freight or flat bed 130,000 cargo tanks	927 million	93.6 billion
Rail	115,600 tank cars	73 million	53 billion[a]
Waterborne	4,909 tanker barges	549 million	636.5 biliion
Air	3,772 commercial planes	285 thousand	459 million
Total		1.5 billion	784 billion

[a]Technically 1983 data; 1982 data had too many errors to allow calculations.

SOURCE: OTA calculations based on Federal data augmented by other resources.

shipment is completed. Thus the data are useful primarily from a historical viewpoints

Data Analysis Issues

To derive useful information on flows for all commodities, OTA contractors had to address three issues before beginning data analysis:

1. What geographical regions should be used in reporting hazardous material flows?
2. What lists of codes should be used in selecting hazardous commodities from the databases?
3. What process should be used in assigning DOT hazard classes to the various commodity codes?

National data resources may not provide State or local flow data at the level of detail that is desired for planning or response. However, regional and State-to-State flow patterns can be obtained and provide helpful information. Figure 2-1 shows the nine regional areas used for this study. The regions correspond closely to those used by the Bureau of Economic Analysis in the U.S. Department of Commerce and to the economic regions of the Nation. They reflect the concentrations of chemical and petroleum production in the West South Central region and manufacturing in the South and Middle Atlantic regions.

Hazardous commodities are defined for this analysis as all commodities listed in 49 CFR, Section 172, including everything from virgin materials to radioactive materials and hazardous wastes. At least 11 hazardous materials commodity codes are used by the different Federal agencies. These include: the RSPA codes (used in DOT's Hazardous Materials Information System (HMIS) spill database); the EPA codes;[9] the United Nations/North American (UN/NA) codes;[10] the Standard Transportation Commodity Codes (STCC),[11] of which there are two versions, the standard codes and the "49" series codes specifically established for hazardous materials; the National Motor Freight Classifications (NMFC);[12] the Army Corps of Engineers codes (AE);[13] and several Bureau of the Census codes, the Transportation Commodity Codes for domestic shipments (1977 Census),[14] the Standard Industrial Classification (SIC) codes for the 1983 Census (technically speaking, the SIC codes are developed and maintained by the Bureau of Economic Analysis, Department of Commerce),[15] the Schedule A codes for imports, and the Schedule E codes for exports.

No two databases use the same identifying code numbers. For example:

the railroad waybill file uses seven-digit STCCs, both 49-series and regular codes;

'Charles E. Sell and Bradford W. Welles, Sandia National Laboratories, *An Assessment of the U.S. Department of Transportation Radioactive Materials Routing Report* (Washington, DC: International Energy Associates Ltd., January 1986), pp. 22-23.

[9]U.S. Environmental Protection Agency, op. cit.

[10]U.S. Department of Transportation, Materials Transportation Bureau, "Hazardous Materials Tables and Hazardous Materials Communications Regulations, " 49 CFR 172, pp. 69-336, November 1984.

'[Interstate Commerce Commission, *Standard Transportation Commodity Code Tariff,* STCC 6001-M (Chicago, IL: Western Trunk Line Committee, Jan. 1, 1985).

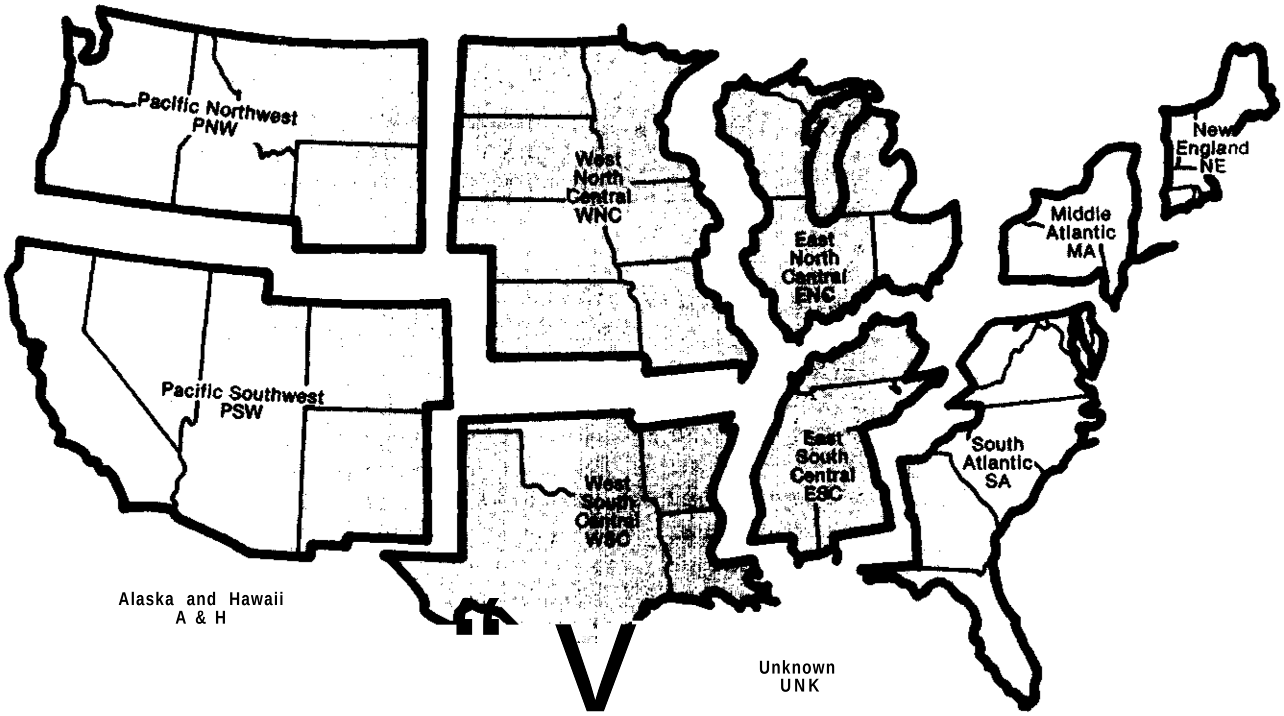
[12]Interstate Commerce Commission, *National Motor Freight Classification* (Washington, DC: American Trucking Association, May 18, 1985).

[13]U.S. Army Corps of Engineers, *Waterborne Commerce of the United States (New* Orleans, LA: Waterborne Commerce Statistics Center, 1984).

[14]U.S. Department of Commerce, Bureau of the Census, *Instructions for Completing the Commodity Transportation Survey, 1977 Census of Transportation,* Form TC-402 (Washington, DC: Sept. 20, 1977),

[15]U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (Washington, DC: U.S. Government Printing Office, monthly).

Figure 2-1.—Regions Used in This Analysis



SOURCE: Office of Technology Assessment.

- the CTS uses five-digit STCCs; and
- the waterborne commerce database uses four-digit Schedule A and Schedule E codes for imports and exports, respectively. See table 2-1 for a summary.

The codes are all used simultaneously, yet very few cross-reference tables have been developed. OTA contractors identified only five:

1. a conversion file between 49-Series STCCs, regular STCCs, and UN/NA codes maintained by AAR;[16]
2. a STCC to SIC conversion table at the four-digit SIC level maintained by AAR, which is in hard copy only;[17]
3. an NMFC to STCC conversion table maintained by the American Trucking Association (ATA);[18]
4. an Army Corps of Engineers' conversion file between AE commodity codes for water and the Bureau of the Census' Schedules A and E codes for imports and exports; and
5. a SIC, Schedule A, Tariff Schedules of the United States Annotated, and Schedule E translation file maintained by the Bureau of the Census.

The UN/NA numbers appear only once. RSPA and EPA numbers do not appear on any conversion table, a serious omission, as they are the two agencies charged most directly with responsibility for hazardous materials information.

Finally, hazardous commodity lists cannot be generated through computerized selection, making considerable preparatory analysis necessary to develop comparable data. For example, in the case of the Schedules A and E codes, a computer process generated a long list of nonhazardous commodities and missed two major hazardous commodities. For this study, as the database-specific commodity lists were developed, each commodity was given a hazard class

[16] Association of American Railroads, *Price List of Publications* (Washington, DC: September 1983).

[17] Ibid.

[18] National Motor Freight Traffic Association, Inc., *STCC/NMFC Converter* (Washington, DC: June 14, 1971).

distinction, so that spill rate statistics could be completed. RSPA has not identified hazard classes for any commodity list except its own, so suitable methods had to be developed to link hazard classes and commodities. This process was complex, and except for the 49-series STCCs, the hazard class assignments were not readily definable and required considerable judgment.

Truck Transport

Truck transport is the sector with the poorest data, yet it presents the most widespread public risk. Consequently, available data resources for this mode will be described in detail. Three principal national databases are available publicly to help analyze trucking flows: the 1977 CTS and the 1977 and 1982 TI&U. However, none presents a complete picture, nor were any designed to do so. The CTS provides origin-to-destination flow data on shipments from manufacturing plants to first destinations only, missing the rest of the distribution chain and all nonmanufactured goods.

TI&U provides a global picture of truck use, but lacks any origin to destination flow information or precise definition of commodities. The 1977 and 1982 TI&U surveys were both used for this report.

The 1977 TI&U contains information on each vehicle's registration and vehicle identification number; physical characteristics such as size, type of body, engine size, transmission type, and braking system; operator class (private, for-hire, owner-operator, etc.); range of operation (e.g., 50 to 200 miles); annual mileage; percentage of mileage in the home State; commodities carried (by percent of miles); and percentage of miles carrying hazardous materials. It is based on voluntary responses from the owners of the vehicles selected. It has no cross-checks except the State registration files from which the survey vehicles were selected. The 1982 TI&U contains data on the character and use of slightly over 90,000 trucks, a State-to-State sample drawn from an estimated universe of 35 million.

Supplementary information is available in the Motor Carrier Census, maintained by BMCS, which contains profiles of approximately 250,000 motor carriers. The database is used primarily to monitor carrier safety, and contains each carrier's State base of operations, the States served, the type of commodities carried and, for hazardous materials, the kind of container and tank or package used to carry commodities in each of the hazard classes designated by RSPA. Also, it contains information on the carrier's classification, such as: ICC common; ICC exempt; private; miles operated; number of drivers; and number of trucks, truck tractors, and trailers, segmented by type of ownership—owned, leased, or trip-leased.

The ICC Waybill Sample contains data on truck shipments that make use of rail for some portion of the move, such as piggyback or container on flatcar/truck on flatcar shipments.

Trade organizations generally do not keep flow data. ATA, for example, keeps only aggregate statistics on tons and ton-miles. Moreover, the firms submitting data are principally less-than-truckload carriers, so information about bulk shipments is lacking. Shipper organizations, like the American Petroleum Institute (API), the Chemical Manufacturers Association, the Petroleum Marketers Association, and the National Association of Chemical Distributors, are in much the same position as ATA.

Individual firms, however, do keep data on their own movements. Trucking firms generally keep computerized traffic databases that include origin, destination, commodity (by a variety of codes), shipment weight, and shipment date. Major shippers, like the large chemical and petroleum companies, also keep computerized data on their truck shipments. They record origin, destination, commodity (often on the basis of some marketing coding scheme), shipment weight, and shipment date.

Other types of data are kept by consulting firms, such as Transportation Research and Marketing, which has developed a National Motor Truck Data base (NMTDB).[19] Established to develop marketing information by AAR in 1977, NMTDB contains information on approximately 36,000 movements per year, some 4,000 of which involve hazardous materials. The data is collected at 18 selected truck stops, typically in the West and Midwest, to sample long-haul moves. The database includes origin city and State, destination city and State, commodity, vehicle characteristics, operator characteristics, and an operator profile. It is cross-checked to a limited

[19] Frances M Larkin and K. Eric Wolfe, "Rail-Competitive Truck Characteristics, 1977 -1982," unpublished typescript, 1983.

extent against fuel sales at the truck stops and volume counts on selected Interstates.

The TI&U shows that in 1982, 467,000 trucks were involved in carrying hazardous materials and collectively generated 1.6 billion truck-miles. This compares to 327,000 trucks and 1.3 billion truck-miles in the 1977 TI&U. The data show a 43 percent growth in the fleet size and a 23 percent growth in truck-miles compared to 1977 data, or 6 and 4 percent per year, respectively. The vehicles were predominantly either large, private tank trucks carrying petroleum and chemicals most of the time, or vans operated by for-hire carriers carrying hazardous materials less than 25 percent of the time. Mixed shipments were carried by 24 percent of the trucks and represented 35 percent of the truck-miles.

Trucks and Truck-Miles Based on the 1977 and 1982 TI&U Surveys

Table 2-3 shows the truck fleet breakdown for 1982. The comparable data for 1977 may be summarized as follows. Liquid tank trucks accounted for 30 percent of the fleet and 57 percent of the truck-miles. About 65 percent of the trucks had an operating range under 200 miles and accounted for 56 percent of the truck-miles. The trucks that operated over 200 miles accounted for 21 percent of the fleet and generated 40 percent of the truck-miles. Private carriers operated 78 percent of the trucks and generated 52 percent of the truck-miles. ICC common carriers were the second largest in size, at 12 percent of the fleet, and they generated 26 percent of the truck-miles. The common carrier trucks

Table 2-3.-1982 Truck Inventory and Use Survey Breakdown of the Hazardous Materials Fleet (467,000 trucks; 16,236 million truck-miles)

Statistic	Trucks (thousands)	Truck-Mites (millions)
Percent of miles Involved in carrying hazardous materials:		
Below 25°/0	243.8	10,282
25-490/o	117.0	2,971
50-74%0	20.5	776
75-1000/0	80.3	2,191
Not reported	5.0	15
Body type		
Van	140.8	7,016
Tank (liquid)	130.3	4,317
All other (28 categories).	195.5	4,903
Principal product:		
Mixed cargoes	113.5	5,716
Petroleum	136.6	3,491
Chemicals	60.3	2,069
All other (24 categories).	156.2	4,960
Gross weight (lbs):		
10,000 or less *(2* categories)	122.5	1,818
19,501-33,000 (2 categories).	90.8	1,578
40,001-50,000	36.1	1,479
50,001-60,000	34.4	1,983
60,001-80,000	110.9	8,083
All other (8 categories).	71.9	1,295
Range of operation:		
Within 50 miles	269.7	4,888
50-200 miles	90.9	4,075
Over 200 miles.	73.1	6,749
Off-road.	32.3	525
Not reported	0.6	—
Operator class:		
Business use	275.8	6,200
Motor carrier	153.3	8,391
Owner/operator	21.1	1,423
All other (5 categories).	16.4	222

SOURCE: Office of Technology Assessment

were driven 76,000 miles per truck per year, and the private trucks 22,000 miles.

The smaller trucks were used for local movements, while the larger ones dominated for operations over 200 miles. In fact, more than 85 percent of the "over 200 mile" truck-miles were in vehicles weighing 60,001 to 80,000 pounds. In addition, detectable populations of large trucks contributed to both fleet size and truck-miles in the under- and over-200 mile categories. The States with the largest fleets were Pennsylvania, California, and Ohio; those that had the most truck-miles were Ohio, Texas, and Pennsylvania.

Tons and Ton-Miles by Hazard Class

The two largest hazard classes transported by truck are flammable liquids and Poison B, regardless of whether measured by tons or ton-miles. Poison A, flammable compressed gas, and flammable solid are the next most important classes by tonnage; flammable solid, combustible liquid, and corrosive material are most important according to ton-miles.

The 1977 TI&U showed the truck-mile breakdown among commodities as 47 percent petroleum, 17 percent chemicals, and 36 percent "all other." In contrast, the CTS reported the ton-mile breakdown as 36 percent petroleum, 53 percent chemicals, and 11 percent "all other," thus clearly missing much of the petroleum flow. Furthermore, the CTS shows 65 million tons of petroleum being shipped by truck in 1977, whereas data supplied by API for 1984 indicates at least 105 million tons were delivered by truck. Petroleum consumption declined during the 7-year period. Moreover, the CTS shows no petroleum flow in the Southeast, one of the three largest flows in the API data.

Partial compensation for the missing petroleum flows can be made by assuming that all of the marine and pipeline shipments of gasoline, distillates, and kerosene are eventually made by truck. This assumption boosts the CTS tonnage estimate from 133 million tons to 566 million tons, or more than a fourfold increase. Region-to-region flow patterns based on this hybrid database are shown in table 2-4. Seventy-two percent of the flows are intraregional, led by shipments in the West South Central, East North Central, and Pacific Southwest regions. Classified by hazard class, the CTS data show flammable liquid is the largest class, whether measured in tons or ton-miles. The next largest category is Poison B, reflecting the chemical shipments. These statistics must be viewed as best estimates, however, because the completeness of the commodity flow data is questionable, and the specificity of the commodity definitions is limited.

Petroleum and gasoline shipments account for almost half of all truck transport of hazardous materials. To offset the lack of petroleum truck shipment data in the CTS, OTA requested assistance from the API Transportation Committee. API conducted a survey of oil companies that operate private truck fleets and received responses from nine of the largest companies. Each provided a profile of the distribution patterns at its terminals, broken down by type of product and type of delivery–whether by proprietary fleet or jobber. * Moreover, for the proprietary deliveries, they provided minimum, average, and maximum delivery distances.

The API survey covers 519 terminals, located in 45 of the 50 States, including Hawaii and the District of Columbia. The States with the most terminals are California with 31, Pennsylvania with 30, and Texas with 28. The survey showed shipments of 27 billion gallons of gasoline (over 25 percent of the national total); 1.0 billion gallons of diesel fuel (2 percent); 1.3 billion gallons of distillates (5 percent); and 0.8 billion gallons of other products, principally aviation gasoline, Jet A, and turbine fuel.

Among these, 44 percent of the gallons are delivered by jobbers. In fact, jobbers deliver 78 percent of petroleum products other than gasoline and 39 percent of the gasoline (see table 2-5). Hence, oil companies have only partial responsibility for highway movements of petroleum. The average delivery distance is short, at 28 miles, and distances do not differ markedly by geographic region—the maximum delivery distances are all less than 250 miles.

Chemicals represent the second largest category of hazardous materials transported by truck. The TI&U data show that 13 percent of the trucks carrying hazardous materials 75 to 100 percent of their miles were hauling chemicals and generated 17 per-

*A jobber is an independent petroleum marketer, who buys a truckload of product from the petroleum company at the terminal and delivers it as a private marketer to his own customers.

Table 2-4.—Hazardous Commodity Flows by Truck According to the 1977 Five. Digit Commodity Transportation Survey Database[a]

All flows in thousands of tons: From !/To -	New England	Middle Atlantic	South Atlantic	East North Central	East South Central	West North Central	West South Central	Pacific Northwest	Pacific Southwest	Alaska & Hawaii	Unknown[b]	All
New England	13,863	136	36	202	26	20	28	7	35	0	0	14,353
Middle Atlantic	1,077	63,020	3,056	2,022	269	265	475	34	246	1	20	70,485
South Atlantic.	238	949	43,482	766	474	226	167	3	114	1	342	46,772
East North Central.	257	1,009	953	110,434	790	2,696	522	53	316	3	25	117,058
East South Central.	132	341	787	587	9,251	282	352	11	158	0	7	11,908
West North Central.	7	57	75	520	74	22,152	229	1,572	2,518	0	3	27,207
West South Central.	58	729	803	1,006	3,651	573	171,379	63	840	0	1,222	180,324
Pacific Northwest . .	0	1	3	1	0	285	1	18,846	70	1	0	19,208
Alaska and Hawaii	–	—	—	—	—	—	—	—	—	3,146	—	3,146
Pacific Southwest . .	9	415	17	132	43	110	66	656	73,244	2	1,005	75,699
All	15,641	66,657	49,212	115,680	14,578	26,609	173,219	21,245	77,541	3,154	2,624	566,160

[a]It was assumed that all shipments of gasoline, distillates, and kerosene by marine and pipeline utilized truck for final delivery.
[b]Unknown includes Puerto Rico, Virgin Islands, other U.S. territories, and foreign.

Note: Boldface indicates top five flows, for example, 171,379

SOURCE" Office of Technology Assessment

Table 2-5.—Gallons by Product Type Based on the American Petroleum institute Survey of Producers With Large Proprietary Fleets (519 Terminals)

	Proprietary delivery			Jobber delivery	
Product	Number of terminals	Gallons (millions)	Average distance (miles)	Number of terminals	Gallons (millions)
Gasoline	349	16,544	28	424	10,588
Diesel fuel	66	251	39	81	830
Other distillates	88	486	32	160	959
Propane	0	0	—	71	469
Other			18		
Turbine fuel	2	75	—	5	37
Jet fuel	4	17	—	19	
Aviation gasoline		0		1	
All	349[a]	17,373	28	497[a]	13,604

[a]This is not a total of this column. Of the 519 terminals, 349 had proprietary delivery, and 497 had jobber delivery.

SOURCE: Office of Technology Assessment,

cent of the truck-miles. A State-to-State analysis of the CTS indicates 59.7 million tons of chemicals were moved by truck. About 60 percent of the chemical flow was intraregional led by the West South Central, South Atlantic, and Middle Atlantic regions with an average length of haul of 253 miles.

At OTA's request, several major chemical companies provided flow data on their 1983 and 1984 shipments of hazardous materials. Each of the databases included origin State, destination State, commodity, tons, and number of shipments. Combined, the firms encompass 5 percent of the tons for the flows shown in the State-to-State the CTS data. The private flow data agreed with the CTS on 8 of the 10 largest movements, although their rankings differ, indicating that the CTS may be a reasonable reflection of the major flows, although the actual volumes are questionable.

Railroads

Commodity flow analysis is the easiest for railroads. The ICC waybill database, while encompassing a 1 to 6 percent sample of all railcars, provides information on every movement of these cars, with the exception of detailed routing information. It is not possible to tell which of two or more possible tracks a car has traveled between origin and destination. The waybill shows origin and destination city and State, commodity (seven-digit STCC), number of cars, shipment weight, shipment cost rail revenue, and the railroad junctions traversed. It is based on carloads terminated by all the Class I carriers and some of the Class IIs and Class IIIs. Since AAR took responsibility for collecting the waybills and preparing the samples in 1983, numerous edits and cross-checks have been introduced, and the quality of the sample has improved.

AAR, the major rail trade organization, maintains a comprehensive database, TRAIN II, on the movements of about 80 percent of all railcars. Each railroad participating in TRAIN II submits location and status information on all the cars on its lines. Shippers, many of whom own their own railcars, and other railroads can determine daily where their cars are and their respective status. For each car, the database includes present location at an origin, destination, or intermediate point; empty/loaded status; and the commodity being carried (seven-digit STCC). AAR presently uses TRAIN II to develop summaries of hazardous material flows; it has prepared tables of carload originations and terminations by STCC for each State, as well as tables showing U.S. flows for all hazardous commodities, ranked by total carloadings.

Most railroads, and certainly the major ones, maintain traffic flow databases. A few keep times and locations for all events in the car movement cycle,[20] while most keep waybill data, such as shipper, consignee, online and offline origins and destinations, cars, tons, and revenue.

This analysis of hazardous materials transported by rail was based on the waybill files for the years 1972 to 1983, and examination of the 1977 CTS.

[20]George F. List, et al., *Evaluation of MoPac's Freight Car Scheduling Sysrem*, FRA-ORRP-8 *1-3* (Washington, DC: U.S. Department of Transportation, 1981).

Between 1972 and 1983, the total number of hazardous records in the waybill file grew from 11,388 to 15,687, a compounded increase of 3 percent a year. For 1983, the waybill file indicates 73 million tons of hazardous commodities were transported by rail, generating 53 billion ton-miles. Chemicals are the largest commodity group, constituting 68 percent of the tons and 66 percent of the ton-miles. Petroleum ranks second at 23 percent of tons and 20 percent of the ton-miles, followed by commodities in the "all other" category.

The largest hazard class was flammable liquids with 26 percent of the tonnage, followed by corrosive materials with 25 percent and flammable compressed gases with 12 percent. In conjunction with combustible liquids and nonflammable compressed gases, these five hazard classes account for 85 percent of the 1983 tonnage. Poisons and radioactive materials are small portions of the flows; radioactive materials are less than 0.03 percent, Poison B is less than 3 percent, and Poison A is less than 0.1 percent.

Origins and destinations are concentrated and the level of concentration is increasing. The waybill file shows a drop from 1,472 origin and 3,210 destination Standard Point Location Codes in 1972 to 1,129 and 2,410 in 1983, respectively. The 15 largest junction volumes are shown in table 2-6. Region-to-region flows appear in table 2-7. More than 25 percent of the flows originate in the West South Central region; more than 20 percent of them terminate there as well. The three largest flows are West South Central to West South Central, South Atlantic to South Atlantic, and West South Central to South Atlantic. The private chemical manufacturers data confirm these flow patterns, although there are some differences due to market share.

The primary car type is the tank car, accounting for 85 percent of the tons, 79 percent of the ton-miles, and 81 percent of the car loadings. At the end of 1984, the active tank car fleet numbered 183,000, of which 115,600 were used for hazardous materials. The majority of these were 111I As, 112s, 103s, and 105 As. Covered hopper cars ranked second in tonnage, carrying 6 percent; but intermodal flatcars ranked second in loadings and ton-miles, due to the large quantities of alcohol being shipped in trailers and intermodal portable tanks.

A breakdown of the hazardous tonnage by length of haul shows that the most tonnage travels between O to 250 miles, but the distribution extends beyond 4,000 miles, with an average length of haul at 728 miles.

Water Transport

Commodity flow analysis for the marine transport is straightforward but difficult. The U.S. Army Corps of Engineer's Waterborne Commerce Statistics Center (WCSC) database includes 100 percent of all commodity movements, both domestic and international, missing only military cargo moved in Department of Defense vessels. Information provided on each movement includes: origin district,

Table 2-6.–Fifteen Largest Junction Volumes, 1977 and 1983

1977		1983	
Junction	Tons (000)	Junction	Tons (000)
New Orleans	4,198	New Orleans	5,149
Chicago	4,008	East St. Louis	4,429
East St. Louis	3,509	Chicago	4,038
Kansas City	2,768	Shreveport	3,331
Shreveport	2,695	Kansas City	2,508
Memphis	2,183	Memphis	2,355
Chattahoochee	1,918	Cincinnati	1,491
Atlanta	1,716	Richmond	1,092
Montgomery	1,603	Potomac Yard (Arlington, VA)	1,049
St. Louis	1,474	Effingham (GA)	830
Birmingham	1,414	St. Louis	773
Cincinnati	1,379	Corsicana (TX)	770
Potomac Yard (Arlington, VA)	1,057	Mobile	702
Effingham (GA)	757	Fort Worth	675
El Paso	724	Dallas	663

SOURCE: Office of Technology Assessment.

Table 2-7.—Hazardous Commodity Flows by Rail According to the 1983 Waybill Statistics

All flows in thousands of tons: From I/To -	New England	Middle Atlantic	South Atlantic	East North Central	East South Central	West North Central	West South Central	Pacific Northwest	Pacific Southwest	All
New England	985	53	37	28	6	1	7	2	3	1,112
Middle Atlantic	681	1,710	542	827	110	103	495	10	54	4,532
South Atlantic	91	732	5,842	1,215	716	510	364	11	117	9,598
East North Central	319	1,470	820	2,527	610	735	629	83	220	7,413
East South Central	17	400	2,933	901	2,401	125	1,028	8	191	8,004
West North Central	23	95	110	991	349	1,739	642	102	245	4,296
West South Central	281	1,582	4,266	3,370	3,577	1,889	10,626	283	2,038	27,912
Pacific Northwest	–	66	16	174	11	423	106	1,551	488	2,835
Pacific Southwest	39	144	366	624	130	146	919	551	3,331	6,250
All	2,436	6,252	14,932	10,557	7,910	5,671	14,816	2,601	6,687	71,962

Note: Boldface indicates lop five flows, for example, 10,626

SOURCE. Office of Technology Assessment

port, dock, and date; destination district, port, dock, and date; commodity (four-digit code); shipment weight (short tons); operator; vessel description; and the waterways traversed, including entry and exit mileposts. It is based on data submitted by carriers, shippers, and vessel owners in response to comprehensive reporting requirements. However, two major information shortcomings create difficulties. First, the commodity definitions are very broad; only 30 out of a possible 163 codes pertain to hazardous materials. Second, while complete routing information exists, no mileage data are provided in the basic flow records, which means the mileage information for every flow must be computed and added to the database if ton-mile statistics are to be developed. Because of cost constraints, the OTA analysis did not develop ton-mile statistics.

Analysis of the WCSC data shows that a billion tons of cargo were shipped by marine transport in 1982. Hazardous commodity shipments constituted 55 percent of the total or 549 million tons. The flows are concentrated, as noted in table 2-8, with the 10 top region-to-region flows accounting for 65 percent of the total tonnage. Intraregional shipments in the West South Central region alone account for about 25 percent of the total tonnage. The pattern of flows follows the distribution of petroleum, since 85 percent of the hazardous tonnage is crude or processed petroleum.

From 1977 to 1982, the tonnage increased less than 4 percent; however, the commodity mix changed significantly. Chemical shipments dropped 13 percent and petroleum products dropped 22 percent, while the "all other" category doubled in size. More importantly, the mix of chemical products changed. Fertilizers rose to the second- and third-ranked positions displacing second-ranked sodium hydroxide and third-ranked benzene and toluene. Furthermore, this trend toward declining large bulk shipments of high hazard chemicals is likely to continue. Manufacturers are substantially reducing their inventories of raw materials in a variety of ways for both economic and safety reasons.[21]

Tankers and tanker barges are the principal vessels (91 percent); the other major vessel type is the dry cargo barge with 8 percent of the total. The five-digit CTS database captures only 40 percent of the flows and has a vastly different breakout of commodities. It misses the two major waterborne flows, crude oil and fertilizer, because they are not manufactured products.

Air Transport

Air transport has the weakest data for analyzing hazardous materials commodity flow. The only available database is the CTS, which, as previously noted, includes shipments from point of manufacture to first destination only. Federal Aviation Administration (FAA) inspectors sometimes perform 90-day records checks, but the only information they keep is the number of hazardous class shipments, not the overall percentage or the total volume.

The CTS indicates that 52,700 tons of hazardous materials were transported by air, or 8 percent of all air cargo tonnage. Chemicals account for 80 percent of this total, consisting of cosmetics, drugs, * and agricultural chemicals including fungicides and herbicides. As maybe calculated from table 2-9, 79 percent of the tonnage, including the largest flow, is interregional, unlike the other transport modes. The average length of haul is over 1,000 miles. When the CTS data were compared with a private air carrier's records of its hazardous material flows, the inadequacy of the CTS information became apparent. The air carrier reported substantial hazardous materials shipment volumes for eight of the nine Pacific Northwest originating flows where the CTS showed no movement at all. One of these was the 12th largest region-to-region flow. Of the 72 remaining flows for other originating regions, there were 11 flows where the carrier's tonnage exceeded that shown in the CTS, and 3 more where the carrier's tonnage was nearly equal to the total shown by the CTS. Although the CTS data were for 1977 and the carrier's data for 1983 and 1984, they nonetheless demonstrate that the CTS data are not a useful reflection of hazardous material flows by air.

[21] Monsanto Co., *One Year Later: Report of the Monsanto Product and Plane Safety Task Force* (Saint Louis, MO: December 1985); and Ron Jacobsen, Distribution Manager, Rohm & Haas, personal communication, January 1986.

*Because they contain small amounts of hazardous chemicals, cosmetics and drugs are regulated as hazardous materials.

Table 2-8.—Hazardous Commodity Flows by Water According to the 1982 Waterborne Commerce Statistics Center Database

All flows in millions of tons: From ↓/To →	New England	Middle Atlantic	South Atlantic	East North Central	East South Central	West North Central	West South Central	Pacific Northwest	Pacific Southwest	Alaska & Hawaii	Unknown[a]	All
New England	2.4	0.5	—	—	—	—	—	—	—	—	—	2.9
Middle Atlantic	20.9	**65.4**	3.6	0.3	0.2	—	2.2	—	—	—	0.6	93.2
South Atlantic	1.6	8.9	23.4	0.1	0.3	0.2	0.2	—	—	—	0.6	35.3
East North Central	—	1.8	1.2	9.4	3.4	2.3	3.4	—	—	—	—	21.6
East South Central	—	0.8	5.6	1.2	6.1	0.5	7.4	—	0.6	—	0.2	22.4
West North Central	—	0.	—	2.7	1.4	0.8	3.8	—	—	—	—	8.9
West South Central	7.7	13.1	**24.5**	6.3	11.1	3.7	**75.0**	—	2.0	—	5.7	149.1
Pacific Northwest	—	—	—	—	—	—	—	16.9	2.4	0.8	—	20.1
Pacific Southwest	—	0.1	0.2	—	—	—	1.0	5.2	**31.0**	1.5	—	38.9
Alaska and Hawaii	—	—	—	—	—	—	0.7	18.0	**30.9**	6.1	38.7	94.4
Unknown[a]	0.7	15.2	5.4	—	2.1	—	30.7	—	0.5	—	7.9	62.4
All	33.3	105.9	63.9	20.0	24.6	7.5	124.4	40.1	67.4	8.4	53.7	549.2

[a]Unknown includes Puerto Rico, Virgin Islands, other U.S. territories, and foreign.
Note: Boldface indicates top five flows, for example, **75.0**.

SOURCE: Office of Technology Assessment.

Table 2-9.—Hazardous Commodity Flows by Air According to the 1977 Five-Digit Commodity Transportation Survey Database

All flows in thousands of tons: From I/To -	New England	Middle Atlantic	South Atlantic	East North Central	East South Central	West North Central	West South Central	Pacific Northwest	Pacific Southwest	Alaska & Hawaii	All
New England	–	0.2	—	0.5	0.1	—	—	—	0.1	—	0.9
Middle Atlantic ... , . .	0.2	2.1	0.9	1.9	0.1	0.5	0.8	0.2	3.9	—	10.6
South Atlantic.	0.1			0.1	0.5	0.4	0.1	—	0.3	—	1.8
East North Central . . .	0.2	0.8	0.3	0.1	—	1.2	0.1	—	2.2	—	4.9
East South Central . . .	–	—	0.1	—	—	—	3.8	—	0.3	—	4.2
West North Central . .	–	0.1	0.1	0.1	—	—	0.3	—	0.1	—	0.7
West South Central . .	–	—	—	—	—	0.1	4.3	—	0.1	—	4.5
Pacific Southwest. . . .	0.8	0.1	—	18.1	—	0.6	0,4	—	4.4	0.4	24.8
All	1.3	3.3	1.7	20.8	0.7	2.8	9.8	0.2	11.4	0.4	52.4

Note, Boldface Indicates top five flows, for example, 18.1.

SOURCE Office of Technology Assessment.

State and Local Studies

OTA reviewed numerous State and local information-collection projects to determine whether a Federal data system would provide useful additional information. The research uncovered a variety of approaches to State and local data collection. When a State undertakes a study, a lead agency is usually designated, often the department of transportation or State Police, with assistance provided by an office of emergency preparedness or comparable agency. For cities, municipal planning staffs, fire departments, private consulting firms, or university-based research groups do most of the data gathering and analysis.

Techniques and results vary according to the particular interests, resources, and experience of the agencies involved. Nonetheless, OTA has identified types of useful data, effective methods, and commonly encountered problems. The following kinds of studies can provide the background information necessary for planning and emergency preparedness:

- Inventory of hazardous materials stored at fixed facilities. Records the quantity and type of hazardous commodities stored in manufacturing, wholesaling, distribution, or storage facilities within the jurisdiction. Data are obtained by means of questionnaires, interviews, and inspections; and from public records, such as fire inspection records and business tax records.
- Hazardous materials transportation analysis. Identifies the quantity and type of hazardous materials transported through the jurisdiction by each transportation mode and the most frequently used routes. Data are gathered by questionnaires, roadside inspections, and review of company records.
- Hazard assessment or identification of hazards and high-risk locations. Analyzes factors such as population density, transportation system characteristics, and past incidents to determine where the risk of a hazardous materials incident is greatest or where the impact would be the most severe.

An inventory of fixed facilities is often the first step in the data-gathering process. Any second step is usually a transportation analysis. A hazard assessment is frequently last, since it draws on data collected in the first two studies.

Fixed Facilities Inventories

Knowledge of the extent and nature of hazardous materials manufacture and storage in the community is essential for prevention and response planning. A facilities inventory can guide the purchase of equipment, choice of training, location of response facilities, and assignment of personnel, and can provide a good indication of the hazardous materials transported in the jurisdiction.

One of the first decisions necessary in undertaking a hazardous materials inventory is what should be inventoried and in what detail. Some jurisdictions studied by OTA chose to locate all hazardous materials, including paint thinner stored in retail stores, but most concentrated on chemicals manufactured or stored in bulk. Memphis, for example, limited its inventory to 255 manufacturing sites.[22] At the other extreme, the cities of Santa Clara County, California, inventoried all materials identified by DOT as hazardous and stored in any quantity at commercial facilities, including drug stores; the inventory is kept current by the county. The majority of communities, however, have limited their surveys to selected commodities identified by the staff and advisory committees and to major facilities, measured by employment levels.[24]

The methods used for collecting data vary. In Memphis and Indianapolis, the initial data-collection method was a questionnaire. Questionnaires sent under the auspices of the Memphis Fire Department asked for data on storage of material in 19 DOT hazard classes. Although followup to the questionnaire was a lengthy process, the city currently has information on the type, quantity, and location of stored hazardous materials, including site plans and names, addresses, and phone numbers of emergency contacts.[25] In Indianapolis, only 20 to 25 percent of the 1,200 local industries surveyed submitted responses to the questionnaire and ex-

[22] National Conference of State Legislatures, *Hazardous Materials Transportation Regional Workshops* (Denver, CO: 1983), p. 65.

[23] Cambridge Systematic, inc., *Community Teamwork–Working Together To Promote Hazardous Materials Transportation Safety* (Washington, DC: U.S. Department of Transportation, 1983), p. 6.

[24] U.S. Congress, Office of Technology Assessment, Transportation *of Hazardous Materials: State and Local Activities,* OTA-SET-301 (Washington, DC: U.S. Government Printing Office, February 1986), ch. 4.

[25] National Conference of State Legislatures, op. cit.

tensive followup was necessary to collect sufficient data. The Association of Bay Area Governments, around San Francisco, identified target commodities but did not have the budget or personnel to administer questionnaires. Instead, Bay Area planners produced a series of small maps, showing the locations of manufacturing firms that frequently used the selected group of hazardous materials, anticipating that each county would eventually survey individual firms.[26]

Santa Clara County collects information by means of a regulatory procedure, which also finances the hazardous materials control program. To obtain a business license, all firms selling, using, or producing hazardous materials must provide local officials with an inventory and pay a fee based on the amount of materials stored. The fees help support the county's emergency response team and hazardous materials inspections. Local manufacturers and merchants are advised on the proper storage and handling of hazardous materials during these inspections.

Inventories can provide information for many purposes in addition to planning. In Oregon, the Multnomah County Fire Department collects information on hazardous materials storage at fixed facilities as part of routine fire inspections. The county's Office of Emergency Management stores the information in a computer along with data on chemical characteristics of the commodities, transportation routes frequently used, and performance profiles of major carriers. The county's specialized hazardous materials team has access to this database through a computer terminal located in the response vehicle. The computer system can provide information on where a specified product can be found at the site, how it is stored, and other chemicals that may be present. The system also provides information on the characteristics of all the chemicals known to be in the county, based on DOT and other standard classifications, and the names of organizations to call for additional product information.[27]

State Inventory Studies

Massachusetts is one of the few States that has completed a fixed facilities inventory. For each of the State's 14 fire districts, State analysts used manufacturing directories to locate the firms with more than 100 employees that used or produced hazardous materials.[28]

In March 1983, the State of New Jersey passed a law requiring every firm manufacturing or handling hazardous substances to file a completed survey form with the State Department of Health and the county or local health, fire, and police departments. This information effectively provides a facilities inventory.

The State of Maryland has created a computerized registry of all toxic and carcinogenic substances stored at fixed sites. The State Department of Health and Mental Hygiene began gathering the data in 1979 with funds from an EPA grant. Currently, the registry contains inventories of more than 400 industrial users of toxic or carcinogenic substances. Updated annually, the data comprise detailed information on 54 target chemicals selected by the department, including the maximum quantities stored and how they are transported. The staff estimates that the development of the computerized registry system cost over $400,000, not counting software development funded by the EPA grant, and annual operating costs.[29]

Community Support

The success of inventory efforts depends on the cooperation of public agencies, such as the fire and police departments, and private groups, such as chemical manufacturers, shippers, and carriers. Advisory committees can be instrumental in obtaining such cooperation. Often appointed by elected officials, such committees are usually multidisciplinary and composed of representatives from first response agencies, local industry, local and interstate carriers, public officials, educators, experts in hazardous materials, and environmentalists.

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[26] Association of Bay Area Governments, San Francisco, CA, *Hazardous Spill Prevention and* Response *Plan*, 2 vols. (Washington, DC: U.S. Department of Transportation, Research and Special Programs Administration, 1983).

[27] Puget Sound Council of Governments, Seattle, WA, *Central Puget Sound Region Risk Analysis Report: Regional Hazardous Materials Inventory*, interim report (Washington, DC: U.S. Department of Transportation, 1980).

[28] Energy Resources, Inc., *Phase 1: Determine the Nature and Scope of Hazardous Materials Transportation in the Massachusetts Region, Volume I* (Cambridge, MA: U.S. Department of Transportation, 1982), pp. 4-36.

[29] Max Eisenberg, Environmental Program, Maryland Department of Health and Mental Hygiene, personal communication, March 1985.

Although private sector support has at times been problematical, in April 1985, CMA announced an industrywide program designed to make chemical industry expertise available to local agencies, including furnishing planning groups with material safety data sheets on commodities manufactured and stored in the community .30 However, concerns about protecting trade secrets or other information considered to be proprietary (e.g., health or exposure data) have made some manufacturers unwilling to comply with requests for information. In response, many States and municipalities have enacted "right-to-know" laws requiring the release of information on the hazards associated with chemicals produced or used in a given facility. Such laws are useful tools for data-collection activities.

Transportation Studies

In addition to fixed facility inventories, State and local governments have tapped a variety of public and private sources to collect data on truck, rail, air, and water transportation. Small **towns** and rural counties are particularly interested in transportation data because they see their greatest risk as a hazardous materials accident on an Interstate highway or railroad line passing through their jurisdiction. The type and quantity of hazardous materials carried by each mode and the principal routes used comprise the information most frequently collected for planning, risk analyses, routing decisions, and emergency response preparation, Because the data-gathering problems are different for each mode, highway, rail, air, and water transport are discussed separately.

Truck Studies

State and local data-collection projects reviewed by OTA put the highest priority on information about highway transport of hazardous materials because trucks far outnumber other types of hazardous materials carriers, carry the largest share of the hazardous materials shipments, and are involved in the greatest number of accidents and spills.

Several State databases are currently being developed. New York, for example, is computerizing the data collected by its State Police during their roving truck inspections. Other States with similar information include Virginia,[31] New Mexico,[32] Washington,[33] and Colorado.[34]

State and local planners have devised special means to collect data on highway transport of hazardous materials. The primary methods are questionnaires, visual surveys, and inspections. Several jurisdictions have sent out questionnaires to shippers, carriers, and manufacturers requesting information about hazardous materials shipments and the routes most frequently used.

Analysts in the Puget Sound Region of Washington State, using questionnaire responses, truck route locations, and other information provided by local governmental departments, mapped the routes by which 85 target commodities moved within and through the region. Memphis used a questionnaire to gather data from local shippers and manufacturers,[35] although State Highway Department tax records showed that truckers substantially underreported the flammables category on the questionnaire. In a survey conducted recently of manufacturers and transporters of hazardous materials in the New York City and New Jersey area, only 20 percent of those solicited returned completed questionnaires.[36]

Other jurisdictions have resorted to visual surveys of trucks along major highways. Checkpoints, usually at weigh stations, are set up, and government employees or students count the placarded trucks passing through, recording the commodity class of each shipment. Moreover, several States have conducted surveys of the volume and types of hazardous materials carried by truck. In many cases, the States have had the resources and the authority to

[30] Chemical Manufacturers Association, press release, Washington, DC, April 1985.

[31] Dennis L. Price, et al., *Multi-Modal Hazardous Materials Transportation in Virginia*, VDOTS/SPO-16 (Richmond, VA: Virginia Department of Transportation Safety, 1981).

[32] James D. Brogan, "Routing Models for the Transportation of Hazardous Materials—State Level Enhancements and Modifications," prepared for presentation at the 64th Annual Meeting of the Transportation Research Board, unpublished typescript, 1985.

[33] National Conference of State Legislatures, *Hazardous Materials Transportation: A Legislator's Guide* (Washington, DC: February 1984).

[34] Ibid.

[35] City of Memphis, Division of Fire Services, *Hazardous Materials Task Force Final Report* (Memphis, TN: 1981), p. 24.

[36] Raymond Scanlon, Port Authority of New York and New Jersey, "A Regional Study on Hazardous Materials Transportation," Howard S. Cullman Fellowship 1982-83 Report, unpublished typescript, p. 15.

combine a visual survey with an inspection and driver interview.

A full-scale study was carried out in 1977 to 1978 by the Virginia Department of Transportation Safety as part of a multimodal analysis of hazardous materials transportation. During July and August 1977, all trucks passing 38 survey points on Interstate and primary roads were stopped by State or local police. Shipping papers were inspected, and the drivers were interviewed on the types of materials carried, origin and destination of the trip, and the sequence of routes taken. Officers also checked to see if the placarding was correct and classified the carrier as company-owned, independent, common carrier, or personal vehicle. The study findings provided Virginia officials with a current database on commodity flow and a good measure of the level of compliance with existing Federal and State regulations. The survey found that 13 percent of the trucks carried hazardous materials, of which 76 percent were flammable, combustible, or corrosive liquids. Petroleum products were the most common cargoes. The heaviest hazardous materials traffic was on Interstate highways in and around cities, because urban areas are the principal origins and destinations of petroleum products. The number of placarding violations found by inspectors increased from 34 percent in 1977 to 55 percent in 1978.[37]

Over a l-year period from October 1981 to September 1982, Washington State surveyed the amounts of hazardous materials moving through the State and the type of carrier used. The Washington State methodology was similar to that of the Virginia study. The State Utilities and Transportation Commission set up checkpoints at 11 locations on major highways. All trucks were stopped and checked for 4-hour periods twice a month. The checks included an inspection of shipping papers and an interview with the driver about cargo, quantity carried, origin, destination, and type of carrier. The data were tabulated and sorted using the Automated Hazardous Materials Surveillance Program, a computer program designed for the study that can sort survey data according to date, location, commodity, and truck type and cross-check it with accident and violation data. Researchers found that although independent truckers carry 50 percent of the cargo, they are involved in 75 percent of the accidents.[38]

In 1982 and 1983, the South Dakota Department of Public Safety surveyed drivers and inspected approximately 340,000 trucks at highway checkpoints. Fewer than 1 percent of the trucks carried hazardous materials. The most common hazardous materials cargos were flammable liquids, explosives, corrosives, and flammable gases. The survey found that 55 percent of the hazardous materials shipped was intrastate, primarily flammable liquids and gases. Most intrastate shipments were local deliveries of 25 miles or less, usually originating in one of the larger cities. Although most deliveries were local, carriers indicated that their trucks spent as much as 40 percent of their time on Interstate highways.[39]

OTA research indicates that even when a comprehensive State transportation data-collection effort has been undertaken, cities within the State are often unaware of the resource and consequently do not make use of it.

Rail Studies

Data collection on bulk rail shipments of hazardous materials is extremely important to rail distribution centers such as Memphis and Indianapolis, where data are needed for emergency planning and response purposes. Information on commodities transported, measured by rail carloads, is generally available on request from the major railroads. Information indicating the location of hazardous materials cars in the train and instructions on emergency response procedures are available on the train as well as through railroad offices. However, the availability and detail of the data depend on the extent to which the line is computerized. AAR has compiled a list of the 138 chemicals most frequently carried by the railroads. It has developed detailed fact sheets for these commodities that are incorporated into computerized train information and waybills.[40]

[37]Price, et al., op. cit., p. XIII.

[38]U.S. Department of Transportation, Materials Transportation Bureau, *SHMED Program Workshop Proceedings, Salt Lake City, Utah, 1983* (Washington, DC: 1983), p. 206.

[39]Ibid., p. 186.

[40]Patrick J. Student (cd.), *Emergency Handling of Hazardous Materials in Surface Transportation* (Washington, DC: Bureau of Explosives, Association of American Railroads, 1981).

Most State and local governments do not collect rail data, although Oregon requests some data from the railroads annually on shipments within its boundaries. Two States with strong rail divisions, New York and New Jersey, do have databases, but these are derived from ICC data. In a few instances, localized data have been collected; the State of Washington[41] and Indianapolis, Indiana,[42] are examples.

Massachusetts, as part of a 1981 planning project, inventoried all the major rail lines in the State and obtained information on the types and quantities—in carloads—of hazardous materials shipped by three of the four largest railroads. Furthermore, Virginia, as part of its multimodal study, collected data from the 10 railroads serving the State. The railroads provided waybill samples for subsections of each line. With this information, analysts estimated the number of cars per day carrying hazardous materials, the tons of hazardous materials carried per day, and the number of trains containing hazardous materials cars. Corrosives accounted for almost half the volume of hazardous materials transported by rail, followed by flammable liquids, and nonflammable compressed gas. The heaviest rail flow of hazardous cargo was in and around cities, a reflection of the demand for petroleum products in urban areas.[43] Finally, the State of Oregon requires annual summaries by milepost segment of all rail shipments of Class A explosives and poisons. These data are used for emergency response planning.

Air Transportation Studies

The transportation of hazardous materials by air is controlled by the FAA's Civil Security Division. Since hazardous shipments account for less than 3 percent of total hazardous materials tonnage moved nationally and since shipments, though numerous, are generally small, State and local governments have not been particularly concerned about air transport. Only Virginia has collected any primary data,[44] consisting of information on hazardous materials passing through many of its major airports. However, FAA conducted surveys of the types and quantities of hazardous materials shipments at the New Orleans, Memphis, and Boston airports, and provided local planners with the data. Data on shipment characteristics for air freight carriers can be obtained to augment FAA data. Local planners do not have access to information on hazardous materials carried by military aircraft.

Water Transportation Studies

Ports play an important role in hazardous materials commerce. For example, 4.5 million tons of hazardous materials pass through the Port of Seattle each year—about 27 percent of the total cargo handled. Over half of the Nation's chemicals move through the Port of Houston annually. State and local planners rely on data from the Army Corps of Engineers as their primary data source. The Corps provided Massachusetts researchers with the annual tonnage by commodity group for 1978 for both Boston Harbor and the nearby New Bedford Harbor. However, the data classification system used by the Corps does not always identify specific commodities—for example, the "Basic Chemicals" category contains some nonhazardous materials. This leads to overestimates of the actual amounts of hazardous materials, but none of the States or cities contacted by OTA found this a sufficient reason to conduct an additional study. Two port cities, Seattle and Boston, supplemented the Corps' data with information on tonnage of commodities available from local regulatory agencies and the U.S. Coast Guard.

Shipments of Radioactive Materials and Wastes

In 1973 to 1975 and 1977 to 1981, two series of studies involving a number of States were conducted jointly by NRC and DOT for the purpose of collecting information on the transportation of low-level radioactive materials. Data were gathered on low-level radioactive waste sites; shipments by highway, air, and water; and the history of accidents and incidents. Findings were used to determine gaps in Federal regulatory programs and in Federal and State enforcement efforts.[45]

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[41] National Conference of State Legislatures, *Hazardous Materials Transportation: A Legislator's Guide*, op. cit.

[42] City of Indianapolis, *Demonstration Project To Develop a Hazardous Materials Accident Prevention and Emergency Response Program: Final Reports, Phases Z-IV* (Washington, DC: U.S. Department of Transportation, Research and Special Programs Administration, 1983).

[43] Price, et al., op. cit., pp. 13-15.

[44] Ibid.

[45] Stephen N. Salomon, *State Surveillance of Radioactive Materials* Transportation, NUREG-1OI5 (Washington, DC: U.S. Nuclear Regulatory Commission, Office of State Programs, 1984), p. 5.

Data on movement for high-level radioactive materials and wastes, including spent fuel, are treated differently from other hazardous materials data–both legally and institutionally. DOT has primary responsibility for monitoring low-level radioactive materials and wastes, while DOT and NRC share regulatory and enforcement authority for high-level radioactive materials and wastes. NRC requires licensees to provide advance notice for certain nuclear shipments; to provide physical protection of special nuclear materials including spent nuclear fuel to prevent theft, diversion, or sabotage; and to notify NRC regional offices of impending special shipments of nuclear materials. A study conducted by the Battelle Memorial Institute for DOT analyzed States' use of the information on transport shipments of spent nuclear fuel through their jurisdictions. Of the States surveyed, 14 out of 15 maintain a file of notifications. Five States pass the information on to other State agencies; two make subsequent notifications to other divisions of the same agencies; and six subsequently notify officials at both the State and local levels. Two States make no further notification for security reasons. The primary benefit of notification identified by almost all States surveyed was that awareness of impending shipments allowed them to take precautions and alert emergency response agencies.[46]

Registration Notification Requirements as Tools for Data Gathering

OTA examined registration and notification requirements as potential data resources for hazardous materials planning. The most basic information needed is the identities and locations of suppliers, manufacturers, and carriers of hazardous materials. A governmental entity may acquire this information by requiring such firms to register. Although it has the authority to do so, RSPA does not have a registration program and thus has no complete record of the firms it regulates or their locations. Because RSPA cannot provide this basic information, some State and local governments have imposed their own registration requirements. Pennsylvania, California, and Denver, for example, require registration. However, the purpose of the Denver registration program, enacted in 1985, is not primarily to gather information, but rather to fund enforcement activities.[47]

State and local governments typically give two reasons for enacting notification requirements: to provide data for planning (including better routing and safety regulations), and to improve emergency response. The Battelle study, cited above, identified 136 State and local notification laws pertaining to hazardous materials transportation. Over two-thirds of the jurisdictions identified information needs for planning as an important reason for their laws, citing the need to know about the types and quantities of materials shipped through their jurisdictions, trip scheduling, and routes frequently used. Many also indicated they require advance notification to alert response teams when a potentially hazardous shipment is due.

The study concluded that most of these regulations produce little usable data either because they apply to a very narrow range of materials or because they are not enforced. For further discussion of registration and notification issues, see chapter 4.

Hazard and Risk Assessments

Federal Risk Assessment.–During the last decade, the Federal Government has sponsored a number of efforts to formulate risk assessment models and apply them to hazardous materials transportation safety. The Coast Guard, for example, used models originally developed for emergency response purposes as the basis for its Population Vulnerability Model, which calculates the travel and chemical reactions of marine cargo spills over time, and estimates their effects on the surrounding population and property. Sandia Laboratories quantified the severities of hazardous materials transportation accidents in the air, truck, and rail modes.[49] Battelle Pacific Northwest Laboratory used Sandia's results to develop a general risk assessment methodology, which was first applied to truck shipments

[46] Battelle Memorial Research Laboratories, Battelle Human Affairs Research Center, *Assessment of Stare and Local Notification Requirements for Transportation of Radioactive and Other Hazardous Materials* (Seattle, WA: Jan. 11, 1985), pp. 88-112.

[47] Cathy Reynolds, Denver City Council, in U.S. Congress, Office of Technology Assessment, "Transcript of Proceedings—Transportation of Hazardous Materials Advisory Panel," unpublished typescript, June 27, 1985, p. 230.

[48] National Materials Advisory Board, *The Application of Quantitative Risk Assessment Techniques in the U.S. Coast Guard Regulatory Process, NMAB-402* (Washington, DC: National Academy Press, 1982),

[49] R.K. Clarke, et al., *Severities of Transportation Accidents,* SLA-74-0001 (Albuquerque, NM: Sandia National Laboratories, 1976).

of radioactive materials,[50] and later extended to other modes of transportation and to other hazardous materials transportation by truck and rail in the Central Puget Sound Region.[51]

DOT has sponsored several risk assessments concerning the rerouting of hazardous materials. For example, a computer-based network model of the U.S. rail system was used to study the effects on risk levels of a policy to reroute railroad shipments of hazardous materials to avoid populated areas.[52] The model was also used in conjunction with a study of catastrophic derailment risks.[53] Risk-based criteria have been developed to enable State and local authorities to designate routes for truck shipments of hazardous materials. DOT has also sponsored the development of risk assessment worksheets and guidelines for large and small community routing and emergency planning.[54]

State and Local Hazard and Risk Assessment.– Public concerns about the risks of hazardous materials transportation are likely to persist and intensify, accentuating the need for risk or hazard assessment at the regional level. This generally consists of two stages: 1) the development of an inventory of hazardous materials activity and exposure in the region, and 2) the estimation and evaluation of risks based on that information. OTA finds that the first stage can be performed very well at the State and local level. In fact, the data-collection process can be beneficial in itself, because of the contacts and communication it fosters. It is the process of evaluating the risks and making decisions based on them that has been the source of difficulty, especially in the cities where disputes over routing decisions have reached the courts. The worksheet approaches developed under DOT sponsorship for highway routing[55] and community planning[56] are helpful, but insufficient, because they reduce the results to a single number known as "expected risk." A risk profile showing frequency in comparison to consequence is more helpful than a single number, which provides no insight into whether the concern is about frequent spills that may be of low consequence (gasoline, for example) or infrequent spills of a more dangerous substance like chlorine, and does not usually indicate the uncertainty of the risk estimate.

The importance of making regionally acceptable risk-based decisions suggests that DOT could provide State and local governments with better tools for risk assessment. The technical complexities of a thorough risk assessment could be handled through an assistance program similar to the one employed by the Urban Mass Transportation Administration for those using the Urban Transportation Planning System (UTPS) computer software as a basis for regional transportation planning.[57] A computer model estimating population at risk along transportation corridors has been developed at Oak Ridge National Laboratory. The model may be revised for microcomputers, and with a good user's manual could be a useful risk assessment tool for State and local governments.[58] In addition, following the UTPS precedent, a program of training courses could be established and a staff organized for system maintenance and assistance to the users. This type of program would provide practical assistance for jurisdictions considering routing alternatives.

OTA reviewed a number of State and local hazard and risk studies, because they are important for contingency planning, for practical decisions about locating response equipment and allocating manpower, and for developing routing plans. This last area, routing, has been the source of a great deal of interjurisdictional conflict; for further discussion, see chapter 4.

[50] T.I. Sweeney, et al., *An Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck,* Report No. 1846 (Richland, WA: Battelle Pacific Northwest Laboratory, 1975).

[51] W.B. Andrews, *Hazardous Materials Transportation Risks in the Puget Sound Region* (Richland, WA: Battelle Pacific Northwest Laboratory, 1981),

[52] T.S. Glickman, "Rerouting Railroad Shipments of Hazardous Materials To Avoid Populated Areas," *Accident Analysis and Prevention,* vol. 15, No. 5, 1983, pp. 329-335.

[53] T.S. Glickman and D.B. Rosenfield, "Risks of catastrophic Derailments involving the Release of Hazardous Materials," *Management Science, vol. 30, No. 4, 1984,* pp. 503-511.

[54] E.J. Barber and L.K. Hildebrand, Peat, Marwick, Mitchell & Co., *Guidelines for Applying Criteria To Designate Routes for Transporting Hazardous Materials,* FHWA-IP-80-20 Implementation Package (Washington, DC: Federal Highway Administration, 1980); and E.R. Russell, et al., *A Community Model for Handling Hazardous Materials Transportation Emergencies* (Washington, DC: U.S. Department of Transportation, Research and Special Programs Administration, 1981).

[55] Barber and Hildebrand, op. cit.

[56] Russell, et al., op. cit.

[57] U.S. Department of Transportation, *User-Oriented Materials for UTPS—An Introduction to Urban Travel Demand Forecasting* (Washington, DC: 1977).

[58] Edward L. Hillsman, Research Staff, Oak Ridge National Laboratory, personal communication by letter, May 15, 1986.

Few jurisdictions have used sophisticated mathematical techniques of risk analysis to estimate the probability of an incident and its severity. Most communities find it adequate to map the areas where the risk of a hazardous materials incident is highest or where there would be the greatest public danger or the most damage. Data for this type of study can be assembled either from a fixed facility inventory or a transportation study. Much useful information is also available from public records routinely kept for other purposes by State and local public works, transportation, environmental, and planning departments. Normally, a hazard assessment requires the following kinds of information:

- transportation network maps and descriptions;
- highways and streets used by hazardous materials carriers;
- tunnels, bridges, and rail crossings;
- railroad yards and truck terminals;
- highway, rail, air, and water accident data;
- locations of past hazardous materials incidents and materials involved;
- concentrations of hazardous materials manufacturing or storage sites;
- areas of high population density and environmental sensitivity;
- location of schools, hospitals, and other especially vulnerable sites; and
- water supply and sewer facilities.

A risk assessment could also include special analyses of the types and quantities of hazardous materials transported through the community and the location of emergency response teams and equipment.

Conclusions

OTA finds that Federal data-collection activities provide modal transportation data of varying completeness. OTA experience in analyzing many Federal databases for this report establishes that data integration is not a technical problem; with careful analysis, comparative data on commodity flow can be developed. However, the quality of the data is not outstanding, and the data are incomplete innumerous areas, particularly for truck and air transport. These shortcomings mean that current policy decisions must be based on inadequate information, a separate concern that warrants further study.[59] OTA concludes that if RSPA were to conduct analyses of existing data similar to that undertaken for this study, it would benefit by having aggregate commodity flow information to use as a denominator in analyzing its spill and accident records. Such data might not completely satisfy State or local needs for information about shipments, but they can show State-to-State and regional transportation patterns.

Furthermore, OTA concludes that State and local data collection has enormous value in and of itself. The information gathered is only part of that value; the communication, cooperation, and coordination between the public and private sectors that are an inevitable result of the effort are extremely important. Community right-to-know laws are useful tools for State and local governments in obtaining data, and national right-to-know legislation would bolster implementation of such laws, where industry resistance remains.

Some city officials and planning personnel have continued to express a need for a national commodity flow data resource. An annual printed summary provided by DOT is most frequently mentioned, and OTA concludes that annual DOT summaries of shipments would provide useful national, regional, and State flow pattern information. Although some desire for real-time notification of especially high-hazard shipments has been voiced, emergency response officials consulted by OTA generally prefer to do local inventories and transportation surveys and to prepare their personnel for any eventuality. They point out that detailed real-time information would be overwhelming to track and useless for planning and preparedness.[60] As one fire chief said: "What am I supposed to do? Follow the truck around waiting for an accident to happen?"[61]

However, some local officials who want real-time tracking of hazardous materials, have called for DOT to develop a publicly accessible database to

[59] Martin Crutsinger, "U.S. Statistical Problems Seen, " *Washington Post*, Mar. 18, 1986, p. El.

[60] U.S. Congress, Office of Technology Assessment, *Transportation of Hazardous Materials: State and Local Activities*, op. cit., ch 4.

[61] Thomas Hawkins, Jr., Chief, Arlington County Fire Department) Arlington, VA, personal communication, January 1986.

provide information on shipments.[62] Such real-time data are probably the only way to keep current on shipments if that is the goal, since many hazardous materials orders are for truck delivery within 36 hours or less. Other shipments are seasonal, related to agricultural or manufacturing cycles. Finally, customers may suddenly change supply sources for economic reasons, rendering periodic data collection instantly obsolete. The technological groundwork for a real-time system to track hazardous waste shipments, which represent less than 1 percent of hazardous materials shipments, has been developed by a private firm, although the system has not been tested in operation.

However, even if the technical difficulties for implementing such a system for all hazardous materials could be resolved, the cost has been estimated to be more than $100 million.[63] OTA finds that while development of a real-time database limited to tracking only certain highly hazardous shipments is technically feasible, its utility for emergency response is questionable. Furthermore, development of online telephone access to real-time information on all hazardous materials shipments is not feasible, nor would it be cost-effective.

If Congress chooses to provide support for data gathering, several options are available. DOT could be required to exercise its authority under 49 U. S. C., Section 1805(b) and develop a registration program for hazardous materials shippers, transporters, and container manufacturers. OTA finds that a registration program would provide DOT with essential information about the community it regulates and with some commodity shipment information that could be made available to State and local jurisdictions. DOT could make use of the information for setting priorities for rulemaking, research, and for enforcement actions. A modest registration fee could be imposed to cover costs of administering the program.

In addition, Congress could require DOT to integrate, analyze, and report annually on trends from relevant Federal databases kept by the modal administrations and the Bureau of the Census. For this effort to be effective:

- The collection of data on truck movements must be improved.
- Conversion or bridge tables for the commodity codes used by different agencies and in 49 CFR, Section 172, must be created. Alternatively, each agency might be required to use a common code for commodities.
- Sufficient funds must be allocated to support the effort. OTA estimates that the equivalent of one man-year of effort, between $45,000 and $75,000, would provide a modest start.

Finally OTA finds that a summary of commodity flow data in comparison with DOT accident data in the required annual report to Congress would be useful.

[62] The National League of Cities (NLC) has retained in its transportation position paper a request for a U.S. Department of Transportation report on commodity flow. Barbara Harsha, NLC transportation staff, personal communication, January 1986.

[63] Jon Mulholland, Source Data Network, personal communication, November 1985.

PART II: ACCIDENT AND SPILL INFORMATION SYSTEMS

Statistics generated by hazardous materials accident and spill databases can be used within agencies and departments to measure program effectiveness, to improve accident and spill prevention by identifying and analyzing causes and events, and for regulatory and enforcement analysis. A reliable incident/accident database can also be used to improve emergency response and disaster preparedness by identifying trouble spots. Knowledge of high accident frequency locations and the flow of hazardous materials provides communities with an understanding of the probability of an accident or spill and the materials likely to be involved, tools for risk assessment.

Spill Report Systems

Each of the DOT modal administrations keeps separate modal accident data, and several agencies keep data specifically on releases of hazardous materials. However, RSPA is the official DOT repository of hazardous materials release information. A transportation-related incident or release is defined in DOT regulations as any unintentional release of a hazardous material during transportation, or during loading/unloading or temporary storage related to transportation. Every release, except for those from bulk water transporters and those motor carrier firms doing solely intrastate business, must be reported to RSPA in writing as prescribed in 49 CFR, Parts 171, 174.45 (rail), 175.45 (air), and 176.48 (marine vessels). The only other exceptions are consumer commodities that present a limited hazard during transportation, such as electric storage batteries and certain paints and materials. These exceptions do not apply to hazardous waste releases or those involving aircraft. A written response must be prepared by the carrier on a prescribed form, F5800.1 (see figure 2-2), and submitted to RSPA within 15 days of discovery of the release. While carriers are required to report, any interested party may report. A RSPA contractor logs the written report information into a computerized database.

This database, called HMIS, became the central system for spill data in 1971. Prior to that time, hazardous materials regulatory authority had been divided among DOT modal administrations, and a wide range of hazardous materials reporting systems had evolved. Since collecting and maintaining this data became a RSPA responsibility, the only major change in the incident reporting requirements occurred in 1981, when battery spills and spills of less than 5 gallons of paint were eliminated from required reporting, reducing the number of reports processed by RSPA considerably. The HMIS database is the only one devoted exclusively to hazardous materials transportation spills, and consequently is the one most useful for examining packaging, labeling, accident cause, and safety issues.

Carriers are also required to make an immediate telephone report to the National Response Center (NRC) when a spill has resulted in one or more of the following consequences as a direct result of the hazardous material:

- a fatality;
- a serious injury requiring hospitalization;
- estimated carrier or other property damage exceeding $50,000;
- fire, breakage, or suspected contamination involving the shipment of radioactive materials or etiologic agents; and
- a situation such nature that the carrier judges should be reported.[64]

NRC is staffed 24 hours a day by the Coast Guard and handles the reporting of all significant hazardous materials spills under agreements with DOT and EPA. Established in 1974, NRC has two 24-hour toll-free telephone lines to receive notifications and several other lines to relay calls to emergency response agencies that may need to know of the release. However, the NRC telephone number does not appear in DOT's ***Emergency Response Guidebook.****

Telephone reports received by NRC are logged every evening into a computer operated at the DOT Transportation Systems Center where the information is retained and managed by RSPA. RSPA uses the NRC telephone reports occasionally, for serious releases, but relies primarily on the written reports that it receives directly as the basis for its database on incidents, casualties, associated damages, and a multitude of descriptors related to the material, container, cause, and location of the release.

In many cases, carriers involved in a release have telephoned CHEMTREC, a chemical transportation emergency center established in 1971 by CMA. Since 1980, CHEMTREC has been required to notify NRC of significant hazardous materials transportation releases—those which have or might cause considerable harm to the public or the environment. A call to CHEMTREC fulfills only the NRC telephone reporting requirements; it does not fulfill the Federal written reporting requirements. The CHEMTREC toll-free telephone number is given in DOT's *Emergency Response Guidebook.*

Although reporting releases is a regulatory requirement, OTA found evidence that the compliance rate is low. One State official has estimated that 30 to 40 percent of reportable hazardous materials incidents are never reported.[65] EPA Region VII officials have independently estimated that only about 10 percent of all reportable releases under 100 gal-

[64] 49 CFR 171.15.

*U.S. Department of Transportation publishes and distributes the *Emergency Response Guidebook* free of charge on request. It contains examples of hazardous materials marking and shipping information and basic guidance on appropriate first response actions.

[65] Stephen W. Ballou, "Memo From Iowa Department of Water, Air and Waste Management," unpublished typescript, May 6, 1985.

Figure 2=2.–DOT incident Report Form F5800.1

DEPARTMENT OF TRANSPORTATION — Form Approved OM8 No. 04.S613

HAZARDOUS MATERIALS INCIDENT REPORT

INSTRUCTIONS: Submit this report in duplicate to the Director, Office of Program Support, Materials Transportation Bureau, Department of Transportation, Washington, D.C. 20590, (ATTN: DMT-412). If space provided for *any* item is inadequate, complete that item **under Section** H, "Remarks", keying to the entry number being completed. Copies of this form, in limited quantities, may be obtained from the Director, Office of Program Support. Additional copies in this prescribed format maybe reproduced and used, if on the same size and kind of paper.

A INCIDENT

1. TYPE OF OPERATION
   1 ☐ AIR 2 ☐ HIGHWAY 3 ☐ RAIL 4 ☐ WATER 5 ☐ FREIGHT FORWARDER 6 ☐ OTHER *(Identify)* ____

2. DATE AND TIME OF INCIDENT *(Month Day Year)* ____ a.m. ____ p.m.

3. LOCATION OF INCIDENT

B REPORTING CARRIER, COMPANY OR INDIVIDUAL

4. FULL NAME

5. ADDRESS *(Number, Street, City, State and Zip Code)*

6. TYPE OF VEHICLE OR FACILITY

C SHIPMENT INFORMATION

7. NAME AND ADDRESS OF SHIPPER *(Origin address)*

8. NAME AND ADDRESS OF CONSIGNEE *(Destination address)*

9. SHIPPING PAPER IDENTIFICATION NO.

10. SHIPPING PAPERS ISSUED BY
    ☐ CARRIER ☐ SHIPPER
    ☐ OTHER *(Identify)* ____

D DEATHS, INJURIES. LOSS AND DAMAGE

DUE TO HAZARDOUS MATERIALS INVOLVED

11. NUMBER PERSONS INJURED

12. NUMBER PERSONS KILLED

13. ESTIMATED AMOUNT OF LOSS AND/OR PROPERTY DAMAGE INCLUDING COST OF DECONTAMINATION *(Round off in dollars)*
    $

14. ESTIMATED TOTAL QUANTITY OF HAZARDOUS MATERIALS RELEASED

E HAZARDOUS MATERIALS INVOLVED

15. HAZARD CLASS (*Sec. 172.101, Col. 3)	16. SHIPPING NAME (*Sec. 172.101, Col. 2)	17. TRADE NAME

F NATURE OF PACKAGING FAILURE

18. *(Check all applicable boxes)*

☐ (1) DROPPED IN HANDLING	☐ (2) EXTERNAL PUNCTURE	☐ (3) DAMAGE BY OTHER FREIGHT
☐ (4) WATER DAMAGE	☐ (5) DAMAGE FROM OTHER LIQUID	☐ (6) FREEZING
☐ (7) EXTERNAL HEAT	☐ (8) INTERNAL PRESSURE	☐ (9) CORROSION OR RUST
☐ (10) DEFECTIVE FITTINGS, VALVES, OR CLOSURES	☐ (11) LOOSE FITTINGS, VALVES OR CLOSURES	☐ (12) FAILURE OF INNER RECEPTACLES
☐ (13) BOTTOM FAILURE	☐ (14) BODY OR SIDE FAILURE	☐ (15) WELD FAILURE
☐ (16) CHIME FAILURE	☐ (17) OTHER CONDITIONS *(Identify)*	19. SPACE FOR DOT USE ONLY

Form DOT F 5800.1 (10-70) (9/1/76)
*. Editorial change to incorporate redesignation per HM-112.

Figure 2-2.—DOT Incident Report Form F5800.1—Continued

G PACKAGING INFORMATION . *If more than one size or type packaging is involved in no. * of material show packaging information separately for each. If more space is needed, use Section H "Remarks" below keying to the item number.*

	ITEM			#1	#2	#3
20	TYPE OF PACKAGING INCLUDING INNER RECEPTACLES *(Steel drums, wooden box, cylinder, etc.)*					
21	CAPACITY OR WEIGHT PER UNIT (5S *gallons, 65 lbs., etc.)*					
22	NUMBER OF PACKAGES FROM WHICH MATERIAL ESCAPED					
23	NUMBER OF PACKAGES OF SAME TYPE IN SHIPMENT					
24	DOT SPECIFICATION NUMBER(S) ON PACKAGES *(21 F', 17E, 3AA, etc., or non ●)*					
25	SHOW ALL OTHER DOT PACKAGING MARKINGS *(Part 178)*					
26	NAME, SYMBOL, OR REGISTRATION NUMBER OF PACKAGING MANUFACTURER					
27	SHOW SERIAL NUMBER *OF CYLINDERS.* CARGO TANKS, TANK CARS, PORTABLE TANKS					
28	TYPE DOT LABEL(S) APPLIED					
29	IF RECONDITIONED OR REQUALIFIED, SHOW	a	REGISTRATION NO. OR SYMBOL			
		e	DATE OF LAST TEST OF INSPECTION			
30	IF SHIPMENT IS UNDER DOT OR USCG SPECIAL PERMIT, ENTER PERMIT NO.					

H REMARKS . Describe essential facts of incident including but not limited to defects, damage, probable cause, stowage, action taken at the time discovered, and action taken to prevent future incidents. Include any recommendations to improve packaging, handling, or transportation of hazardous materials. Photographs and diagrams should be submitted when necessary for clarification.

31. *NAME* OF PERSON PREPARING REPORT (*Type or print)*	32. SIGNATURE
33. TELEPHONE NO. *(Include Area Code)*	34. DATE REPORT PREPARED

Reverse of Form DOT F 5800.1 (10-70)

ions are reported to EPA, the States, or NRC, although 90 percent of releases over 100 gallons are reported; and 20 percent of all polychlorinated biphenyl releases are reported.[66] Transportation spills constitute 26 percent of the total number of incident reports compiled by this EPA region.[67]

The hazardous materials regulated community is so large that inspection of every facility, manufacturer, shipper, and carrier is not feasible. Enforcement agencies use a variety of criteria to determine how best to deploy their inspection resources, and violation and release records are frequently used to identify areas on which to concentrate inspection efforts. The Coast Guard, for example, has redirected its inspection efforts to "high-priority" vessels, the definition of which includes a vessel with a reported previous hazardous materials incident. BMCS and the Federal Railroad Administration also use selection criteria to determine inspection priorities, based in part on release experience.[68] However, since compliance with the release reporting requirement is low, many firms go for years without seeing an inspector, and problems remain uncorrected.

The incentive for reporting, as required by the Federal enforcement program, is to avoid the possibility of a civil or criminal penalty that can be imposed if a person knowingly violates a Hazardous Materials Transportation Act regulation. Civil penalties, more common than criminal penalties, can include a liability of up to $10,000 per violation or 1 year imprisonment, or both. Criminal penalties are subject to a fine of up to $25,000 or 5 years imprisonment, or both. However, even when violators are penalized, the level of the penalty is often insufficient to deter future violations, because the costs of compliance are greater than those of potential penalties. Thus, some operators consider penalties to be an occasional cost of doing business.[69] For further discussion of penalty levels, see chapter 4.

Despite widespread mistrust in the reliability of the HMIS, its information is acknowledged to be the best available, and frequent requests for Federal accident and spill data come from the private sector, including legal professionals, industry analysts, private citizens, consultants, and university researchers. In most cases, DOT handles these through distribution of a hard copy of the requested material, although a few databases are also accessible through online queries via telephone access.

Modal Accident Data Systems

Independent of the RSPA release reporting system are several accident reporting systems maintained by various modal administrations.* These systems were designed to cover all transportation accidents under the jurisdiction of the particular administration, not just those involving hazardous materials. In many cases, however, special identifiers have been placed in the reporting format that permit the designation of an accident involving hazardous cargo. These databases are useful secondary data, as the accident reports are usually based on reporting procedures independent of RSPA procedures, and thus are not subject to the same deficiencies. However, the different agencies use different location codes for accidents, ranging from point codes to relative location from a nearby town, making it difficult to identify routes where route characteristics may contribute. In addition, other sources of information exist that are useful for understanding releases and accidents related to the transportation of hazardous materials.

The Coast Guard maintains two databases that include recognition of accidents and spills involving hazardous materials: 1) the Commercial Vessel Casualty File (CVCF), and 2) the Pollution Incident Reporting System (PIRS). These databases could be

[66] ICF, Inc., "Economic Analysis of Reportable Quantity Adjustments Under Sections 102 and 103 of the Comprehensive Environmental Response, Compensation, and Liability Act," unpublished typescript, March 1985.

[67] William J. Keffer, "Incident Activity Report," periods covering June-August 1985, memo to distribution, U.S. Environmental Protection Agency Region VII.

[68] U.S. Department of Transportation, Research and Special Programs Administration, *A Guide to the Federal Hazardous Materials Transportation Regulatory Program* (Washington, DC: January 1983).

[69] National Conference of State Legislatures, *Hazardous Materials Incident Reports* (Washington, DC: U.S. Department of Transportation, Research and Special Programs Administration, February 1984).

*The term "accident" refers to a vehicular accident. Most hazardous materials transport releases are not caused by vehicular accidents themselves, but by other causes such as faulty valves or closures. Conversely, most vehicular accidents do not involve vehicles that are transporting hazardous materials.

used to fill a gap in the HMIS, which is particularly weak in the marine mode.

CVCF includes all vessel accidents, both domestic and foreign, occurring since 1963 in U.S. waters, subject to the following criteria:

- actual physical damage to property in excess of $25,000;
- material damage affecting the seaworthiness, maneuverability, or efficiency of a vessel;
- stranding or grounding (with or without damage);
- loss of life; and/or
- injury causing any person to remain incapacitated for a period in excess of 72 hours, except injury to harbor workers not resulting in death and not resulting from vessel casualty or vessel equipment casualty.

The records include vessel characteristics, event, cause, fatalities/injuries, and monetary damage; specific vessel codes indicate whether the vessel was carrying hazardous cargo.[70]

The PIRS database consists of reports generated in response to requirements of the Federal Water Pollution Control Act and the Comprehensive Environmental Response, Compensation, and Liability Act. It includes all polluting releases into U.S. waters and identifies transport-related releases by hazardous substance name. The database also includes the quantity released, cause of the incident, and the date and location.[71] According to Coast Guard officials, the PIRS database has unedited files where major errors often appear, and only closed cases are available for analysis from the database.

The Bureau of Motor Carrier Safety has maintained a database on accidents since 1973. It includes any motor carrier accident in which a fatality or injury occurred or for which at least $2,000 in property damage was incurred. Reports are filed on Form 50-T, which requests carrier identification and address, location of the incident, characteristics of the event, cause, information on the cargo, and consequences of the accident. The carrier identification, cargo description, and certain accident characteristics are recorded, so that congruence between the HMIS database and BMCS database maybe achievable for releases caused by vehicular accidents.

The Federal Railroad Administration maintains its own accident/incident database from information generated by railroads, inspectors, and RSPA. The database includes information similar to the accident characteristics described in the Coast Guard and BMCS databases, although FRA has its own definition of incidents and accidents. FRA performs a number of internal consistency checks to strengthen the validity of the database. These include the elimination of double-counting of events when more than one railroad files a report, spot checks of suspicious events, and occasional audits of railroad internal records. Over the past 10 years, over 80,000 records have been included in the FRA file. Approximately 1,000 of these have involved releases of hazardous materials. FRA also maintains an RSPA-enhanced database on hazardous materials spills, which includes accident location information, railroad code, and STCC.

The Federal Aviation Administration maintains a computerized accident/incident database at its National Field Office in Oklahoma City. This database consists of air accidents officially reported to the National Transportation Safety Board (NTSB) and reports filed by FAA field inspectors. FAA makes a distinction between an accident and an incident based on the dollar damage incurred in the reported event. The FAA database includes the pilot involved, the carrier, time-of-day, and other descriptors such as contributing circumstances and accident (incident) severity. It is apparently possible to identify hazardous materials accidents/incidents in this database; according to FAA officials, 11 accidents/incidents involving hazardous materials have been reported in the past 5 years. Although OTA made several requests for additional information, FAA did not respond.

The National Highway Traffic Safety Administration's (NHTSA) National Center for Statistics and Analysis maintains accident data on police-reported accidents, including those resulting in nonfatal injury and/or property damage. The file, the National Accident Sampling System (NASS), was developed to provide an automated, comprehensive national traffic accident database. The accidents investigated in NASS are a probability sample of

[70] U.S. Coast Guard, *Coding Instructions for the Automated File of Commercial Vessel Casualties* (Washington, DC: February 1984).

[71] U.S. Coast Guard, *Polluting Incidents In and Around U.S. Waters, Calendar Year 1981 and 1982* (Washington, DC: December 1983).

all police-reported accidents in the United States. The data for a NASS-selected accident is collected by each State under contractual agreement with NHTSA and includes characteristics of the accident, driver, occupants, and vehicle. Data relevant to this study include the vehicle number, type of carrier, and whether BMCS regulated; characteristics of the roadway where the accident occurred, vehicle body type, body/trailer configuration, vehicle curb and cargo weight; and impact of the accident. Although the specific commodity being carried is not described, sufficient information exists to track accidents likely to involve hazardous materials, and recently a hazardous materials "flag" was added to the record description. Outside of the date and location of the accident, there is little congruence with the data collected by RSPA; however, the characteristics of the driver, road, and traffic may be important determinants of hazardous materials accidents.[72]

Those accidents resulting in loss of human life are also classified separately in NHTSA's Fatal Accident Reporting System (FARS). The FARS file contains data on vehicles and persons involved in fatal accidents, defined as an accident in which an accident-related death occurred within 30 days of the accident. FARS includes all fatal accidents that occur in the United States. Other than this distinction, however, the information collected parallels the NASS data structure.[73] Table 2-10 shows the incident/accident databases.

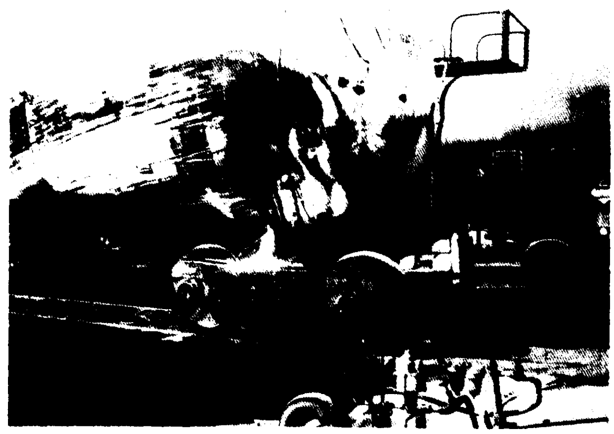
Other Relevant Databases

Environmental Protection Agency.–EPA regional offices receive notifications from many sources of releases of hazardous substances; the reports are integrated into a regional release reporting system. Data recorded include the release date, company involved, spill location, nature of the emergency, material spilled and volume, source of the spill, responding agency, nature of the response, and resolution. Several EPA regions maintain this information in computerized files. EPA uses National Response Center reports in addition to spills reported to EPA regional offices, States, and local governments to formulate regulatory policy.

National Response Center.–Although telephone reports to NRC are primarily to stimulate a response action, the information provided can be used for policy analysis. Data items include the location of the incident, mode of transportation involved, material involved, and quantity released. The material definitions are coded differently from those in HMIS, and causal factors are not considered in any fashion. However, the NRC database provides a more balanced picture of releases by different modes, particularly marine transport.

National Transportation Safety Board.–NTSB investigates transportation accidents in any mode, based on the definition in 49 CFR of a major vehicular accident for each mode. NTSB may use the NRC telephone report information to help determine whether to proceed with its own investigation.

An NTSB investigation includes a multiple-day field investigation involving the shipper, carrier, government agencies, associations, and other interested parties. The investigations take place over several months, so that the full impact of the accident can be assessed. One consequence of this timeframe is that the accident damages reported by NTSB are substantially greater than those reported by carriers



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[72]National Highway Traffic Safety Administration, *National Accident Sampling System (NASS), Analytical User's Manual* (Washington, DC: 1981).

[73]National Highway Traffic Safety Administration, *Fatal Accident Reporting Systems (FARS), User's Guide* (Washington, DC: August 1981).

Table 2"10.—Incident/Accident Databases

Database	Kept by	Years	Modes	Accidents	Incidents	Exclusive hazardous materials focus	Exclusive transport focus
Hazardous Materials Information System	DOT, Office of Hazardous Materials Transportation, Research and Special Programs Administration	1971 to present	All	Yes	Yes	Yes	Yes
Commercial Vessel Casualty File	U.S. Coast Guard	1983 to present	Marine	Yes	No	No	Yes
Pollution Incident Reporting System	U.S. Coast Guard	1971 to 1985	All	Yes	Yes	Yes	No
Truck Accident File	DOT, Bureau of Motor Carrier Safety, Federal Highway Administration	1973 to present	Highway	Yes	No	No	Yes
Railroad Accident File	Association of American Railroads	1973 to present	Rail	Yes	Yes	No	Yes
Air Accident File	Federal Aviation Administration	—	Air	Yes	Yes	No	Yes
National Accident Sampling System	National Highway Traffic Safety Administration	1983 (Hazardous materials flags added in 1983)	Highway	Yes	No	No	Yes
Fatal Accident Reporting System	National Highway Traffic Safety Administrate ion	1983 (Hazardous materials flags added in 1983)	Highway	Yes	No	No	Yes
National Response Center	U.S. Coast Guard	—	All	Yes	Yes	Yes	No
National Transportation Safety Board File	National Transportation Safety Board	—	All	Yes	No	No	Yes
U.S. Department of Energy Data B	Sandia National Laboratories	1979 to present	All	Yes	Yes	Yes	Yes
Washington State Accident File	Washington State Utility and Transportation Commission	1978	Highway	Yes	No	No	Yes

SOURCE: Office of Technology Assessment.

to RSPA.[74] NTSB maintains a database on the vital statistics of each investigated accident. Railroad and aviation accident data are stored in computer files. Highway and marine accident data are stored on coding sheets, but have not yet been logged into the computer system.

Department of Energy.–At the Sandia Laboratories, DOE maintains an online database on all radioactive incidents, based on the HMIS file and information from the Nuclear Regulatory Commission on the loss of control of radioactive materials. The database consists of approximately 70 percent HMIS records and 30 percent NRC records. NRC is the lead agency in conducting investigations of transport accidents involving radioactive materials. These investigations focus on mechanical analyses of the containers involved in the accident, for the purpose of improving the safety of the containers.[75] Table 2-2 presents a summary of these databases.

State and Local Agency Accident Data Systems

Accident and spill databases maintained by State and local agencies vary considerably depending on the authorities involved and the level of commitment the organization has made to managing hazardous materials transportation problems.

The most difficult data-gathering problem in State and local studies has been obtaining reliable information on past hazardous materials releases. Most fire departments do not keep separate records of hazardous materials incidents, although fire departments in some large metropolitan areas are beginning to develop special hazardous materials report forms for use in internal planning. State and local planners usually must rely on outside sources, some of which may be unreliable or contradictory. The experience of San Francisco Bay Area planners illustrates the difficulty of collecting data on releases: of 16 Federal, State, regional, and local sources contacted, only 9 could provide data on past releases within the timeframe requested for the study. Moreover, these sources did not have a common format, and sources reporting the same incident often varied considerably.[76] The staff conducting a current California study for the State legislature found it necessary to consult three separate databases to develop a reliable release record for the State highway system.

State and local agencies have concentrated on developing accident reporting systems rather than release reporting systems and focus much of their attention on the highway mode. This is due to the role of the State and local police in reporting traffic accidents, and a well established and coordinated network of accident management.[78] There have, however, been several State and local attempts to focus on hazardous materials releases, many of them funded by DOT as demonstration projects.*

Other State and regional projects have explicitly examined hazardous materials releases, but have relied heavily or exclusively on HMIS for their data. These include an analysis of hazardous materials transport by rail conducted by the State of New Jersey[79] and a multimodal study of the transportation of hazardous materials in the New York-New Jersey region.[80]

[74] U.S. General Accounting Office, *Programs for Ensuring the Safe Transportation of Hazardous* Materials Need Improvement (Washington, DC: November 1980).

[75] Lawrence Livermore National Laboratory, *Mechanical Analysis of a Transportation Accident Involving Empty Shipping Casks for Radioactive Materials Near Hilda, South Carolina in November 1982,* NUREG/CR-3452 (Washington, DC: U.S. Nuclear Regulatory Commission, October 1983); Lawrence Livermore National Laboratory, *Simulation of Loading Conditions for* a *Type A* Package Containing *Americium-241 Involved in an Airplane Crash at Detroit Metro Airporr in January 1983,* NUREG/CR-3536 (Washington, DC: U.S. Nuclear Regulatory Commission, January 1984); Lawrence Livermore National Laboratory, *A Highway Accident Involving Radiopharmaceuticals Near Brookhaven, Mississippi, on December 3, 1983,* NUREG/CR-4035 (Washington, DC: U.S. Nuclear Regulatory Commission, April 1985); SRI International, *Mechanics ofa Highway Accident at Wichita, Kansas, Involving Natural Uranium Concentrate,* NUREG/CR-0992 (Washington, DC: U.S. Nuclear Regulatory Commission, August 1979).

[76] Association of Bay Area Governments, "issues and Recommendations," *San Francisco Bay Area: Hazardous Spill Prevention and Response Plan,* vol. 1 (Washington, DC: U.S. Department of Transportation, Research and Special Programs Administration, February 1983).

[77] Linda Turnquist, Analyst, California Transit (CALTRANS), personal communication, March 1986.

[78] Some States have mandatory reporting of hazardous substance releases similar to CERCLA requirements although many local agencies are unaware of these reporting requirements. See ICF, Inc., *Economic Analysis of* Reportable Quantity *Adjustments* Under Sections 102 *and 103 of the Comprehensive Environmental Response, Compensation, and Liability Act* (Washington, DC: March 1985).

*An additional Federal initiative has been the State Hazardous Materials Enforcement Development (SHMED) program, The focus has been on establishing uniform transportation safety standards for hazardous materials and the enforcement of these standards.

[79] New Jersey Department of Transportation, Office of Freight Services, *Movements and Incidents of Hazardous Materials in New Jersey* (Trenton, NJ: The New Jersey State Legislature, December 1984).

[80] Scanlon, op. cit.

More sophisticated State applications include the use of computerized accident recordkeeping systems used with flow data to determine highway accident rates and high risk locations. The States of Utah, Washington, and New York, for example, maintain computerized accident recordkeeping databases that contain police accident investigation reports. When a heavy truck is involved, the carrier name, vehicle type, contributing circumstances, accident severity, and other information are required. In the case of the State of Washington, the United Nations number of the cargo is also included.

This type of database permits extracting information about heavy vehicle accidents where hazardous cargo was involved. The information can be checked against movement data to determine accident rates of vehicles transporting hazardous cargo. The accident rates can be used subsequently to compute transport risk profiles and identify safer routes for hazardous materials. The capability to do this exists in the States of Washington and New York, but has not been utilized by the States, partly because of the fragmentation of State government responsibilities. Accident and movement data reside in different offices, and still other offices are responsible for policy analysis. Both States are, however, moving toward conducting better analyses of the data that is collected and maintained.

The State of Maryland has largely overcome these problems. Several years ago, Maryland began a surveillance system of hazardous cargo movements at multiple check points and different times of the day. A State release reporting system was also instituted under which any hazardous materials release is entered into the database. These two sources of information are subsequently compared to determine the level of hazardous materials transport safety in the State. This information has been used to demonstrate a preferred nuclear materials routing system in Maryland. However, the accomplishments in Maryland have come only after IO years of activity and significant coordination among State agencies, demonstrating how time-consuming and painstaking such a process is.

State data-collection capabilities will be further enhanced when an integrated Federal-State data network, known as SAFETYNET, is made operational by BMCS. SAFETYNET will tie together the present BMCS Motor Carrier Safety database with HMIS and various computer-based State systems. The Motor Carrier Safety database now contains information on more than 200,000 interstate carriers and 30,000 hazardous materials shippers. It can report all of the known carriers domiciled in a region, rank them by the average number of driver and vehicle violations found per inspection, list the number of truck inspections each carrier has undergone, and give the date of the most recent safety audit. Once SAFETYNET is operating, BMCS and participating States should be able to:

- input driver-vehicle inspection data,
- update and query inspection data,
- update and query carrier census data,
- query safety management audit summary data,
- query accident report summary data,
- query inspection workload data, and
- generate system reports.[81]

A demonstration program involving four States–North Carolina, Colorado, Oregon, and Michigan —is in progress. The eventual goal is to include all States in SAFETYNET, but this may take 10 years or more to accomplish. Funding is to be provided through a variety of Federal and State programs.

Carrier Release Data

Virtually all carriers retain copies of reports on accidents and releases that they have filed with the appropriate authorities. However, OTA contractors found, based on conversations with carriers, that the methods used for reporting information on Form F5800. 1 are arbitrary. There was a consensus among carriers that the primary purpose of the form is to record a release, not to establish accurate details, and that the 15-day reporting requirement is too short. For example, relatively small damage is often reported as no damage; when the damage is measurable, the carriers usually report the out-of-pocket cost and include the loss of cargo only and not the cleanup cost. There is little evidence that carriers use the release reports for any purpose beyond fulfilling the reporting requirement. Carriers also em-

[81] J.A. Reyes Associates, inc., "SAFETYNET: The Motor Carrier Safety Information Network," prepared for the U.S. Department of Transportation, Federal Highway Administration, Bureau of Motor Carrier Safety, unpublished typescript, November 1984.

phasize that it is inappropriate for them to be required to report releases that occur during loading and unloading, since they often do not perform this function and are unaware of a release having occurred or the details concerning it. *

The Association of American Railroads maintains its own release database from inspector, railroad, Form F5800. 1, CHEMTREC, and telephone reports. Information includes date, location, release type, source of data, deaths and injuries, and estimated damage. The damage estimates can be segmented by equipment, lading, fire, and other damage. The AAR database goes back to 1973.

Completeness and Accuracy of HMIS

The HMIS database is extremely important as the basis for most studies of hazardous materials transport safety in the United States. To assess the adequacy of HMIS for this purpose OTA addressed two concerns:

1. nonreporting of spills as documented in other databases that allow identification of hazardous materials releases, and
2. misreporting of spills as documented by information on the same incident in other release and accident databases.

To document the extent of nonreporting and misreporting, OTA contractors compared the HMIS database with relevant secondary databases on releases and accidents. However, in most cases, other reporting systems cover a much broader spectrum of releases and accidents than simply hazardous materials transport, and are thus not oriented for analyses of the industry at the level of detail theoretically available in the HMIS database. Moreover, databases differ on the definition of a reportable release. Despite these difficulties, OTA concludes that analysis of secondary data is essential to ensure adequate records.

At OTA's request, contractors undertook additional analysis to provide further documentation and develop estimates of nonreporting for HMIS keeping in mind that reports to HMIS of injuries and deaths are required only if the release occurs during interstate transportation and if damage is due to the hazardous material. The methodology for this effort was to match accidents with possible releases in secondary databases, such as NTSB and the BMCS Truck Accident File (TAF) with reported incidents in the HMIS database. Those releases for which an HMIS report could not be identified were included in the computation of nonreporting bias.

Misreporting estimates were developed by studying releases in the HMIS database for which the information reported by the carrier is inconsistent with information available in other reports for the same incident. The methodology used to address this issue is based on comparing reported consequences for matching releases.

The Coast Guard's Commercial Vessel Casualty File reporting criteria are detailed earlier in this report. While CVCF criteria differ somewhat from those for HMIS, they reflect similar objectives, including release consequence. While CVCF does not explicitly identify the vessel's cargo, it does have a detailed vessel-type definition from which releases likely to involve hazardous materials can be identified. For the purposes of this analysis, tanker ships and tanker barges were considered. A direct comparison between CVCF and HMIS was conducted for the period 1976-80.

CVCF analysis shows that collisions and grounding constitute the bulk of reported incidents, with relatively few releases caused by fire, explosion, or material failure, The primary cause of failure is most often "fault of other vessel/personnel. " Inclement weather has a relatively minor impact on the overall number of reported incidents. (See table 2-1 1.) The most frequent general locations of marine hazardous materials releases were along the Gulf of

Table 2.11.–Waterborne Incidents Reported to the Commercial Vessel Casualty File by Primary Cause, 1976=80

	Number of incidents	Percentage of total
Poor weather	208	3
Equipment failure	502	8
Depth less than charted	138	2
Fault of other vessel/ personnel	4,240	69
Other	1,066	
Total	6,154	‘7

SOURCE: Office of Technology Assessment.

*This point was emphasized by Cynthia Hilton, Manager, The Chemical Waste Transportation Council, personal communication by letter, May 20, 1986.

Mexico, probably reflecting the major petroleum and chemical activities in that region. (See table 2-12.) This contrasts greatly with the HMIS analysis, which lists high frequency marine release locations as Louisiana, California, New Jersey, Puerto Rico, and Maryland.

A comparison of CVCF release reports and consequences with marine releases contained in the HMIS database appears in table 2-13. The number of reportable releases is off by a factor of 41; over four times as many injuries have been reported to CVCF; 24 deaths have been reported to CVCF, with no fatalities listed in HMIS. However, because of the format of the CVCF report, it is impossible to determine if the injury or death was due to the hazardous material or some other cause, such as collision forces. The average damage per release is four times greater in CVCF, implying that the procedures used in CVCF reporting acknowledge more substantial destruction than reported by carriers to RSPA. For the period 1976-80, damage apparently related to hazardous materials releases reported to CVCF exceeds $189 million, or over $50 million more than the damage total in HMIS for 1976 to 1984 on all transport modes combined.

Truck Accident File.–The BMCS Truck Accident File includes all reported vehicular accidents involving hazardous and nonhazardous cargo. Three common descriptive fields exist for HMIS and TAF: year, month, and State of release. Thus, an HMIS incident occurring at a different location in the State or on a different day during the same month might be erroneously matched; hence, the nonreporting estimate from this analysis should be considered a lower bound. A data field within the database permits isolation of accidents involving vehicles carrying hazardous materials. Table 2-14 identifies the States where data for 1983 showed that accidents occurred most frequently. The top five States from the RSPA database are Pennsylvania, Ohio, Illinois, New York, and Texas, respectively. Although most of the same States appear at the top of both the TAF and HMIS databases, the order is not the same. Table 2-15 displays the TAF-reported injuries and deaths for 1983. The impact to the community–the number of other people killed and injured as a consequence of a hazardous materials accident—dwarfs the impact to the driver and other riders.

A comparison of TAF and HMIS statistics for 1983 appears in table 2-16. The databases contain information on 502 matching incidents, the consequences of which appear in tables 2-17 and 2-18. Carrier-reported incidents underestimate the deaths, injuries, and damages associated with hazardous ma-

Table 2-12.—Waterborne Incidents Reported to the Commercial Vessel Casualty File by General Location, 1976-80

Inspection unit	Number of incidents	Percentage of total
New Orleans	1,065	17
New York	516	8
Galveston	424	7
Paducah	359	6
Memphis	357	6
Houston	331	5
Port Arthur	324	5
Mobile	300	5

SOURCE: Office of Technology Assessment.

Table 2.13.–Commercial Vessel Casualty File (CVCF) Comparison With the Hazardous Materials Information System (HMIS) Database, 1976.80

	CVCF	HMIS database
Number of incidents	6,154	150
Injuries	57	13
Deaths	24	
Average damage per incident ($)	$30,817	$7,843

SOURCE: Office of Technology Assessment,

Table 2-14.—Truck Accidents by General Location Using the Truck Accident File, 1983

State	Number of incidents	Percent of total
Texas	152	9.5
Pennsylvania	107	6.7
New York	79	4.9
California	79	4.9
Ohio	66	4.1

SOURCE: Office of Technology Assessment.

Table 2.15.—Truck Accident File Reported Injuries and Deaths, 1983

	Deaths	Injuries
Driver	28	474
Relief driver	2	38
Authorized rider	2	62
Unauthorized rider	2	
Others	120	897
Total	154	1,479

SOURCE: Office of Technology Assessment.

Table 2-16.—Truck Accident File (TAF) Comparison With Hazardous Materials Information System (HMIS) Database, 1983

	TAF	HMIS database
Number of vehicular accidents	1,602	approx. 211[a]
Injuries	1,479	max. 121[b]
Deaths	154	max. 8[b]
Average damage per accident	$16,800	approx. $l,534[c]

[a]Approximation is based on the total highway incidents for 1983 multiplied by the percentage of incidents which are result of vehicular accidents (4.5%).
[b]These numbers are 1983 totals for all accidents and incidents.
[c]This is the average reported damage per incident fOr 1983

SOURCE: Office of Technology Assessment.

Table 2-17.—Hazardous Materials Information System (HMIS) Misreporting Consequences Using the Truck Accident File (TAF) Databases, 1983

	Number of matching incidents	Deaths	Injuries	Damages
TAF	502	50	490	$10,077,004
HMIS.	502	5	59	4,404,092

SOURCE: Office of Technology Assessment,

Table 2=18.—Hazardous Materials Information System (HMIS) Misreporting Consequences Using the National Response Center (NRC) Database, 1983

		Deaths		Injuries	
Mode	Number of matching incidents	NRC	HMIS	NRC	HMIS
Air		0	0	0	0
Rail	243	4	0	21	42
Highway	449	16	6	117	23
Water	1	0	0	0	0

SOURCE: Office of Technology Assessment,

terials transport incidents. Approximately 8 times as many vehicular accidents involving hazardous materials were reported to TAF as to HMIS, resulting in at least 12 times as many injuries and 19 times as many deaths. Finally, the average damage per incident is considerably larger for the TAF database. This can be partially explained by the facts that the HMIS estimate includes other releases, which may be less destructive, than those related to accidents and that damages reported to HMIS are estimated based on the consequences of the hazardous material involved only.

Despite the loosely matching criteria, of the 1,602 hazardous materials accidents appearing in TAF, only 502 or 31 percent could be found in the HMIS database. The missing accidents caused a combined impact of 104 deaths, 989 injuries, and $16,867,056 in damages. Among the more notable nonreported accidents are the following: Highland Park, Illinois, on March 22, 1983, killing one, injuring four, and causing $120,000 in damages; Kemmerer, Wyoming, on April 7, 1983, killing five, injuring two, and causing $26,500 in damages; Georgetown, Kentucky, on May 1, 1983, killing three, injuring nine, and causing $75,000 in damages; and Hurricane, Utah, on November 21, 1983, killing three, injuring three, and causing $100,000 in damages.

National Response Center.–This database is not designed for policy analysis purposes; however, some limited relevant analyses can be conducted. Reports to NRC could include hazardous substance spills, which EPA requires be reported but RSPA does not, unless the substance is specifically listed in the Hazardous Materials Table.

The matching methodology consisted of searching on four common fields: year, month, day, and State of incident; the results are shown in table 2-19. Table 2-20 displays NRC and HMIS statistics for numbers of reported incidents, deaths, and injuries in 1983. In total, NRC-reported injuries and deaths are significantly larger than those reported in the HMIS database, although there is considerable fluctuation at the modal level. The data dem-

Table 2-19.—Hazardous Materials Information System (HMIS) Nonsporting Consequences Using the National Response Center Database, 1983

Mode	Number not found in HMIS database	Percentage nonmatching	Deaths	Injuries
Rail	510	68	2	10
Highway	431	49	12	72
Air	11		1	0
Water	552	99	0	29

SOURCE: Office of Technology Assessment.

Table 2-20.—Hazardous Materials Information System (HMIS) Nonreporting Analysis Using the National Transportation Safety Board (NTSB) Database, 1976.83

Mode	Number of incidents in NTSB database	Number not found in HMIS database	Percentage nonmatching
Rail	258	165	64
Highway. . .	6	3	50
Water	7	6	86

SOURCE: Office of Technology Assessment.

Table 2-21.-Hazardous Materials Information System (HMIS) Nonreporting Consequences Using National Transportation Safety Board Database, 1976-83

Mode	Number not found in HMIS	Deaths	Injuries	Damages
Rail	165	37	92	$89,443,936
Highway. . . .	3	12	41	125,000
Water	6	13	18	16,360,000

SOURCE: Office of Technology Assessment.

onstrate serious nonreporting problems for the air transport industry. The NRC database has limited usefulness in quantifying damage estimates, since this is not a reporting requirement. Table 2-19 shows the results of comparisons between the databases for matching incidents; valid comparisons can be made only for the rail and highway modes.

The National Transportation Safety Board examines only hazardous materials incidents that have serious consequences; thus theoretically, all NTSB incidents should also have been reported to RSPA and included in HMIS. NTSB incident reports include information on injuries, deaths, and damages, and share five matching fields with HMIS: year, month, day, city, and State. HMIS files for 1976 to early 1983 were studied to find information matching NTSB data; the results are shown in table 2-20. The analysis indicates that 50 percent or more of the most serious hazardous materials transport incidents go unreported to RSPA. OTA did not attempt to determine whether this percentage changed over time. Most NTSB hazardous materials reports for which sufficient information was available were for rail incidents, and nearly two-thirds of NTSB incidents were not reported in HMIS.

Table 2-21 displays the consequences of the unreported incidents. For rail alone, the injuries and damages of unreported incidents appearing in the NTSB database exceed the total reported injuries and damages for all HMIS rail incidents from 1976 to 1984. Among the more notable omissions are an incident in Maryland, Oklahoma, on December 15, 1976, which resulted in 3 deaths, 11 injuries, and an estimated $880,700 in damages; Crestview, Florida, on April 8, 1979, which injured 14 people and caused $1,258,500 in damages; Pisgah, California, on May 11, 1980, which killed 1 person, injured 3, and caused $2,889,000 in damages; and Benton, Iowa, on August 15, 1982, which injured 1 and caused $2,140,000 in damages.

Although the sample size for highway and marine is too small for good analysis, in two other modes NTSB showed serious incidents that were not reported to HMIS. For example, a highway incident on December 28, 1977, in Goldonna, Louisiana, which killed 2 people, injured 11, and caused $125,000 in damages, and a marine incident in Good Hope, Louisiana, on August 30, 1979, which killed 12 and resulted in $10,500,000 in damages were not reported to HMIS. (See table 2-17.)

Examples of misreporting include a rail release in Newton Falls, Ohio, on May 9, 1979, that caused an estimated damage of $1,407,000 in the NTSB report; according to the HMIS database, no damage was reported. In another case, NTSB reported $2,540,000 in damages caused by a rail release in Hastings, Iowa, on July 10, 1980; the HMIS report shows no damage.

NTSB reviews the incidents it investigates over an extended period of time and holds discussions with a number of involved and affected parties. In contrast, RSPA requires reports to be submitted by the carrier within 15 days of the incident. Table 2-22 displays the consequence statistics of NTSB and HMIS for matching incidents. For the rail mode, RSPA estimates of death and injury are within range of NTSB reports. However, damage estimates are off significantly, by a factor of 7 to 8.

The Association of American Railroads Data= base.–AAR maintains a hazardous materials incident file that includes a data field identifying the primary source of the report. AAR data corroborate the results of the HMIS comparison with NTSB data; over 60 percent of reportable rail releases are not being reported to RSPA. Of 13,706 incidents

Table 2-22.–Hazardous Materials information System (HMIS) Misreporting Consequences Using the National Transportation Safety Board (NTSB) Database, 1976-83

Mode	Number of matching incidents	Deaths		Injuries		Damages	
		NTSB	HMIS	NTSB	HMIS	NTSB	HMIS
Rail	93	33	28	192	315	$62,589,360	$8,437,363
Highway.	3	11	11	21	8	138,070	2,119,820
Water	1	9	0	0	0	0	0

SOURCE: Office of Technology Assessment

examined in the file, the primary sources were reported as follows:

Inspector . . . .3,356 (24 percent)
Railroad. . . . . 365 (3 percent)
Telephone . . . . 834 (6 percent)
CHEMTREC . . . . 1,901 (14 percent)
Unknown . . . . .1,978 (14 percent)
Form F5800.1 . . . .5,272 (38 percent)

Washington State Accident File (WSAF).–WSAF is maintained by the Washington Utilities and Transportation Commission. OTA contractors examined this database because, while it includes all highway freight accidents, it also contains a unique identifier for accidents involving hazardous materials. Moreover, this database has useful information not available in HMIS records, such as location type (urban/rural), type of accident, road surface, light conditions, type of road, truck contributing circumstances, truck driver/vehicle actions, truck vehicle condition, and truck driver sobriety.

Data from 1984 show the following: the locations of hazardous materials accidents were split evenly between rural and urban sites. Two-thirds of the accidents were property damage only, with very few showing major property damage. One-third of the accidents occurred on roads that were wet, icy, or covered with snow. Nearly three-quarters of the accidents occurred in daylight. Roughly 85 percent of the accidents occurred on two-lane or four-lane roads, in contrast to 12 percent at intersections. Eighty percent of the accidents involved flammable liquids. Of the 331 reported accidents, only 11.5 percent resulted in a reported spill. Not including “no contributing circumstances, ” “driver inattention” was cited as the most frequent contributing factor. Roughly 70 percent of the accidents occurred while the vehicle was being driven along a straight path, followed by right and left turns at 8 and 6 percent, respectively. In over 80 percent of the accidents, the vehicle had no cited defect. Finally, driver drinking causing impairment was cited only once.

Spills contained in WSAF were compared to HMIS to explore the issues of nonreporting and misreporting. Only 58 of 331 records, or 18 percent, were found in the HMIS database. For those records that matched, HMIS reported no deaths, no injuries, and $438,894 in damages, in contrast to 2 deaths, 22 injuries, and $956,370 reported in WSAF.

These findings raise serious questions about the integrity of the RSPA reporting system both for unreported incidents and inaccurately reported incidents.

The problem of underreporting in HMIS is most serious for marine incidents, as indicated by NTSB, the National Response Center, and CVCF data; moreover, based on more limited NRC data, underreporting of air incidents is also high. The number of reportable incidents maybe underestimated by factors of at least 10 and 20, for air and water, respectively. For highway and rail transport, the number of reportable incidents may be underestimated by factors of at least 2 and 3, respectively. Furthermore, major events, resulting in deaths, injuries, and significant damage, have gone unreported to DOT. Misreporting creates underestimates of damages more than of deaths and injuries.

When the nonreporting and misreporting estimates for each mode are applied as multipliers to HMIS incident and damage estimates, HMIS reports for 1976 to 1984 of 79,257 incidents resulting in $144,751,240 in damage should be adjusted to 178,683 incidents resulting in $1.47 billion in damage, according to OTA calculations. This analysis indicates a more serious safety problem than is presend y acknowledged by DOT and lends credence to the concerns voiced by State and local officials.

HMIS Uses

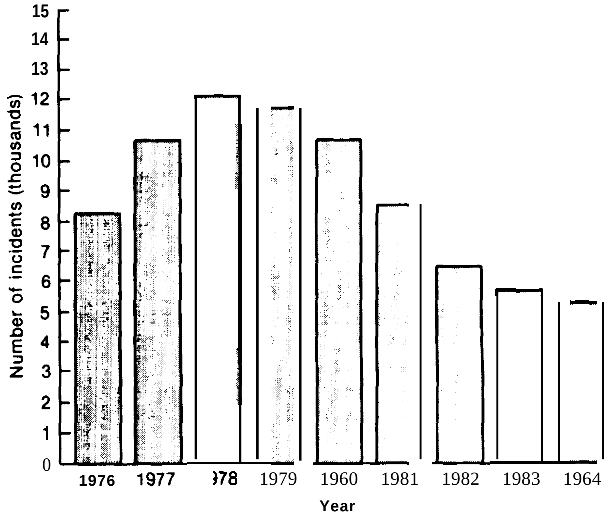
The underreporting in HMIS makes it of questionable value for some types of analysis. However, it provides the best data available on container problems. When matched against rudimentary commodity flow data, several conclusions useful for helping to make management decisions can be drawn. Conversely, many issues simply cannot be resolved even by the most painstaking analysis, because too many questions remain unanswered. A review of the possible uses of HMIS follows.

For the 9-year period studied by OTA, the total number of incidents by year reported to HMIS was 79,253. As figure 2-3 shows, a general increase in reported incidents occurred through the late 1970s, even after changes in reporting requirements, followed by a significant decline beginning in 1980. However, because there is no similar annual commodity flow data, it is impossible to establish whether incident rates have dropped, perhaps indicating a safer system, or whether the number of movements has decreased, resulting in similar or worse incident rates. It is also possible that nonreporting has increased or that the loosening of reporting requirements in 1981 led carriers to assume that they need not report any small spills.

Table 2-23 displays the results of a study of incident location by mode. Heavy concentrations of incidents occur in Pennsylvania, Ohio, Illinois, Texas, and California, probably due to major industrial activity and significant truck and rail corridors of travel for materials destined for other States. So few marine releases are reported to HMIS that no conclusions can be drawn about water transport. Tennessee is the most frequent site for air incidents, probably because Memphis is a major air freight hub.

Human error is the primary cause of 62 percent of incidents, followed by package failure, and vehicular accidents. (See figures 2-4 and 2-5.) The more specific reasons for incident occurrence appear in table 2-24. The predominant cause of failure varies considerably by mode, although external puncture and loose and defective fittings are often reported. These problems frequently occur during loading or unloading operations or when cargo shifts during transport, resulting in container bottom, body, or side failure, often caused by damage from other freight.

Figure 2-3.—HMIS incidents by Year



SOURCE: Office of Technology Assessment.

These conclusions point to issues that deserve recognition and either further study or development of countermeasures. For example, public information programs to reduce the likelihood of hazardous materials being shipped by parcel post as baggage might be undertaken by the Postal Service and the airlines. Thorough analysis of loading, unloading, blocking, and bracing operations and procedures is needed for all modes, but especially for truck, rail, and air. Standard procedures and industry training programs could be developed.

The analyses also identified several other problems in the industry deserving recognition and resolution. The use and integrity of MC-306 tank trucks and trailers for the highway mode, 11 1A tank cars for the rail mode, and 17E containers* warrant further examination, especially those used to carry corrosives, which OTA's analysis shows have the highest incident rate of all commodities. Finally, the condition of containers involved in incidents and the frequent use of nonspecified or unauthorized containers suggest the need for improved governmental inspection and enforcement activities. On the other hand, HMIS data show that vandalism and terrorism have not been serious problems.

*17Es are the most commonly used metal drum or pail container types.

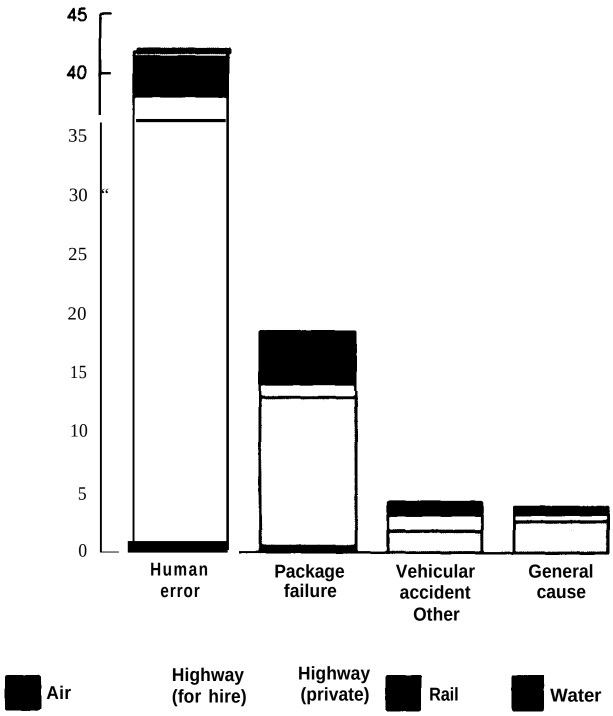
Table 2-23.–Number of Incidents[a] by Location and Mode, 1976-84

	Mode							
State	Air	Highway (for hire)	Highway (private)	Rail	Water	Freight forwarder	Other	Total
Alabama	4	1,269	67	**410**[b]	—	5	—	1,755
Alaska	23	35			8		1	79
Arizona	8	934	59	262	—	—	2	1,265
Arkansas	—	1,170	25	251	—	—	2	1,448
California	76	2,470	430	817	15	3	22	3,833
Colorado	34	1,119	52	73	—	—	2	1,280
Connecticut	4	383	53	16	—	—	—	456
Delaware	—	171	27	68	—	2	—	268
District of Columbia	3	71	38	2	—	—	—	114
Florida	20	1,676	89	518	2	2	1	2,308
Georgia	16	2,331	41	334	2	2	3	2,729
Hawaii	9	6	12	—	1	1	—	29
Idaho	—	149	28	60	—	—	1	238
Illinois	49	3,340	125	828	—	8	3	4,353
Indiana	5	2,155	76	189		5	1	2,431
Iowa	3	1,110	27	95	—	—	2	1,237
Kansas	—	1,167	44	166		2	3	1,382
Kentucky	7	799	135	169	—	—	2	1,112
Louisiana	13	1,101	84	372	22	3	14	1,609
Maine	—	**68**	11	44	—	—		124
Maryland	10	**1,105**	134	45	9	2	5	1,310
Massachusetts	16	**832**	80	88	2	5	2	1,025
Michigan	17	**2,274**	114	254	—	7	5	2,671
Minnesota	13	**1,213**	44	99		—	1	1,370
Mississippi	—	**823**	47	90	—	1	3	964
Missouri	14	**2,518**	101	143	1	4	1	2,782
Montana	1	**205**	27	72	—	—	1	306
Nebraska	3	**719**	7	51	—	1	1	782
Nevada	3	**106**	11	17	—	—	—	137
New Hampshire	—	**55**	9	9	—	—		74
New Jersey	11	**1,604**	109	180	14	11	8	1,937
New Mexico	4	**717**	38	94	—	—	—	853
New York	56	**3,133**	210	211	7	5	14	3,636
North Carolina	5	**2,408**	54	235	1	5	10	2,718
North Dakota	—	**55**	28		—	—	—	101
Ohio	16	**4,804**	143	328	—	14	8	5,313
Oklahoma	12	**645**		46	—	1	—	754
Oregon	4	**355**	59	165	—	—	—	583
Pennsylvania	28	**6,473**	245	322	3	34	4	7,109
Puerto Rico	4	**4**	3	—	12	1	1	25
Rhode Island.,.......,.,	—	**107**	13	3	—	—	—	123
South Carolina	4	**1,351**	33	108	5	2	3	1,506
South Dakota	–	**84**	16	5	—		—	105
Tennessee ....,.	337	**2,478**	73	203	2	1	1	3,097
Texas	48	**2,642**	212	1,265	6	4	14	4,191
Utah	1	**494**	27	16	—	1	—	539
Vermont	—	**34**	16	2	—	—	1	53
Virginia	3	**1,671**	67	124	7	4	5	1,881
Washington	13	**812**	121	133	7	5	2	1,093
West Virginia	1	**471**	43	65	—	1	—	581
Wisconsin	6	**1,975**	49	56	—	—	1	2,087
Wyoming	1	**211**	51	60	—	1	2	326

[a]Incidents refers to the number of hazardous materials releases. For highway transport, a report is required only for releases that occur to a company engaged in interstate transportation.
[b]Boldface numbers indicate five states with the highest number of incidents for each category.

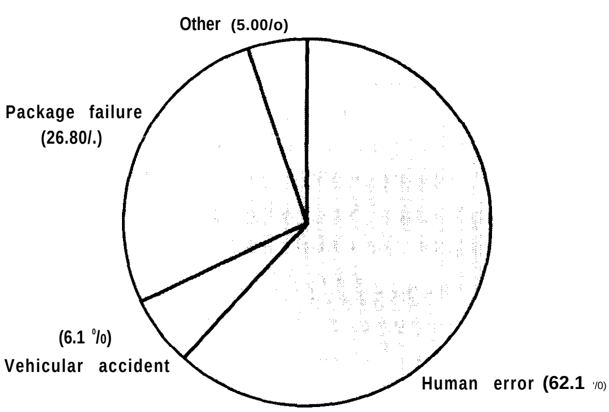
SOURCE: Office of Technology Assessment.

Figure 2-4.—General Causes of Spills by Mode According to the HMIS



SOURCE: Office of Technology Assessment contractor report.

Figure 2-5.—General Causes for All Modes



SOURCE: Office of Technology Assessment.

Despite the fact that several years of data can be examined, catastrophic events are rare enough that a single release in a given mode, hazard class, or container category, can distort the analysis of particular segments of the industry. More complete data might provide a more balanced picture, despite this problem, and would permit using release reports as a management tool.

Conclusions

HMIS was the subject of considerable criticism in 1980 from the U.S. General Accounting office (GAO) for the following reasons:[82]

1. RSPA is not receiving reports on all spills because it relies on voluntary reporting from carriers;
2. companies involved only in the loading, unloading, or storage of hazardous materials (e.g., shippers and freight forwarders) are not required to submit hazardous materials incident reports;
3. reports are not required by RSPA for spills involving hazardous materials shipped in bulk by water;
4. DOT has elected not to require firms involved only in intrastate transportation to submit hazardous materials spill reports;
5. RSPA has no systematic procedure for refining reported data that are incomplete or inaccurate; and
6. the total consequences of spills are understated significantly due to the time limit on reporting and soliciting solely the carrier's perspective.

Each of these factors works to understate the overall impact of hazardous materials transportation releases. OTA finds that the database deficiencies noted in the GAO report persist and that the total volume of hazardous materials releases is seriously underestimated. Moreover, the value of HMIS for deriving distributions of events, causes, and consequences, and multimodal comparative analyses is questionable. OTA finds that improvements to the RSPA incident reporting system are needed to ensure more accurate and comprehensive diagnostic and evaluative studies of hazardous materials transportion safety.

The major areas for improvement include:

- initiatives to ensure complete reporting of hazardous materials releases,
- coordinated working agreements between RSPA and other governmental agencies covering data

[82] U.S General Accounting Office, op. cit.

Table 2=24.-Cause of Failure by Mode, 1976-84

		Mode							
Number	Code	Air	Highway (for hire)	Highway (private)	Rail	Water	Freight forwarder	Other	Total
	Dropped in handling. . .	239[a]	4,334	95	**30**	16	18	11	4,743
	External puncture	81	12,051	362	**481**	39	56	35	13,105
3	Damaged by other freight	62	**8,192**	53	146	8	30	7	8,498
4	Water damage	2	**62**	2	16	2	—	—	84
5	Damage from other liquid	2	69	1	5	—	—	—	77
6	Freezing	—	182	21	12		2	—	218
7	External heat	3	116	17	53	:	1	1	194
8	Internal pressure.	57	**666**	113	399	19	1	4	1,259
9	Corrosion or rust	6	641	36	118	4	1	2	808
10	Defective fittings	60	3,375	321	2,883	27	2	18	6,666
11	Loose fittings	257	7,851	421	3,684	22	18	29	12,282
12	Failure inner receptacle	35	622	17	60		—	1	735
13	Bottom failure		3,780	66		4	7	3	3,960
14	Body/side failure.	64	2,517	105	279	14	18	9	**3,006**
15	Weld failure	4	728	50	**70**	13	3	4	**872**
16	Chime failure.	2		12		1	2		**610**
17	Other conditions.	129	2,492	282	**328**	22	5	20	**3,278**
18	Hose burst	—	872	83	**7**		—	3	**966**
19	Load/unload spill	2	5,985	1,283	**72**	2	—	9	**7,353**
20	Cargo shifted/fell	30	6,127	120	**357**	14	22	7	**6,677**
21	Improper loading.	18	2,381	15	**62**	5	10	1	**2,492**
22	Vehicle accident	3	2,145	972	**994**	3	1	12	**4,130**
23	Venting	—	13	25	**120**	—	—	**1**	**159**
24	Release of fumes	3	46	9	**147**	**—**	—	**2**	**207**
25	Friction	1	101	8	**17**	**2**	2	—	**131**
26	Static electricity	—	8	—	**2**	—	—	—	10
27	Metal fatigue	—	531	4	**12**	1	1	—	549

[a]Boldface indicates top two causes of failure in each mode.

SOURCE: Office of Technology Assessment.

sharing and developing the capability to match release reports,

- development of software to identify misreporting and nonreporting, and
- additional data-entry/data-validation clerks and staff to ensure complete, accurate reports.

Moreover, the accuracy of DOT's Hazardous Materials Information System can be improved without large expenditures for technology improvements. For instance, Form F5800. 1 does not clearly specify the data items RSPA attempts to collect from it. The carrier issuing the report is given considerable latitude in describing the incident; consequently, the data-entry staff must make subjective judgments on how the reports should conform to the HMIS record structure. RSPA is currently revising the form. In this process, questions on the form about cause, characteristics, and consequence should be structured so that the respondent selects specific entries from lists of potential choices, as in Part F (Nature of Packaging Failure) on the present form. This would create a uniform basis of reporting and decrease the redundant entries in the database, particularly for container types. Furthermore, it would make the data-entry process more efficient and provide a more concise database.

RSPA has expressed interest in condensing the information required on Form F5800. 1, citing the cumbersome problem of managing a large historical database.[83] However, the amount of information now requested on Form F5800. 1 is not excessive when contrasted with that for other reporting systems such as NASS, FARS, TAF, and CVCF. In comparison to other incident/accident databases, the volume and complexity of reports received annually by RSPA are relatively small.

[83]" Detailed Hazardous Materials Incident Reports," Federal *Register, vol.* 49, No. 53, Mar. 16, 1984, pp. 10042-10047.

The data fields in the current HMIS database cover most of the major elements of a hazardous materials transport incident. However, additional information on the age and registration number of the vehicle, driver, weather conditions, cargo weight, type of event (e.g., in transit/loading/unloading), and package type (e.g., bulk/nonbulk) would be useful. Inclusion of the telephone number for the National Response Center on Form F5800. 1 could remind the carrier to provide a telephone report if warranted.

Revising the criteria for requiring a written report has been recently proposed by RSPA.[84] Since most small package incidents have minor consequences, RSPA is considering a new reporting criteria for Form F5800.1 requiring its completion only if an incident results in any of the circumstances set forth in 49 CFR 171.15 or involves:

- bulk packaging,
- shipments aboard aircraft or in air terminals,
- property damage equal to or in excess of $1,000 including cleanup,
- evacuation,
- packages or hazardous materials under an exemption, or
- any quantity of hazardous waste that has been discharged during transportation.

Deleting the requirement for reporting smaller spills would deprive DOT of *its* primary source for evaluating small packages carried in less-than-load lots. See chapter 3 for a discussion of the impact of such a change on small packaging requirements.

The issue of the carrier's primary responsibility for notification of releases warrants examination. Possible changes include extending the reporting time limit to 30 days to encourage more complete evaluation of incident characteristics and consequences. Furthermore, shippers and receivers could be held responsible for reporting loading/unloading incidents, if RSPA develops a system to indicate possible redundant reports. Immediate telephone followup to obtain information missing from reports would permit complete data to be entered into the HMIS database. Finally, comparisons of HMIS reports to reports filed with other systems, such as NRC, CVCF, TAF, and NTSB, could identify discrepancies and identify nonreported incidents meeting HMIS reporting criteria.

These changes would require the cooperation of several agencies in furnishing data to RSPA and designing their reports with common data fields to permit direct comparisons. Although modifying reporting and database formats can be costly and time-consuming, two alternatives could make expensive changes unnecessary:

1. Conversion or bridge tables could be constructed to transform other agency data items into data items contained in the HMIS database so RSPA could conduct nonreporting analyses.
2. Data items required for matching could be added to other agency report forms and databases.

OTA finds that HMIS misses numerous releases recorded in other Federal databases, in part because bulk marine releases and those occurring during solely intrastate commerce need not be reported, and because the reporting requirement is not enforced. Furthermore, little effort is made to include data other than that reported on Form F5800.1 in RSPA's annual report, making the report an inadequate reflection of the safety of the transportation of hazardous materials.

Moreover, OTA analyses of flow and accident data indicate that relatively few of the HMIS data can be used as indicators. A major accident in any single year or on any mode can skew the data significantly. However, when combined, current Federal accident and spill databases can provide more complete information on the dimensions of hazardous materials transportation safety problems.

A California study, being conducted for the State legislature, compared three separate databases showing highway spills and determined that at least 500 spills occur annually on the State highway system alone, excluding the city streets. The study demonstrates that several databases must be used to generate reasonably complete data, even for a single State. These results show driver error as the single largest cause of spills and imply that concentration on addressing truck-related issues such as driver training and qualifications is essential for safety improvements.

[84] Ibid.

The intent of the HMTA clearly indicates the need for an adequate annual summary of the safety of hazardous materials transportation, making improvement to HMIS an urgent issue. OTA concludes that including bulk marine and intrastate releases in the HMIS reporting requirement and enforcing the requirement are important priorities. Increased cooperation and information sharing among DOT agencies, EPA, and State enforcement officials are also essential. Congress could require DOT to extend accident reporting requirements to all hazardous materials spills whether they occur during interstate or intrastate transport and regardless of mode. A coordinated national spill reporting center, with reporting procedures and common data report fields that must be implemented by all Federal agencies, could be designated. Congress might wish to require display of a toll-free number for the national report center as the place to call for reporting accidents. DOT, NRC, or HMIS staff provide natural homes for this coordinating role. Moreover, if formats including common data fields were decided on, accident reports collected at the State level could be submitted periodically to the regional DOT or EPA office. The regional Federal offices would provide annual updates to the national center. Several regional EPA offices already work with the States in their regions and have good computerized reporting systems. Spill reports should be checked at the regional level for accuracy and completeness, before being submitted to the national data-collection center.

The annual DOT reports to Congress on the transportation of hazardous materials could be required to document accidents by State, container types, mode, and cause. Improvement of the RSPA spill report Form F5800. 1 and coordination with modal administrations to develop common data fields that are less open to subjective interpretation could make the form reflect more accurately the causes and details of the spill.