HAZARDOUS MATERIALS SHIPMENTS

Prepared by

The Office of Hazardous Materials Safety
Research and Special Programs Administration
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***SUMMARY*:**

The Office of Hazardous Materials Safety presently estimates the number of hazardous materials shipments in the United States at more than 800,000 per day. Approximately 500,000 daily shipments involve chemical and allied products (SIC 28); about 300,000 involve petroleum products; and at least 10,000 other shipments involve waste hazardous materials, medical wastes and various other hazardous materials. Shipments are defined as equivalent to deliveries, and in most instances may be distinguished from the number of movements, trip segments, or other measures. The estimated number of *movements* associated with these shipments exceeds 1.2 million per day (Table 1).

Table 1: HAZARDOUS MATERIALS SHIPMENTS MOVEMENTS and TONS [1]

Product Group	Daily Shipments	Daily Movements [2]	Annual Tons Shipped	Annual Tons Moved
Chemicals & Allied	500,000	900,000	0.53 billion	0.85 billion
Petroleum Products	300,000	300,000	2.60 billion	3.03 billion
Other	10,000	10, 000	0.01 billion	0.02 billion
TOTALS	**> 800,000**	**> 1,200,000**	**>3.1 billion**	**> 3.9 billion**

While only about 43% of all hazmat *tonnage* is transported by truck, approximately 94% of the individual *shipments* are carried by truck. The air mode, while almost negligible in terms of tonnage, also has a share of individual shipments that greatly exceeds its percent of tonnage carried: less than 1% of all hazmat tonnage but about 5% of all hazmat shipments. In contrast, enormous amounts of hazmat tonnage are carried by rail, pipeline and water modes, and in some markets they are the only modes that haul hazmat products. Yet, the total number of shipments for all three of these bulk commodity modes is less than 1% (Table 2).

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[1] Based on 1993 Bureau of Census Commodity Flow Survey (CFS) shipment distribution data for standard transportation commodity classification (STCC) 28 ; 1995 CMA tonnage figures (SIC 28); 1995 EPA hazardous waste shipment and manifest data; 1996 DOE Energy Information Administration data; 1996 Waterborne Commerce Statistics; and 1997 BTS Air Carrier Traffic Statistics.

[2] Movements are defined in Section 3 and discussed further in Appendix C. They correspond to the movement of vehicles, rail cars, etc. that carry shipments, and in some cases they are equivalent to shipments.

Table 2: HAZMAT SHIPMENTS, MOVEMENTS and TONS by MODE

	Shipments	%	Movements	%	Tons Shipped	%	Tons Moved	%
	CHEMICALS & ALLIED PRODUCTS							
Truck	445,218	90.3%	830,761	89.36%	808,662	55.52%	894,452	37.30%
Rail	3,723	0.8%	11,169	1.20%	335,070	23.00%	1,005,210	41.92%
Pipeline	34	0.0%	34	0.00%	127,500	8.75%	127,500	5.32%
Water	82	0.0%	164	0.02%	181,279	12.45%	362,558	15.12%
Air	43,750	8.9%	87,500	9.41%	4,049	0.28%	8,098	0.34%
SUBTOTAL -- a	**492,807**	100%	**929,628**	100%	**1,456,560**	100%	**2,397,818**	100%
	PETROLEUM PRODUCTS							
Truck	313,689	99.5%	313,689	99.15%	2,857,470	40.04%	2,857,470	34.39%
Rail	448	0.1%	1,344	0.42%	40,320	0.57%	120,960	1.46%
Pipeline	839	0.3%	839	0.27%	3,146,250	44.09%	3,146,250	37.87%
Water	253	0.1%	506	0.16%	1,091,646	15.30%	2,183,292	26.28%
Air	-	0.0%	-	0.00%	-	0.00%	-	0.00%
SUBTOTAL -- b	**315,229**	100%	**316,378**	100%	**7,135,686**	100%	**8,307,972**	100%
	OTHER HAZMAT							
Truck -- c	10,000	98.6%	10,000	95.9%	43,048	92.43%	43,048	80.27%
Rail	144	1.4%	432	4.1%	3,526	7.57%	10,578	19.73%
Pipeline	-	0.0%	-	0.0%	-	0.00%	-	0.00%
Water	-	0.0%	-	0.0%	-	0.00%	-	0.00%
Air	-	0.0%	-	0.0%	-	0.00%	-	0.00%
SUBTOTAL	**10,144**	100%	**10,432**	100%	**46,574**	100%	**53,626**	100%
	TOTAL HAZMAT							
Truck	768,907	93.98%	1,154,450	91.88%	3,709,180	42.94%	3,794,970	35.27%
Rail	4,315	0.53%	12,945	1.03%	378,916	4.39%	1,136,748	10.57%
Pipeline	873	0.11%	873	0.07%	3,273,750	37.90%	3,273,750	30.43%
Water	335	0.04%	670	0.05%	1,272,925	14.73%	2,545,850	23.66%
Air	43,750	5.35%	87,500	6.96%	4,049	0.05%	8,098	0.08%
DAILY TOTALS -- d,e	**818,180**	100%	**1,256,438**	100%	**8,638,820**	100%	**10,759,416**	100%
ANNUAL TOTALS -- f	**298,635,700**		**458,599,870**		**3,153,169,300**		**3,927,186,840**	

" - " is negligible and, in some instances, might actually be zero.

-- a Daily shipment subtotal is rounded to 500,000 in Table 1and in text.

-- b Daily shipment subtotal is rounded to 300,000 in Table 1 and in text.

-- c This figure is at least 10,000 and could range as high as 80,000 or more daily shipments. Waste hazmat, medical waste, various industrial products and other materials comprise this category. Virtually all shipments in the "Other" hazmat category are transported by truck. See Appendix G for detailed estimates within the "Other" category.

-- d Daily *shipment* TOTAL rounded to > 800,000 in Table 1 and text.

-- e Daily *movement* TOTAL rounded to > 1,200,000 in Table 1 and text.

-- f Annual tons *shipped* and *moved* are rounded to > 3.1 billion and > 3.9 billion in Table 1 and text.

1. BACKGROUND - INTRODUCTION:

Ensuring the safe transport of hazardous materials within the United States is primarily the responsibility of the U.S. Department of Transportation (DOT). Within DOT, the Research and Special Programs Administration (RSPA) issues the Hazardous Materials Regulations (HMR) and provides training, enforcement, technical support, information and policy guidance to protect the transportation community and the general public against the safety risks inherent in transporting hazardous materials.

Hazardous materials (hazmat) shipment information plays an important role in RSPA's ability to achieve its mission. Developing cost-effective regulations and helping emergency responders plan for hazmat transport risks are among the activities that rely on information about hazmat shipments occurring in the U.S.

For the past decade, government and hazmat industry officials have used an estimate of more than 500,000 shipments to characterize daily hazmat traffic in the U.S.-- and implicitly the level of risk to the transport community and general public. That estimate was not unreasonable. A 1988 DOT (Volpe Center) study, for example, indicated some 546,000 daily shipments, consisting primarily of petroleum products and chemicals & allied products. [3] Other data sources suggested shipment levels of at least a similar order of magnitude. [4]

This brief report and its underlying analysis are an attempt to update the 500,000 daily shipment estimate. At the same time, the report introduces the concept of hazardous materials *movements*, with the intent of supplementing *shipment* data with a measure that conveys additional information about hazmat transport risk. The appendix materials identify component estimates, underlying assumptions, data sources, and other related information. Virtually all figures in both the text and appendix are estimates and could be rounded to nearest thousands, million, etc. Where precise figures are used, the intent is not to convey a false sense of precision, but rather to facilitate tracking the data and methodology used.

2. DEFINITIONS: Shipment, Movement.

Shipment. The definition of *shipment* used in this analysis is consistent with the Bureau of Census definition which uses the concept of an *individual delivery*. Instructions for the 1992 Commodity Flow Survey (CFS) note:

A "shipment" (or "delivery") is an individual movement of commodities **from** your

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[3] The Volpe study produced an estimate of 200 million annual shipments. That figure divided by 365 days = 546,000 daily shipments. The study covered truck only, but truck was accurately assumed to constitute the vast majority of individual shipments.

[4] The Bureau of Census Truck Inventory Use Survey (TIUS) figures suggest estimates of a similar magnitude. For example, TIUS indicated there were 340,000 trucks in 1987 belonging to the nation's total hazmat fleet: 99,000 hauling primarily petroleum; 47,000 hauling chemicals; 88,000 mixed; and 107,000 other. The 1992 TIUS study indicates 365,000 vehicles in the hazmat fleet. If it is assumed that some trucks deliver multiple hazmat shipments every day while other trucks are not used at all, a preliminary estimate of more than 500,000 daily shipments would not be unreasonable.

establishment **to** one customer OR **to** another location of your company (including a warehouse, distribution center, retail or wholesale outlet). A shipment uses one or more modes of transportation, including parcel delivery, U.S. Postal Service, courier, private truck, for-hire truck, rail, water, pipeline, air, and other modes.

Please note that for this survey:

A full or partial truckload can be considered **one** shipment **only** if all the commodities are destined for one buyer/receiver at one location. If the truck makes multiple deliveries on a route, **each stop is considered (at least) one shipment.**' (*emphasis in the original*, 1993 CFS, p. E-18)

This definition does have certain limitations, some of which are identified and discussed in Section 3. Overall, however, the definition provides a consistent and useful base line for analyzing freight traffic generally and hazmat traffic in particular.

Movement. We are unaware of any formal definitions of "movement" in the context of hazardous materials transportation statistics, but implicit meanings of the word seem intuitive. If a single container of freight is hauled by truck to a rail intermodal terminal; placed on a rail car and hauled 1,000 miles to a second rail intermodal terminal; and then placed on a truck for final delivery, that one *shipment* is presumed to entail three separate *movements*: 1) highway 2) rail, and then 3) highway again. Following that general schematic, we would define a movement of hazardous materials as:

Transportation by a single vehicle, rail car, aircraft, vessel, or other mode from a point of origin to a point of either: a) transfer to another vehicle, train, aircraft, vessel or other mode or b) final delivery of the freight, whichever comes first.

It should be noted that while a movement associated with a shipment and a movement associated with a vehicle (rail car, aircraft, etc.) are often the same, the relationship does not hold in all cases. For example, in the intermodal shipment just described, each *movement* of the shipping container does correspond with a separate truck or rail car movement.

When small package and less-than-truckload (LTL) shipments are consolidated, however, a single **vehicle** movement may incorporate the movement of numerous individual shipments. For example, an intermodal situation might involve a freight container with, say, 12 different pallets of bagged chemicals, with each pallet destined for a separate customer. In that same situation, the 12 pallets could have originated from a single origin point; been transported as a group of pallets aboard a single truck from the manufacturer to the rail facility; as a group while aboard a single rail car; and then, upon arrival at the destination railroad facility, as 12 individual pallets each distributed aboard a separate delivery vehicle. Each pallet or shipment was transported by two different vehicles and one rail car, or thus *moved* three different times for a total of 36 *movements.* Yet, the total number of vehicle and rail movements associated with these 12 shipments was only one truck, plus one rail, plus twelve subsequent truck movements for fourteen total *movements* (1+1+12 = 14), not thirty-six.

In Table 1 and elsewhere in this report, the estimates of hazmat movements correspond to the separate vehicle, rail car, aircraft or vessel movements associated with the shipments, not the

individual shipment movements themselves. For the preceding example, this report would consider the appropriate estimate of *movements* as 14, not 36. This concept of movement is discussed further in Section 3 and in Appendix C.

3. SHIPMENTS, DELIVERIES, MOVEMENTS and OTHER MEASURES:

How *shipments*, *movements*, and similar terms are defined greatly affects the estimates of those measures. The following schematics show how various shipment and mode configurations have different implications for estimating shipments, movements, vehicle trips, etc. This section is not suggesting that there is government or industry-wide agreement on the use of the terms. Rather, the schematics are presented to illustrate terminology and help show the basis on which the different measures are tallied (Figure 1).

Schematic #1 in Figure 1 represents a truckload (TL) operation, with material loaded at Point A, shipped directly to Point B, and unloaded at Point B. That operation can be viewed as one shipment, one delivery, and one movement.

Figure 1: SHIPMENT and MOVEMENT SCHEMATICS

SCHEMATIC #			No. of Shp	No. of Mov
# 1)	TL:	A ---------- Truck ---------- > B	**1**	**1**
# 2)	LTL:	A ---------- Pick-up Truck ---------- > B ---------- Line-haul Truck ---------- > C ---------- Delivery Truck ---------- > D	**1**	**3**
# 3)	Rail:	A ---------- Rail ---------- > B	**1**	**1**
# 4)	Truck/Rail:	A ---------- Truck ---------- > B ---------- Rail ---------- > C ---------- Truck ---------- > D	**1**	**3**
# 5)	Air Cargo:	A ---------- Truck ---------- > B ---------- Air ---------- > C ---------- Truck ---------- > D	**1**	**3**
# 6)	Air Package:	A ----- Van -----> B ----- Van -----> C ---------- Air ----------> D ---------- Air ----------> E ----- Van -----> F ----- Van -----> G	**1**	**6**
# 7)	Heat. Oil Del:	A ---------- Truck ----------> B ------- Tr -------> C ------- Tr -------> D ------- Tr -------> E ------- Tr -------> F	**5**	**5**
# 8)	Other "Milk" Runs:	A ---------- Truck ----------> B ------- Tr -------> C ------- Tr -------> D ------- Tr -------> E ------- Tr -------> F	**5**	**5**

NOTES: Shp = shipments Mov = movements Tr = truck.

Schematic #2 represents a less than truckload (LTL) operation, where a shipment -- say 1,000 lbs. in size but technically any shipment less than 10,000 lbs.-- is picked up at Point A and transported locally to Point B where it is consolidated with other shipments; placed in long-haul carriage to Point C; and sorted at Point C for local distribution to Point D. The report's totals of more than 800,000 daily shipments and more than 1,200,000 daily movements, treat Schematic #2 as involving one *shipment* but three *movements*. (Schematics # 3-5 resemble #1 or # 2).

Schematic #6 represents the expedited shipment of a small package by air. Expedited air shipment operations typically utilize an air hub with a network of local and regional sort centers for ground pick-up and delivery. A package picked-up in the suburbs of a large metro area, for example, and intended for overnight shipment by air, is likely to be transported by small truck or van to a local or regional ground hub; subsequently trucked to the origin city's airport; flown to a hub airport; flown from the hub airport to the destination city's airport; trucked from that airport to the local hub; and trucked to the recipient. That one *shipment* would have six *movements* and one final *delivery*.

Schematic #7 shows yet another type of distribution pattern. For purposes of this analysis and report, an oil delivery truck used to distribute, for example, 2,000 gallons of heating oil to five different residential customers -- with each customer taking an average delivery of 400 gallons -- is considered to make five *shipments* and five *movements*. [5] This kind of distribution pattern, illustrated by the five deliveries in Schematic # 7, is sometimes referred to as a *milk run*. It is assumed that in a milk run situation, the number of *shipments*, *deliveries*, and *movements* are all equal.

Within the estimate of 315,229 daily hazardous petroleum product shipments, there are approximately 90,000 home heating oil (distillate) *milk run* shipments, 50,000 propane *milk run* shipments, and 30,000 lubricants *milk run* shipments. These amounts leave an estimated 145,000 shipments that are not milk runs. For Chemical and Allied Products (SIC 28), the extent of milk runs included in the data is not presently known. (See Appendix B for petroleum products shipment estimates.)

Finally, it may be noted that trip segments, vehicle trips, vehicle loadings, load factors and other measures can be used to characterize hazmat or most any type of freight traffic. In Schematic #2, for example, the transportation from A to B, B to C, and C to D are generally referred to as separate *trip segments*. In theory, those three trip segments would also be referred to as three *vehicle trips*, although informally the total transportation from A to D might be considered by some as a single vehicle trip. In Schematic #7, the 2,000 gallon oil delivery truck is assumed to entail one *vehicle loading*, even though the vehicle makes five deliveries or shipments. Again in Schematic #7, the actual *load factor* (amount inside the vehicle) would be

different for every trip segment: 2,000 gallons on the trip from A to B; 1,600 gallons from B to C;

[5] The assumption is explicit in this report and implicit in the Census CFS data. We say implicit in the CFS data because, while it seems clear from the CFS survey directions that a shipper sending multiple pallets destined for multiple customers should treat those goods as multiple shipments, it is less clear that a local distributor of home heating oil would view a single 2,000 gallon heating oil run to numerous home owners as constituting "multiple shipments."

1,200 gallons from C to D, etc. Still other measures would depend on certain pick-up and delivery assumptions, as well as on other data. In Schematic #1, for example, it is possible to have a loaded *outbound* vehicle trip from A to B and an empty *return* vehicle trip associated with that single shipment. If the vehicle were completely full on the outbound and completely empty on the return, its *empty/loaded* ratio would be 50%.

4. SHIPMENT ESTIMATES as a PROXY for RISK.

Numbers of hazmat shipments, whether estimates or very precise tallies, by themselves provide only a partial look at the risks inherent in hazardous materials transportation. Ten shipments of one commodity, for example, might pose far greater risk than hundreds of shipments of another. Moreover, many other shipment characteristics and assumptions, besides commodity type, help determine the risks associated with any given hazmat traffic.

This report recognizes the limitations of hazmat shipment estimates by themselves as a proxy for risk. Consistent with that recognition, this section briefly discusses some of the many additional factors that would have to be examined, were a comprehensive analysis of hazmat shipment risk to be undertaken.

Movements and Handlings. It has already been suggested that hazmat *movements* provide a more detailed picture of the nation's hazmat traffic than shipment numbers alone. Data in Tables 1 and 2 and the schematics in Figure 1 show that estimated hazmat movements readily exceed the estimated number of shipments. To the extent each *movement* entails a change of vehicle or driver; a loading or unloading of material; or exposure to other workers and the general public at interim destinations that exceeds a shipment's exposure along its route, then *movements* do convey a more complete picture of risk than *shipment* numbers alone.

For some types of traffic, the concept of a *shipment* barely begins to portray the complex configuration of people, equipment and settings associated with that shipment. Results of a recent air carrier and freight forwarder study, for example, amplify just how complex a single air freight "shipment" can be, suggesting that even the tracking of *movements* does not fully characterize a single shipment's potential risk. Referring to a study conducted by Unisys Corp., one industry observer noted:

> "The Unisys study found the typical traditional air cargo shipment takes six days to reach the consignee, is handled 36 times, stored in six locations and generates 12 pieces of paper that must be processed." (Traffic World, 5/26/97, p. 51)

The Unisys study introduces yet another potential risk measure -- *handling*. It is not clear how a tally of "handlings" might compare with a tally of "movements" for any given set of freight shipments, and no formal attempt has been made in this report to estimate total *handlings* for the nation's hazmat traffic. Preliminarily, it would appear that there are at least two *handlings* for every one *movement*. The term is cited here, nevertheless, to indicate yet another dimension by which shipment risk analyses might be expanded.

Annual Figures, Daily Peaks and Seasonal Peaks. It is understood that in any seven day week most freight traffic probably occurs during the six days, Monday - Saturday. Thus, in terms of a snapshot of daily traffic in the U.S., using a 300-day year (representing 6, not 7, days per week) probably provides a more realistic picture and would increase daily estimates by about 14%. Moreover, it is important for emergency response planners who prepare local responders for incident risks to know that most daily traffic may be higher than 7-day per week estimates would suggest. However, to avoid a debate as to whether freight movement in the U.S. is a 7-day per week industry, this report uses the convention of a 365- day year.

In a similar way, seasonal flows of certain hazardous materials products can greatly affect actual daily levels of traffic. Home heating oil, for example, is delivered to far fewer homes in the summer months than during winter months. Thus, a more realistic picture of heating oil shipments might nearly double the deliveries in winter months while cutting summer daily estimates to near zero. No such adjustment has been made in this report, but the potential effect on peak daily estimates is herein noted.

Shipment Quantity; Type and Condition of Infrastructure and Other Factors. Generally speaking, the amount of material being transported affects its potential risk. One hundred pounds of material, for example, is usually less dangerous than one thousand pounds. It is true that a jerrycan (approximately five gallons) full of gasoline might be as risky as a full tank truck of gasoline because of careless bracing or driver indifference to the load. However, the relationship that large quantities are potentially more dangerous than small quantities generally holds true.

Type and condition of infrastructure affect risks. Two-lane rural roads typically have much higher accident rates than divided, multi-lane interstate highways. And similarly, interstate highway segments with narrow shoulders and damaged pavement are generally more risky than interstate segments without these problems.

Numerous other factors further characterize shipment risk. Driver/operator experience and skill level; condition of vehicles, and many other factors all contribute to the safety of hazardous materials transport. Thus, 800,000 daily shipments in the late 1990s might actually be safer than 500,000 daily shipments were in the 1980s. This report makes no judgement on that issue. Instead, to the extent that shipment and movement estimates themselves are instructive, this report attempts to improve the available estimates.

5. HAZMAT INDUSTRY PERSPECTIVE: Trucking, Vehicles and Tonnage.

Prevalence of Trucking. Although productivity and profits for the U.S. freight railroads have reached record highs nearly every year since deregulation by the Staggers Act in 1980, by certain other measures, rail transport in the United States actually peaked in 1929. That was the industry's high water mark in terms of employment, miles of track operated, share of the intercityn freight market, and many other measures. Today, while freight railroads remain a vital part of the nation's transport sector and overall economy, the dominant U.S. freight mode is truck. Although accounting for only about 25% of ton-miles and 45% of total tons moved

annually in the U.S., the trucking sector accounts for over 75% of freight revenues. And, in terms of hazmat shipment count, truck share is close to 94% of all hazmat shipments. Thus, for many measures of the freight market generally, and hazmat shipment estimates in particular, knowing the trucking sector role is key to understanding the broader industry.

Number of Vehicles and Fleet Utilization. The 1992 Truck Inventory and Use Survey (TIUS) indicates that approximately 60 million of the nation's 200 million vehicles are trucks, with the vast majority being personal use pick-up trucks. TIUS figures also show that some 16 million of the 60 million trucks, ranging from pick-ups and vans to heavy combination trucks, are involved in commercial transport activities (*business use*). Finally, the 1992 TIUS figures indicate about 365,000 trucks are in the hazmat fleet, implying that some 2.3% of the nation's commercial truck fleet is involved in hazmat transport (365,000/16,000,000).

The 1996 National Fleet Safety Survey, a report based on a study conducted by the Federal Highway Administration (FHWA) at various nationwide inspection stations, indicated that about 7.0% of the commercial truck fleet they surveyed were vehicles that transport hazardous materials. Because FHWA regulations generally exclude vehicles with a gross vehicle weight (gvw) under 10,000 pounds, however, the number of vehicles comprising the FHWA total commercial vehicle fleet is closer to 5-6 million vehicles. A figure of 7.0% suggests a 1996 hazmat fleet of some 360,000 - 420,000 vehicles -- not unlike the TIUS figure of 365,000.

Of the more than 800,000 daily hazmat shipments, approximately 770,000 are transported by truck (Table 2). Using a hazmat fleet size of 365,000 vehicles suggests that the average hazmat truck delivers just over 2.1 shipments per day. Given the industry's operating conditions, where one truck might be devoted to a single TL shipment for a period of one to three days, but trucks handling LTL and small package shipments might make several deliveries in a single morning, an average fleet utilization figure of multiple shipments per day is to be expected.

Hazmat Tonnage Produced v. Tonnage Shipped. The amount of hazmat produced (consumed) each year in the U.S. is close to 2 billion tons, while the amount shipped is closer to 3 billion tons. This relationship suggests that every ton, on average, is shipped 1.5 times. While the relationship holds for the hazmat industry as a whole, the ratio of tons produced/tons shipped is very different for Chemical & Allied Products than for Petroleum Products.

For Chemicals & Allied, the amount transported is apparently much less than the amount produced. The 1992 CFS shows 545,000,000 tons of Chemical or Allied products (STCC 28) transported in the U.S. For 1995, the Chemical Manufacturers Association (CMA) estimates 642,000,000 tons transported in the U.S. It is generally understood that for economic and/or safety reasons, major amounts of chemicals in the U.S. are "consumed" on plant-sites and converted into other products before they are *shipped* to other destinations. How high the initial production figure is unclear. One chemical industry source estimates that close to one billion tons of chemicals may actually be produced in the U.S., even though only some 642 million tons are transported (using the CMA figure). This suggests a ton shipped/ton produced ratio of only 0.64.

It is reasonable to assume that some or even much of the tonnage which is shipped includes tons (products) that are actually shipped more than once. It is even plausible that the original amount of SIC 28 tonnage that is eventually shipped -- and excluding those tons that are

not shipped -- could be as little as, for example, 320 million tons. This relationship would suggest: one billion tons produced = 680 million tons consumed on site + 320 million tons shipped off site. Once the 320 million tons were shipped, they would be reshipped for a total of 320 million x 2 = 640 million tons shipped. In this analysis and report, the estimates of tons shipped, i.e., the CFS 545 million ton figure and the CMA 642 million ton figure, are considered reasonably reliable data. What the estimate of tons *initially produced* might be is far less certain.

In contrast to chemical and allied product tonnage, petroleum product tons clearly involve, on average, multiple shipments of each ton produced. According to Department of Energy sources, The U.S. supplied about 18 million barrels of petroleum products per day in 1996 (Appendix Table B1). That amounts to a starting supply of nearly one billion tons annually. [6]

Some tons of petroleum products are shipped directly from ports of entry to end users/retail outlets. Tons distributed in that manner would be tallied as shipped once, delivered once, and moved once. Most petroleum products in the U.S., however, are shipped more than once. On average, each ton of petroleum products is shipped about 2.3 times, resulting in annual production of close to 1.0 billion tons but shipment of nearly 2.3 billion tons.

CONCLUDING NOTES:

Review and Recalibration. This report deliberately uses the word "estimate." It does not presume to provide dispositive, unchallengeable "counts." It is well known, for example, that industries continually undertake operational changes to increase efficiencies, reduce risk, or both. In gasoline distribution, for example, the present trend is toward use of larger vehicles and fewer reshipments of product. Even as U.S. daily consumption of petroleum products has grown steadily from 17 million barrels per day in 1992 to close to 19 million barrels per day in 1998, the number of daily petroleum product shipments could be declining, depending upon corporate distribution and fleet utilization strategies. Thus, these estimates may be viewed as subject to continuing review and recalibration. Suggestions from industry and other knowledgeable sources regarding how to improve the underlying data assumptions and the accuracy of the overall estimates are welcome.

1997 Commodity Flow Survey. It may also be noted that preliminary data from the 1997 Commodity Flow Survey should be generally available some time in late 1998, with expanded, final figures available probably in late 1999. Those figures may indicate important changes or trends as to how many hazmat shipments are occurring in the U.S., as well as important information about product type, shipment size and mode of transport.

[6] Eighteen million barrels x 42 gallons x 7.15 lbs./2,000 lbs. x 365 days = 985 million tons.

APPENDIX A

CHEMICALS AND ALLIED PRODUCTS

SIC, STCC, and NAICS. Standard Industrial Classification (SIC) codes, developed initially by the U.S. Department of Commerce and now maintained and updated by the Office of Management and Budget (OMB), provide commodity/product detail at the 2,3, and 4 digit levels. Products included in SIC 28 are designated "Chemical And Allied Products."

The Standard Transportation Commodity Classification (STCC) system was developed by the Association of American Railroads (AAR), is maintained by them, and provides product detail out to 7 digits. At the 2,3, or 4-digit level, most STCC product categories are similar or even identical to SIC code categories. For example, at the 3 digit level for the SIC 28 and STCC 28 commodity groupings, the product categories show close similarity:

Appendix Figure A1: SIC and STCC Product Descriptions

Number	SIC 28 Description	STCC 28 Description
SIC, STCC 28	Chemicals And Allied Products	Chemicals Or Allied Products
SIC, STCC 281	Industrial Inorganic Chemicals	Industrial Inorganic or Organic chemicals
SIC, STCC 282	Plastics Materials And Synthetics	Plastic Materials or Synthetic Fibers, Resins, or Rubber
SIC, STCC 283	Drugs	Drugs
SIC, STCC 284	Soap, Cleaners, And Toilet Goods	Soap or Other Detergents, Cleaning Preparations, Cosmetics, Perfumes
SIC, STCC 285	Paints and Allied Products	Paints, Enamels, Lacquers, Shellacs, or Varnishes
SIC, STCC 286	Industrial Organic Chemicals	Gum or Wood Chemicals
SIC, STCC 287	Agricultural Chemicals	Agricultural Chemicals
SIC, STCC 289	Miscellaneous Chemical Products	Miscellaneous Chemical Products

Although most Department of Commerce data gathering and reporting activities use SIC codes, the Department's Bureau of Census 1993 Commodity Flow Survey (CFS) used the STCC system, obtaining product detail at the 5-digit level.

The North American Industry Classification System (NAICS), developed by the U.S., Canada, and Mexico, has begun replacing the SIC code system, with a US. NAICS manual expected to be published some time in 1998. While having many product categories and designations similar to SIC codes, the NAICS will still differ from SIC codes in a number of ways. "Chemical manufacturing" will replace much of the existing "Chemicals and Allied Products," and have a NAICS code of 325. One of the most important changes incorporated into the NAICS is the provision of product detail at the 6 digit level (v. SIC's 4 digit system).

Report's Use of Term, "Chemicals or Allied Products." The chemical products data used in this report and also displayed in Appendix Table A1 are based on both the Standard Industrial Classification (SIC) code 28, "Chemicals And Allied Products," and the Standard Transportation Commodity Classification (STCC) 28, "Chemicals *Or* Allied Products." For consistency purposes and to conform with prevailing government use of the term, this report refers to the broad category of non-petroleum products as "Chemicals And Allied Products," or just *SIC 28*.

Appendix Table A1. Appendix Table A1 covers Chemicals And Allied Products and is based primarily on the 1993 Commodity Flow Survey (CFS). As discussed in the assumptions page that follows herein, the pounds/tons reported by shippers fit the shipment size categories designated by the CFS and correspond to products included in STCC 28, the railroad industry designation "Chemicals or Allied Products." The total ton figure available from the CFS represents 1993 traffic, and this number has been increased in Table A1 to reflect 1995 data from the Chemical Manufactures Association (CMA).

Appendix Table A1: CHEMICALS & ALLIED PRODUCTS (SIC 28) SHIPMENTS

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
	Weight Category (pounds)	**Average Pounds Per Shipment ***	**SIC 28 Annual Tons (000s)**	**Percent of Total Tons**	**Annual Pounds (000s)**	**Annual Shipments (000s)**	**Daily Shipments (midpoint) ****	**Daily Shipments (upper) *****	**Daily Shipments (10 lb. shp)**	**Percent Of Shipments For Col. 7**
1	< 50	25	1,094	0.2%	2,188,000	87,520	239,781	119,890	599,452	45.6%
2	50 - 99	75	857	0.2%	1,714,000	22,853	62,612	47,433	62,612	11.9%
3	100 - 499	300	5,242	1.0%	10,484,000	34,947	95,744	57,562	95,744	18.2%
4	500 - 749	625	2,838	0.5%	5,676,000	9,082	24,881	20,762	24,881	4.7%
5	750 - 999	875	2,053	0.4%	4,106,000	4,693	12,856	11,261	12,856	2.4%
6	**Subtotal < 1,000**		**12,084**	**2.2%**	**24,168,000**	**159,094**	**435,874**	**256,908**	**795,546**	**82.9%**
7	1,000 - 9,999	5,500	44,145	8.1%	88,290,000	16,054	43,984	24,191	43,984	8.4%
8	10,000 - 49,999	30,000	205,206	37.6%	410,412,000	13,681	37,481	22,489	37,481	7.1%
9	50,000 - 99,999	75,000	52,695	9.7%	105,390,000	1,405	3,850	2,887	3,850	0.7%
10	> 100,000	330,103	231,276	42.4%	462,552,000	1,401	3,839	3,839	3,839	0.7%
11	**Subtotal 1,000 & >**		**533,322**	**97.8%**	**1,066,644,000**	**32,541**	**89,154**	**53,407**	**89,154**	**17.0%**
12	**TOTAL**		**545,406**	**100%**	**1,090,812,000**	**191,635**	**525,029**	**310,315**	**884,700**	**100%**
13										
14	**CMA 1995 tonnage**		**642,000**				**618,014**			
15	If 95% is Hazmat						587,113			
16	If 80% is Hazmat						**494,411**			
17	If 65% is Hazmat						401,709			

* Assumes that different size (weight) shipments are evenly distributed throughout each weight category; therefore, average equals midpoint (rounded).
** Based on Column 2 shipment sizes, i.e., midpoint weights from each size category.
*** Upper bound from each of the size categories displayed in Column 1.

NOTE: For >100,000 lb. category, 3,723 daily shipments assumed to go by rail in 90 ton/carload shipments; 82 shipments assumed to go by water in 2,207 ton shipments; balance is 34 pipeline shipments (daily) at 3,750 tons per shipment. Same assumptions reflected in Columns 6-9.

NOTE: Truck shipment, tonnage, and movement data are derived from this table and Table A2 and are presented in Tables 1 and 2 of text and in Appendix Table D1. The first five weight categories are assumed to include air plus ground package and LTL shipments; air is derived from Appendix E and equals 43,750 daily shipments. Total truck share is the balance in the first five weight categories, plus all shipments in weight category lines 7-9. Figures in lines 14-17 are factored up to reflect CMA's estimated 1995 traffic levels. Line 16 figure reflects assumption that 80% of all products are hazmat. The truck shipments for weight categories 1-5 are each assumed to "move" twice (LTL, small package); shipments in weight categories lines 8-9 move once (TL); those in category line 7 are assumed to be half LTL and half TL, with LTL moving twice and TL once.

NOTE: Figures in Column 3, lines 1-12, reflect tonnage amounts displayed in 1993 Commodity Flow Survey Data, US Summary, p. 91.

Appendix Table A2: ADDITIONAL CHEMICAL SHIPMENT AND TONNAGE DATA

TRUCK SHIPMENTS FOR WEIGHT CATEGORIES UNDER 1,000 lbs.: tons, number, and type		
25 lbs. category	239,781-35,000*growth*.8*25lbs/2000 = tons of LTL	2,353 tons
	239,781-35,000*growth*.8 = no. of LTL shipments	188,271 shipments
75 lbs. category	62,612-2,188*growth*.8*75lbs/2000 = tons of LTL	2,135 tons
	62,612-2,188*growth*.8* = no. of LTL shipments	56,943 shipments
300 lbs. category	95,744-2,188*growth*.8*300lbs/2000 = tons of LTL	13,225 tons
	95,744-2,188*growth*.8* = no. of LTL shipments	88,166 shipments
625 lbs. category	24,881-2,188*growth*.8*625lbs/2000 = tons of LTL	6,683 tons
	24,881-2,188*growth*.8 = no. of LTL shipments	21,386 shipments
875 lbs. category	12,856-2,188*growth*.8*875lbs/2000 = tons of LTL	4,398 tons
	12,856-2,188*growth*.8 = no. of LTL shipments	10,053 shipments
Total Truck < 1,000 pounds, all of which are LTL, Tons =		**28,795 tons**
Total Truck < 1,000 pounds, all of which are LTL, Shipments =		**364,818 shipments**
TRUCK SHIPMENTS FOR WEIGHT CATEGORIES OVER 1,000 lbs.: tons, number, and type		
5,500 lbs. category	43,984*growth*.8 *5,500/2000 = tons	113,987 tons
	43,984*growth*.8 = shipments	41,450 shipments
30,000 lbs. category	37,481*growth*.8 *30,000/2000 = tons of TL	529,823 tons
	37,481*growth*.8 = no. of TL shipments	35,322 shipments
75,000 lbs. category	3,850*growth*.8 *5,500/2000 = tons	136,057 tons
	3,850*growth*.8 = shipments	3,628 shipments
Total Truck > 1,000 pounds		**779,867 tons**
Total Truck > 1,000 pounds		**80,400 shipments**
LTL Component > 1,000 pounds @ half the 5,500 lb. category *		56,994 tons
LTL Component > 1,000 pounds @ half the 5,500 lb. category *		20,725 shipments
TL Component > 1,000 pounds @ half 5,500 lb. category + others *		722,874 tons
TL Component > 1,000 pounds @ half 5,500 lb. category + others *		59,675 shipments
TOTAL TRUCK TONS: 28,975 + 779,867		**808,662 tons**
TOTAL TRUCK SHIPMENTS: 364,818 + 80,400		**445,218 shipments**
TOTAL LTL TONS:	28,795 + 56,994	85,789 tons
TOTAL LTL SHIPMENTS:	364,818 + 20,725	385,543 shipments
TOTAL TL TONS:	56,994 + 529,823 + 136,057	722,874 tons
TOTAL TL SHIPMENTS:	20,725 + 35,322 + 3,628	59,675 shipments

Appendix Table A2: ADDITIONAL CHEMICAL SHIPMENT AND TONNAGE DATA (Cont.)

SUMMARY CATEGORIES	
Rail + water + pipeline ship, all in > 100,000 lb. category = 3,723 + 82 + 34 =	**3,839 shipments**
Total Truck Shipments =	**445,218 shipments**
Truck + W +R + P Shipments = 3,839 + 445,218 =	**449,057 shipments**
Air Hazmat Shipments, @ 43,750 from Appendix E =	**43,750 shipment**
TOTAL SHIPMENTS	**492,807 shipments**

* Half of traffic in category assumed to be LTL; other half TL partial load, single movement shipments.

OTHER NOTES:

--The 1993 to 1995 growth factor, based on CMA figures, is assumed to be 642 million / 545 million =1.178

--Separately derived rail + water + pipeline shipments = 3,723 + 82 + 34 = 3,839

--Air shipments are assumed distributed among first five weight categories as follows:

43,750 total daily air shipments = 35,000 +2188 + 2188 +2188 +2188

--Truck shipments, unadjusted for growth and hazmat percentage, = 494,411 - 43,750 air - 3,723 - 82 -34 = 446,822

Appendix Table A1: ASSUMPTIONS

1) Column 1 shipment weight categories and Column 3 tons for those categories come directly from the 1993 Commodity Flow Survey, United States, Table 8, p. 91.

2) Column 2 average-pounds-per-shipment figures, i.e., shipment sizes, are derived by assuming that all shipments within a given size category are evenly distributed. Thus, the average weight is the midpoint in each category (rounded). For the over 100,000 pound category, a figure of 330,103 pounds or 165 tons is used. As stated in the Table A 1 notes, this figure is comprised of 3,723 rail shipments averaging 90 tons; 82 shipments by water averaging 2,207 tons; and 34 pipeline shipments averaging 3,750 tons (rounding of shipment and tonnage components).

3) Column 5 figures represent the Column 3 ton figures each multiplied by 2,000 pounds.

4) Column 6 figures result from dividing Column 5 figures by the respective Column 2 shipment size. Column 6 figures are annual estimates for the number of shipments in each weight category.

5) Column 7 figures result from dividing Column 6 figures by 365 days. The Column 7 heading reference to midpoint is a reminder that the figures are based on Column 2 shipment sizes which are assumed to be midpoints within the size categories.

6) Column 8 figures are variations on the Column 7 figures and have been derived by using the upper bound in every shipment size category, e.g., 50 lbs., 99 lbs., etc.

7) Column 9 figures are similar to Column 7 figures except that the 599,452 daily shipment entry (first line) is based on an assumption that all shipments under 50 pounds average 10 pounds, instead of the midpoint figure of 25 pounds. This adjustment changes the under-1,000 subtotal and the column total.

This analysis assumes that 80% of all STCC tonnage is hazardous materials. The 1987 U.S. DOT-Volpe Center study (Domenic J. Maio, Tai-Kuo Liu) estimated that 96% of all SIC 28 tonnage carried by trucks – based on the Census Bureau 1977 Commodity

Transportation Survey–was hazardous materials. In Appendix Table A1, the first 8 shipment weight categories are dominated by freight that is transported by truck. While a similar 96% hazmat figure is plausible for these truck shipment categories, an overall 80% figure has been assumed to keep the estimate conservative and thereby accommodate potential differences in the data not yet identified. Closer examination of the data, including analysis of the 1997 CFS, could show an actual number that differs from 80%. To indicate what a hazmat percentage of either 95% or 60% would do to the total daily shipment estimate, the results of these two are displayed in Column 7, lines 15 and 17.

The Chemical Manufacturers Association (CMA) estimate for SIC 28 tons shipped in 1995 is 642,000,000 annual tons. If the same shipment size distributions that apply to the 1993 CFS tonnage of 545,406,000 tons are applied to the 1995 CMA tonnage, the result would be a daily total of 618,014 shipments. With an assumption that 80% of all those shipments involve hazardous materials, the daily hazmat figure is 494,411 shipments. Indexed calibration, shown in Table A2, yields a slightly different number of 492,807 daily shipments, which is the figure appearing in Table 2 and Appendix Table D1. In the report text and Table 1, this figure has been rounded to 500,000 daily shipments.

APPENDIX B
PETROLEUM PRODUCTS

Six tables are included in Appendix B covering petroleum product flows and component shipment estimates. Appendix Table B1 presents data from U.S.DOE's Energy Information Administration and identifies the major flows of the nation's 18.3 million barrels of petroleum supplied daily. Appendix Table B2 uses the Table B1 supply figures and identifies barrel (ton) flows and shipment estimates for various petroleum product groups. Table B3 lists the assumptions used to estimate total petroleum product shipments, and it tallies the mode shares for each of the product groups in Table B2. Tables B4, B5, and B6 provide additional background data for component estimates included in Table B2.

In Appendix Table B4, the basic home heating survey data are provided by the Department of Energy, notably the number of households in each category and the number of gallons consumed annually by each household. The average delivery size and, therefore, the annual number of deliveries, were estimated by RSPA based on its understanding of home heating oil (distillate) and propane tank sizes. The data in Tables B5 and B6 were provided by phone from DOE; for table B5, the underlying data were based on American Petroleum Institute (API) survey information.

Appendix Table B1: PETROLEUM PRODUCT FLOW DATA, 1996
(thousands of barrels per day)

		Supply				Disposition					
		Field	Refinery		Unacc.	Stock	Crude	Refinery		PRODUCTS	
Line	COMMODITY	Production	Produc.	Imports	Crude [-a]	Change [-b]	Losses	Inputs	Exports	SUPPLIED [-c]	Line
1	CRUDE OIL	6,465	--	7,508	215	(124)	(s)	14,195	110	6	1
2	NGLs AND LRGs	1,830	662	211	--	(21)	--	450	53	2,222	2
3	Pentanes Plus	336	--	45	--	(2)	--	171	2	210	3
4	LPGs	1,494	662	166	--	(19)	--	278	51	2,012	4
5	Ethane/Ethylene	627	29	15	--	(13)	--	0	0	683	5
6	Propane/Propylene	525	520	119	--	(s)	--	0	28	1,136	6
7	N Butane/Butylene	150	103	19	--	(8)	--	143	23	113	7
8	Isobutane/Isobutylene	192	11	13	--	1	--	135	0	80	8
9	OTHER LIQUIDS	230	--	585	--	(s)	--	843	22	(49)	9
10	Oth Hydrocarb/Oxy	279	--	51	--	4	--	313	12	0	10
11	Unfinished Oils	-	--	367	--	4	--	416	0	(53)	11
12	Mogas Blend. Comp.	(48)	--	166	--	(8)	--	117	10	0	12
13	Avgas Blend Comp.	--	--	0	--	(s)	--	(4)	0	4	13
14	FINISHED PETR PROD.	82	15,662	1,175	--	(7)	--	--	796	16,130	14
15	Finished Mogas	82	7,565	336	--	(12)	--	--	104	7,891	15
16	Reformulated	--	2,221	174	--	3	--	--	2	2,390	16
17	Oxygenated	340	114	0	--	(10)	--	--	(s)	463	17
18	Other	(258)	5,230	163	--	(5)	--	--	102	5,038	18
19	Finished Avgas	--	20	(s)	--	(s)	--	--	0	20	19
20	Jet Fuel	--	1,515	111	--	(s)	--	--	48	1,578	20
21	Naptha-Type	--	2	2	--	(1)	--	--	2	3	21
22	Kerosene Type	--	1,513	109	--	1	--	--	46	1,575	22
23	Kerosene	--	62	1	--	(s)	--	--	2	62	23
24	Distillate Fuel Oil	–	3,316	230	--	(10)	–	–	190	3,365	24
25	<= 5% sulfur	--	2,084	112	--	5	--	--	51	2,140	25

Appendix Table B1: PETROLEUM PRODUCT FLOW DATA, 1996
(thousands of barrels per day) – cont –

		Supply				Disposition					
		Field	Refinery		Unacc.	Stock	Crude	Refinery		PRODUCTS	
Line	COMMODITY	Production	Produc.	Imports	Crude [a]	Change [b]	Losses	Inputs	Exports	SUPPLIED [c]	Line
26	> 5% sulfur	--	1,232	118	--	(14)	--	--	139	1,225	26
27	Residual Fuel Oil	--	726	248	--	24	--	--	102	848	27
28	Naptha Petro Feed	--	191	55	--	(3)	--	--	0	250	28
29	Oth Oils Pet Feed		200	142	--	(s)	--	--	0	342	29
30	Special Napthas	--	50	9	--	(s)	--	--	21	39	30
31	Lubricants	--	173	11	--	(1)	--	--	34	151	31
32	Waxes	--	26	1	--	(s)	--	--	3	24	32
33	Petroleum Coke	--	664	1	--	1	--	--	285	379	33
34	Asphalt & Road Oil	--	459	27	--	(5)	--	--	7	484	34
35	Still Gas	--	654	0	--	0	--	--	0	654	35
36	Misc Products	--	42	(s)	--	(s)	--	--	(s)	42	36
	TOTAL: Lines 1,2,9, &14	8,607	16,324	9,479	215	(152)	(s)	15,488	981	0	

– a Unaccounted for crude oil represents the difference between the supply and disposition of crude oil.
--b A negative number indicates a decrease in stocks, and a positive number indicates an increase in stocks.
--c Products supplied = Field Production + Refinery Prod. + Imports + Unaccounted Crude
- Stock Change - Crude Losses - Refin. Inputs - Exports.

s = less than 500 barrels per day NGL = Natural Gas Liquids LRG = Liquefied Refinery Gas
LPG = Liquefied Petroleum Gas Oxy = Oxygenates

SOURCE: EIA National Energy Information Center-- "Table 3. U.S. Daily Average Supply & Disposition of Crude Oil and Petroleum Products, 1996," based on various EIA monthly reports.

Appendix Table B2: PETROLEUM PRODUCT SHIPMENT & TONNAGE ESTIMATES (Page 1 of 4)

		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12
			Daily Brls (000)	IMPORTS To Refineries	Imports to Reg Storage	Imports to End Users	FIELD To Export	Field to Refinery	Field to Reg Storage	Field to End Users	Barrels Shipped	Daily Shipments	Daily Tons By Truck
		PRODUCT SUPPLIED *		---------- Daily Barrels ----------				---------- Daily Barrels ----------					
a	1	CRUDE OIL	6	**7,508**			**110**	**6,465**			**6,575**	**263**	
a	2	NGLs and LRGs	2,222										
a	3	Pentanes Plus	210										
a	4	LPGs *	2,012										
a	5	Ethane/Ethylene	683										
a	6	Propane/Propylene	1,136										
a	7	43% Petro Chem Pl Use	488										
a	8	33% Residential/Comm Use	375										
a	9	72% Res Heating Use (del by milk run)	270										
a	10	27% Other	105										
a	11	12% Industrial	136										
a	12	8% farm	91										
a	13	3% internal combustion	34										
a	14	1% other	11										
a	15	N Butane/Butylene	113										
a	16	Isobutane/Isobutylene	80										
a	17	OTHER LIQUIDS	(49)										
a	18	FINISHED PETROLEUM PRODUCTS	16,130			**1,175**					1,175	6,216	176,241
a	19	Finished Motor Gasoline	7,891							82	82	431	12,299
a	20	Reformulated	2,390										
a	21	Oxygenated	463										
a	22	Other	5,038										
a	23	Finished Motor Gasoline											
a	24	54% by MOC to retail outlets, 9000gal	4,261										
a	25	46% by Jobbers	3,630										
a	26	50% straight to outlets, 9000 gal	1,815										
a	27	25% to JS, 9000 reshipped 9000	907										
a	28	25% to JS, 9000 reshipped 2000	907										
a	29	Finished Avgas	20										
a	30	Jet Fuel	1,578										
a	31	Natptha-Type	3										
a	32	Kerosene-Type	1,575										
a	33	Jet Fuel											
a	34	67% piped to airports	1,057										
a	35	33% trucked to airports	521										
a	36	Kerosene	62										
a	37	Home heating use	22										
a	38	Other	40										
a	39	Distillate Fuel Oil	3,365										
a	40	Low sulfur <= 5% (motor diesel)	2,140										
a	41	High sulfur >= 5% (heating oil)	1,225										

Appendix Table B2: PETROLEUM PRODUCT SHIPMENT & TONNAGE ESTIMATES (Page 2 of 4)

		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12
			Daily Brls (000)	IMPORTS To Refineries	Imports to Reg Storage	Imports to End Users	FIELD To Export	Field to Refinery	Field to Reg Storage	Field to End Users	Barrels Shipped	Daily Shipments	Daily Tons By Truck
		PRODUCT SUPPLIED *		---------- Daily Barrels ----------				---------- Daily Barrels ----------					
a	42	Distillate Fuel Oil											
a	43	Low sulfur <= 5% (motor diesel)	2,140										
a	44	54% by MOC to retail outlets, 9000gal	1,156										
a	45	46% by Jobbers	984										
a	46	50% straight to outlets, 9000 gal	492										
a	47	25% to JS, 9000 reshipped 2000	246										
a	48	25% to JS, 2000 reshipped 2000	246										
a	49	High sulfur >= 5% (heating oil)	1,225										
a	50	Residential Heating	480										
a	51	Trucked RS to JS, del. by milk run	480										
a	52	Other	745										
a	53	50% to JS, 9000 reshipped 9000	373										
a	54	50% to JS, 9000 reshipped 2000	373										
a	55	Residual Fuel Oil	848										
a	56	Coastal Barge (15,000 barrel)	848										
a	57	Other	2,365										
a	58	Naptha Petro Feed (consumed on site)	250										
a	59	Other Oils Petro Feed (on site)	342										
a	60	Special Napthas (on site)	39										
a	61	Lubricants	151										
a	62	Waxes	24										
a	63	Petroleum Coke (assumes all rail)	379										
a	64	Asphalt & Road Oil (to asp plnt & resh)	484										
a	65	Still Gas (on site)	654										
a	66	Misc Products (on site)	42										
a	67												
a	68	**TOTAL (Lines 1,2,17,18)**	**18,309**										
a	69	**Barrels Shipped**		**		**1,175**	**110**	**6,465**		**82**	**7,832**		
a	70	**Daily Barrels Shipped (000)**	**7,832**										
a	71	**Annual Tons Shipped (000)**	**420,226**										
a	72	**Daily Tons Shipped (000)**	**1,151**										
a	73	**Daily Shipments**	**6,910**									**6,910**	
a	74	**Daily Tons Shipped By Truck**											**188.541**

* Product Supplied is a net figure. Import and Field crude to refineries, Field to Export, etc. are "inputs" to net Products Supplied. See also App. Table B1. Major tonnage movements (barrels) and shipments in Cols 3-9 (10-11) are additional to post-refinery movements, Cols 13-18.

** All Crude Oil Imports are assumed to be "deposited" directly at refineries, and are thereby excluded from tally of barrels shipped and shipments moving within the U.S.

Appendix Table B2: PETROLEUM PRODUCT SHIPMENT & TONNAGE ESTIMATES (Page 3 of 4)

		Col 1	Col 2	Col 13	Col 14	Col 15	Col 16	Col 17	Col 18	Col 19	Col 20	Col 21
			Daily Brls (000)	Refineries To Export	Refineries to End Users	Refineries to Reg Storage	Reg Storage to End Users	Reg Storage to Jobber Storage	Jobber Storage to End Users	Barrels Shipped	Daily Shipments	Daily Tons By Truck
		PRODUCT SUPPLIED		---------- Daily Barrels ----------				---------- Daily Barrels ----------				
b	1	CRUDE OIL	6									
b	2	NGLs and LRGs	2,222									
b	3	Pentanes Plus	210		**210**					**210**	**8**	
b	4	LPGs *	2,012									
b	5	Ethane/Ethylene	683		**683**					**683**	**27**	
b	6	Propane/Propylene	1,136									
b	7	43% Petro Chem Pl Use	488		**488**					**488**	**53**	
b	8	33% Residential/Comm Use	375									
b	9	72% Res Heating Use	268			**268**		**268**	**268**	**804**	**51,491**	**60,297**
b	10	27% Other	105			**107**		**107**	**107**	**321**	**4,990**	**29,153**
b	11	12% Industrial	136			**136**		**136**	**136**	**408**	**6,342**	**37,050**
b	12	8% farm	91			**91**		**91**	**91**	**273**	**4,244**	**24,800**
b	13	3% internal combustion	34			**34**		**34**	**34**	**102**	**1,584**	**9,218**
b	14	1% other	11			**11**		**11**	**11**	**33**	**512**	**2,943**
b	15	N Butane/Butylene	113		**113**					**113**	**16**	
b	16	Isobutane/Isobutylene	80		**80**					**80**	**7**	
b	17	OTHER LIQUIDS	(49)									
b	18	FINISHED PETROLEUM PRODUCTS	16,130									
b	19	Finished Motor Gasoline	7,891									
b	20	Reformulated	2,390									
b	21	Oxygenated	463									
b	22	Other	5,038									
b	23	Finished Motor Gasoline										
b	24	54% by MOC to retail outlets, 8000	4,261			**4,261**	**4,261**			**8,522**	**22,579**	**639,118**
b	25	46% by Jobbers	3,630									
b	26	50% straight to outlets, 8000 gal	1,815			**1,815**	**1,815**			**3,630**	**9,601**	**272,236**
b	27	25% to JS, 8000 reshipped 8000	907			**907**		**907**	**907**	**2,721**	**9,560**	**272,086**
b	28	25% to JS, 8000 reshipped 2000	907			**907**		**907**	**907**	**2,721**	**23,845**	**272,086**
b	29	Finished Avgas	20		**20**					**20**	**105**	**3,000**
b	30	Jet Fuel	1,578									
b	31	Natptha-Type	3									
b	32	Kerosene-Type	1,575									
b	33	Jet Fuel										
b	34	67% of total piped to airports	1,057		**1,057**					**1,057**	**42**	
b	35	33% some rr; most trucked to	521		**521**					**521**	**2,689**	**76,183**
b	36	Kerosene	62									
b	37	Home heating use	22			**22**		**22**	**22**	**66**	**578**	**6,600**
b	38	Other	40			**40**	**40**			**80**	**1,050**	**11,999**
b	39	Distillate Fuel Oil	3,365									
b	40	Low sulfur <= 5% (motor diesel)	2,140									
b	41	High sulfur >= 5% (heating oil)	1,225									

Appendix Table B2: PETROLEUM PRODUCT SHIPMENT & TONNAGE ESTIMATES (Page 4 of 4)

		Col 1	Col 2	Col 13	Col 14	Col 15	Col 16	Col 17	Col 18	Col 19	Col 20	Col 21
			Daily Brls (000)	Refineries To Export	Refineries to End Users	Refineries to Reg Storage	Reg Storage to End Users	Reg Storage to Jobber Storage	Jobber Storage to End Users	Barrels Shipped	Daily Shipments	Daily Tons By Truck
		PRODUCT SUPPLIED		---------- Daily Barrels ----------				---------- Daily Barrels ----------				
b	42	Distillate Fuel Oil										
b	43	Low sulfur <= 5% (motor diesel)	2,140									
b	44	54% by MOC to retail outlets,	1,156			**1,156**	**1,156**			**2,312**	**6,143**	**173,391**
b	45	46% by Jobbers	984									
b	46	50% straight to outlets, 8000	492			**492**	**492**			**984**	**2,603**	**73,796**
b	47	25% to JS, 8000 reshipped	246			**246**		**246**	**246**	**738**	**2,593**	**73,796**
b	48	25% to JS, 8000 reshipped	246			**246**		**246**	**246**	**738**	**6,467**	**73,796**
b	49	High sulfur >= 5% (heating oil)	1,225									
b	50	Residential Heating	482									
b	51	Trucked RS to JS, del. milk	482			**482**		**482**	**482**	**1,446**	**92,075**	**144,593**
b	52	Other	743									
b	53	50% to JS, 8000 reshipped	372			**372**		**372**	**372**	**1,116**	**3,921**	**111,594**
b	54	50% to JS, 8000 reshipped	372			**372**		**372**	**372**	**1,116**	**9,780**	**111,594**
b	55	Residual Fuel Oil	848									
b	56	Barge (15,000 barrel)	848		**848**					**848**	**57**	
b	57	Other	2,365									
b	58	Naptha Petro Feed (most on site)	250		**2**					**2**	**3**	
b	59	Other Oils Petro Feed (most on site)	342		**1**					**1**	**2**	
b	60	Special Napthas (on site)	39									
b	61	Lubricants	151			**151**	**151**			**302**	**32,503**	**45,298**
b	62	Waxes	24			**24**	**24**			**48**		
b	63	Petroleum Coke (assumes all rail)	379		**379**					**379**	**106**	
b	64	Asphalt & Road Oil (to asp plnt &	484			**484**	**484**			**968**	**12,684**	**144,300**
b	65	Still Gas (on site)	654									
b	66	Misc Products (on site)	42									
b	67											
b	68	**TOTAL (Lines 1,2,17,18)**	**18,309**									
b	69	**Barrels Shipped**			**4,402**	**12,624**	**8,423**	**4,201**	**4,201**	**33,851**		
b	70	**GRAND TOTAL Daily Barrels Shipped**	**41,683**									
b	71	**GRAND TOTAL Annual Tons Shipped**	**2,284,426**									
b	72	**GRAND TOTAL Daily Tons Shipped (000)**	**6,259**									
b	73	**NUMBER Of TIMES Average Ton Moved**	**2.3**									
b	74	**GRAND TOTAL DAILY SHIPMENTS**									**315,170**	
b	75	**Daily Tons Shipped By Truck**										**2,857,470**

-- a, b Coding used to indicate identical product listing, but different distribution phases, on pages 1-2 and 3-4 of Appendix Table B2.

Appendix Table B3: PETROLEUM PRODUCT ESTIMATES -- LINE ITEM ASSUMPTIONS

LINE	PRODUCT or COMPONENT	DISCUSSION	--------- SHIPMENTS BY MODE ---------				TOTAL
			Truck	Rail	Pipeline	Water	
a1	Crude Oil	Assumes 6,575,000 barrels moved by pipeline @ 25,000 barrels per shipment.			263		263
a18	Finished Petro Prod	Import figure given. Assumes all moves direct to end users by 8,000 gallon truck.	6,216				6,216
a19	Motor Gasoline	Field figure given. Assumes all moves direct to end users by 8,000 gallon truck.	431				431
b3	Pentanes Plus	Supply figure given. Assumes all moved direct from refinery to end users via pipeline.			8		8
b5	Ethane/Ethylene	Supply figure given. Assumes all moved direct from refinery to end users via pipeline.			27		27
b6	Propane/propylene	Supply figure given. Lines b7-b14 %s in part from API "Propane Class of Trade Study," 1995 data.					
b7	Propane/propylene	Assumes 34 rail carloads and remainder moves direct from refinery to other plants (end users) via pipeline.		34	19		53
b8	Propane: Res/Com	Percent from API Class of Trade Study; components derived from Home Heating Survey.					
b9	Propane Res Heat	Assumes pipeline to RS; assumes 1/2 rail and 1/2 8,000 trk to JS; home deliveries @ 200 gallons/ home heating customer.	51,255	225	11		51,491
		Delivery tallies based on Residential Heating Survey; see Appendix Table B4.					
b10	Propane: R/C Other	Assumes pipeline to RS; assumes 33 rail carloads and rest by 8,000 gallon truck to JS; deliveries @ 1,000 gal avg.	4,952	33	5		4,990
b11	Industrial	Assumes pipeline to RS; assumes 42 rail carloads and rest by 8,000 gallon truck to JS; deliveries @ 1,000 gal avg.	6,295	42	5		6,342
b12	Farm	Assumes pipeline to RS; assumes 28 rail carloads and rest by 8,000 gallon truck to JS; deliveries @ 1,000 gal avg.	4,212	28	4		4,244
b13	Internal Combustion	Assumes pipeline to RS; assumes 11 rail carloads and rest by 8,000 gallon truck to JS; deliveries @ 1,000 gal avg.	1,571	11	2		1,584
b14	Other	Assumes 4 rail carloads and rest by 8,000 gallon truck to JS; deliveries @ 1,000 gal avg.	508	4			512
b15	N Butane/But	Supply figure given. Assumes 12 rail carloads and remainder by pipeline to other refineries/plants or end users.		12	4		16
b16	Isbut/Isbutylene	Supply figure given. Assumes 4 rail carloads and remainder by pipeline to other refineries/plants or end users.		4	3		7
b19	Fin Motor Gasoline	Supply figure given.					
b24	Fin Motor Gasoline	54% figure from US DOT; pipe to RS; RS to retail outlets (end users) in 8,000 gallon trucks.	22,371	39	169		22,579
b25	FMG by Jobbers	46% figure from US DOT.					
b26	by Jobbers	50% est. EIA; pipeline to RS; RS to retail outlets in 8,000 gallon trucks.	9,528		73		9,601
b27	by Jobbers	25% est. EIA; pipeline to RS; RS to JS in 8,000 gal trucks; reshipped in 8,000 gallon trucks.	9,524		36		9,560
b28	by Jobbers	25% est. EIA; pipeline to RS; RS to JS in 8,000 gal trucks; reshipped in 2,000 gallon trucks.	23,809		36		23,845
b29	Finished Avgas	Supply figure given. Assumes all moved from refinery to end users in 8,000 gallon trucks.	105				105
b30-32	Jet Fuel	Supply and component supply figures given.					
b34	Jet Fuel Piped	67% est. from EIA; assumes direct from refineries to airports (end users) via pipeline.			42		42
b35	Jet Fuel Trucked	33% est. from EIA; assumes direct from ref to airports (end users) via 8,000 gal trucks.	2,667	22			2,689
b36	Kerosene	Supply figure given. Components derived from Home Heating Survey. See Appendix Table B4.					
b37	Kerosene Home	Supply figure derived; assumes Ref to RS by 8,000 gal trk; to JS by 2000 gal.	578				578
b38	Kerosene Other	Supply figure derived; assumes Ref to RS by 8,000 gal trk; to end users by 2000 gal trucks.	1,050				1,050

Appendix Table B3: PETROLEUM PRODUCT ESTIMATES -- LINE ITEM ASSUMPTIONS (Continued)

LINE	PRODUCT or COMPONENT	DISCUSSION	--------- SHIPMENTS BY MODE ---------				TOTAL
			Truck	Rail	Pipeline	Water	
b39-41	Distillate	Supply and low sulphur / high sulphur components given.					
b43	Low Sulphur	Supply figure given. Assumes all is highway motor diesel distributed like gasoline.					
b44	Diesel MOC	54% figure from US DOT; pipe to RS; RS to retail outlets (end users) in 8,000 gal trucks.	6,069	28	46		6,143
b45	Diesel by Job.	46% figure from US DOT.					
b46	by Jobbers	50% est. EIA; pipeline to RS; RS to retail outlets in 8,000 gal trucks.	2,583		20		2,603
b47	by Jobbers	25% est. EIA; pipeline to RS; RS to JS in 8,000 gal trucks; reshipped in 8,000 gal trucks.	2,583		10		2,593
b48	by Jobbers	25% est. EIA; pipeline to RS; RS to JS in 8,000 gal trucks; reshipped in 2,000 gal trucks.	6,457		10		6,467
b49	High Sulphur	Supply figure given.					
b50	Res Heating	Supply figure derived Home Heating Survey.					
b51		Assumes pipeline and 108 rail to RS; 8,000 gal trk to JS; JS to end users (residential users) in 200 gal deliveries.	91,951	108	16		92,075
b52	Other	Supply figure derived as high sulphur remainder; includes commercial, industrial, utilities, and farm users.					
b53	by Jobbers	Assumes pipeline to RS; truck to JS 8,000 gal; reshipped from JS to end users in 8000 gal trucks.	3,906		15		3,921
b54	by Jobbers	Assumes pipeline to RS; truck to JS 8,000 gal; reshipped from JS to end users in 2000 gal trucks.	9,765		15		9,780
b56	Residual Fuel Oil	Supply figure given. Assumes all transported by coastal barge with 15,000 barrel capacity (2,250 tons / shipment).				57	57
b57	Other	Supply figure given.					
b58-60	Naptha, etc.	Assumes 5 rail carloads shipped off site and remainder consumed on site.		5			5
b61	Lubricants	Supply figure given. Assumes truck to RS in 8,000 gal trucks; delivery to end users in average 200 gal lots.	32,503				32,503
b62	Waxes	Supply figure given. Assumes truck to RS in 8,000 gal trucks; hazmat status & final delivery to be identified.					
b63	Petroleum Coke	Supply figure given. Assumes 70 rail carloads and remainder in 1,400 ton river barge from refinery to end users.		70		36	106
b64	Asphalt & Rd Oil	Supply figure given. Assumes 10 rail carloads; remainder in 8,000 gal trks to asphalt plants;2,000 gal trks to construction sites.	12,674	10			12,684
		DAILY SHIPMENT TOTALS	**313,563**	**675**	**839**	**93**	**315,170**
		PERCENT OF TOTAL (market or "mode" share)	**99.49%**	**0.21%**	**0.27%**	**0.03%**	**100%**
		DAILY TONS SHIPPED	**0**	**60,750**	**3,146,250**	**178,650**	**3,385,650**
		PERCENT OF TOTAL (market or "mode" share)	**0%**	**2%**	**93%**	**5%**	**100%**

Appendix Table B4: RESIDENTIAL HEATING SURVEY

Fuel Consumed Housing Characteristic	Households (millions)	Annual Gallons	Delivery Size (a) (gallons)	Annual Deliveries /Household	Total Annual Deliveries	Total Daily Deliveries	Total Daily Barrels
Distillate Home Heating Oil							
Single Family	8.0	753					
Detached	7.4	763	200	3.8	28,231,000	77,345	368,311
Attached	0.6	627	200	3.1	1,881,000	5,153	24,540
Mobile Home: self pick-up	0.3	414	self pick-up				8,102
Mobile Home: w delivery	0.3	414	200	2.1	621,000	1,701	8,102
Multi-family	2.5	495					
2-4 Units (b)	0.9	733	125	5.9	1,759,200	4,820	43,033
5 or More Units ©	1.6	365	150	2.4	146,000	400	38,095
Subtotal, w MHs pick-up	10.8					87,718	**482,081**
Subtotal, w Mhs receiving						**89,420**	482,081
LPG/Propane							
Single Family	6.0						
Detached	5.9	554	200	2.8	16,343,000	44,775	213,216
Attached							
Mobile Home: self pick-up	1.9	423	self pick-up				52,427
Mobile Home: w delivery	1.9	423	200	2.1	4,018,500	11,010	52,427
Multi-family (d)							
2-4 Units	0.2	186	125	1.5	99,200	272	2,427
5 or More Units							
Subtotal, If mobiles pick-up	8.0					45,047	215,643
Subtotal, If mobiles receive						56,057	**268,069**
Subtotal, If half mobiles rec						**50,552**	

Appendix Table B4: RESIDENTIAL HEATING SURVEY (Continued)

Fuel Consumed Housing Characteristic	Households (millions)	Annual Gallons	Delivery Size (a) (gallons)	Annual Deliveries /Household	Total Annual Deliveries	Total Daily Deliveries	Total Daily Barrels
Kerosene							
Single Family	2.6						
Detached	2.5	75	200	0.4	937,500	2,568	12,231
Attached							
Mobile Home: self pick-up	0.7	194	self pick-up				8,858
Mobile Home: w delivery	0.7	194	75	2.6	1,810,667	4,961	8,858
Multi-family	0.3						
2-4 Units	0.2	42	42	1.0	66,667	183	548
5 or More Units							
Subtotal, If MHs pick-up	3.4					2,751	12,779
Subtotal, If MHs receive						7,712	**21,637**
Subtotal, If half MHs receive						**5,232**	
TOTAL, Oil + LPG						**139,972**	**771,787**

(a) Estimates by DHM-60, and represents delivery size "per household". Deliveries per building: divide total household deliveries by the number of households per tank (i.e., sharing one tank).

(b) Assumes average of 3 households/ building or 300,000 buildings; each building with a 500 gallon tank. Also assumes each tank is filled each time with 3/4 its capacity (1/4 still in tank); Households x gallons = total gallons; total gal/ full tank size 3/4 = total annual deliveries.

(c) Assumes 20 households per building; or 80,000 buildings; 3,000 gal. tank

(d) Assumes average of 3 households/ building or 66,700 buildings; each building with a 500 gallon tank. Assumes delivery amount is 375 gallons/tank or 125 gallons per household per delivery.

NOTE: Gaps in data generally indicate insufficient observations in EIA survey.
SOURCE DATA: EIA, "Residential Energy Consumption Survey, " based on 1993 Data.

Appendix Table B5: LIQUID PETROLEUM GAS (LPG/PROPANE) USAGE, 1995

Industry /Sector	Percent Of Total Use
Petrochemical Industry	43%
Residential/Commercial	33%
Industry (general)	12%
Farm	8%
Internal Combustion	3%
Other	1%
TOTAL	**100%**

Source: American Petroleum Institute, "Propane, by Class of Trade."

NOTE: These percentages were applied to 1996 EIA supply figures to obtain propane use estimates in Appendix Table B2.

Appendix Table B6: PETROLEUM DISTILLATE USAGE, 1996

Sector	Annual Gallons (billions)	Annual Barrels (millions)	Daily Barrels (thousands)	Percent Of Total
On-Highway	27.0	643	1,761	51%
Residential	6.9	164	450	13%
Commercial	3.6	86	235	7%
Farm	3.6	86	235	7%
Railroad Industry	3.4	81	222	6%
Marine	2.5	60	163	5%
Industrial	2.3	55	150	4%
Off-Highway	2.2	52	144	4%
Oil Company	0.7	17	46	1%
Utilities	0.7	17	46	1%
Other	0.5	12	33	1%
TOTAL	**53.4**	**1,271**	**3,483**	**100%**

Source: U.S. Department of Energy, EIA.

NOTE: Daily figures used for selected product information in Table B2.

APPENDIX C
ESTIMATING MOVEMENTS AND SHIPMENTS

Shipment Configurations and Modal Discussion. Appendix Figure C2 provides additional information on the matter of estimating *shipments* versus *movements*, a subject briefly discussed in both Sections 2 and 3. Appendix Figure C1 is the same as text Figure 1, and it is replicated herein to facilitate the further discussion.

That a single shipment might entail multiple vehicle, vehicle-rail car, or vehicle-aircraft movements is readily illustrated by examples such as Schematic #2 or Schematic #4. Where generating an estimate of movements grows more complicated is with situations involving shipment consolidation, such as situations illustrated by Schematics #9-12.

It was discussed in Section 2 (p. 4) that small package and LTL truck operations typically consolidate multiple shipments in a single vehicle. The same is true for air freight operations, especially small package air freight, wherein multiple shipments will be transported in a single vehicle or aircraft along one or more legs of the total delivery route. For both surface and air operations, these consolidated shipments could involve many combinations of a single or multiple origin points and a single or multiple destination points. The schematics in Appendix Figure C2 illustrate just some of the possible configurations involving multi-origin and multi-destination shipments. Schematic # 9, in addition to depicting an LTL operation, specifically illustrates consolidation of air package shipments.

In terms of estimating the number movements associated with a given number of shipments, each of the Schematics #9-12 helps illustrate the difference between movements of given shipments and movements of the vehicle (or aircraft, etc.) associated with those shipments. In schematic #10, for example, each of the 5 originating shipments is moved twice, suggesting 5x2 or a total of 10 movements. Yet, there are only 5 + 1 **vehicle movements** involved. Consequently, as indicated earlier, this report would tally Schematic #10 as 5 shipments but 6 movements. The same is true for Schematics #11 and #12. In each of these three later situations, the number of movements is just a little higher than 1.0 times the number of shipments, i.e., a factor of 1.2 times the number of shipments.

In Schematic #9, if the 5 originating shipments travel by LTL truck, there are 5+1+5 = 11 vehicle *movements*. If the 5 shipments travel by air, there are 5+1+1+1+1+5 = 14 vehicle and aircraft *movements* associated with the 5 shipments. These two respective movement factors are 2.2 and 2.8 times the number of shipments. Thus, for Schematics #10-12, the movement factor is close to 1 times the number of shipments; for both the trucking and air components of Schematic #9, the movement factor is over 2.0 and approaches 3.0 times the shipment number. Without access to detailed analysis of which consolidated-operation configurations pervade the freight moving industry, we have assumed an average *movement* factor for LTL, ground package, and air cargo operations of 2.0. These factors were applied to the shipment numbers in Table 2 and helped produce the summary figures in Table 1 (*movements* and *tons moved*).

For estimates of the number of movements in the rail, water, and pipeline sectors, *movement* factors of 3.0, 2.0, and 1.0 times the respective number of shipments have been assumed. For the rail sector, a factor of 3.0

has been used to reflect the frequency with which rail cars may be reconfigured within a train or switched from one train to another, usually after passing through a rail switching yard or so-called "humping" operations. There are certainly situations where one or more rail hazmat cars will travel essentially directly and unimpeded from origin to destination. It is assumed herein that such traffic is the exception, however, and without access to more detailed operational analyses, we have assumed an average movement factor of 3.0 times the number of shipments.

For water mode movements, a factor of 2.0 has been used. That number is assumed to be reasonable, but as to how closely it reflects actual water operations would require research and evaluation beyond the scope of this analysis. One might argue, for example, that passage of a barge through a lock on the inland waterway system is effectively equivalent to the transfer of a truck trailer or container to the rail mode. And, given that typical water shipments entail navigation of multiple locks, a much higher movement factor might therefore be warranted. Similarly, many water mode shipments involve a rail or truck distribution segment at either the origin, destination, or both ends of the water trip. Still, large amounts of waterborne commerce go almost directly from one port to another and are off loaded into the pipeline system. If such traffic is also separately captured by the pipeline mode, the shipment configuration for water would imply one *movemen*t for each one *shipment*. Given these uncertainties, a factor of 2.0 has been assumed and is considered reasonable.

For pipeline, discussions with the industry indicated that even the term "shipment" is not conventional within the pipeline sector, let alone the fact that shipment estimates are generally unavailable. Rather, industry and government officials tend to speak in terms of tons or ton-miles moved. To keep calculations, as well as the concepts, of pipeline *shipments* and *movements* relatively simple, we have assumed that movements are equal to the number of shipments.

Product Categories and Movement Factors. In addition to the differences in movement factors that apply to the modes, as discussed above, movement factors in this report also differ among broad product categories. For **petroleum product** distribution, for example, virtually all shipments are made by truck and entail full truckload movements from one proprietor group to another -- or to the end consumer. Truck vehicle sizes and therefore shipment sizes might differ, but truck shipments that exclude milk runs are the equivalent of movements, and vice versa. Thus, the movement-to-shipment factor is 1.0. Similarly, "milk runs" of home heating oil define *deliveries* as *shipments* and, implicitly, as *movements*.[1]

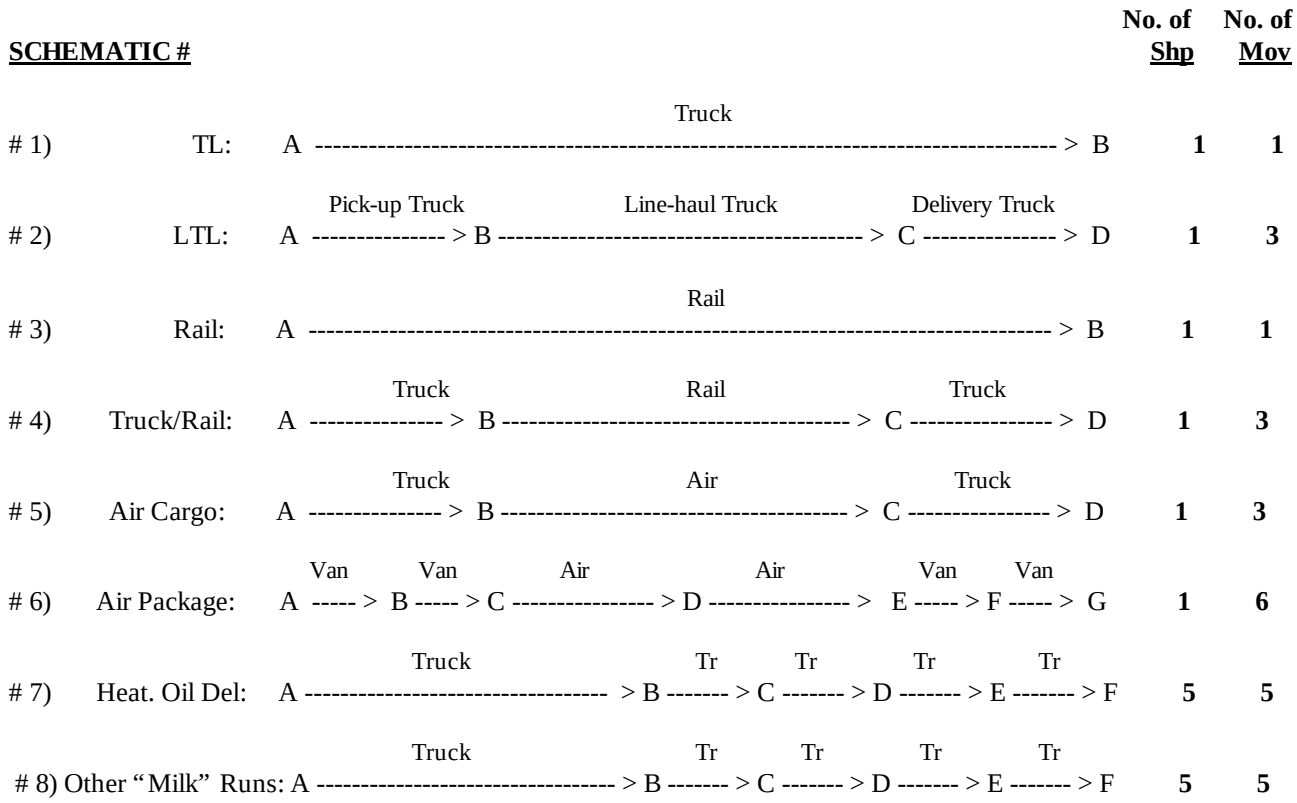
[1] There are some rail and water mode movements of petroleum products, and these (assumed) different movement factors are reflected in Table 2 and Table 1 petroleum product estimates.

For **chemical & allied product** shipments, in contrast, nearly all shipments move by truck in amounts that imply LTL or small package operations, or move by air mode. It is true that the Commodity Flow Survey (CFS) questionnaire appears worded to identify most separate movements as actual shipments -- implying a movement-to-shipment factor of 1.0. However, for intermodal shipments, shippers merely indicate *intermodal* without regard to a tally of individual modes actually deployed for the complete shipment. And, in as much as most LTL and air cargo deliveries are handled by for-hire carriers, it seems that most shippers would indicate a single mode, with the matter of consolidation, redistribution, and other individual vehicle (or aircraft) movements being the unrecorded business of the carriers themselves. In other words, a shipper's private carriage movements from one company facility to another may be identified as separate shipments -- and therefore equal in number to movements -- but for shipments hauled by for-hire carriers, it seems unlikely that movements from one sorting facility to another would be accounted for by any surveyed shipper. Thus, for the Chemical & Allied Products group (SIC 28) which rely on the CFS data, nearly all shipments are assumed in this report to entail multiple movements.

For discussion and analysis purposes, the CFS questionnaire instructions presented on page 4 of the report are repeated below:

> A "shipment" (or "delivery") is an individual movement of commodities **from** your establishment **to** one customer OR **to** another location of your company (including a warehouse, distribution center, retail or wholesale outlet). A shipment uses one or more modes of transportation, including parcel delivery, U.S. Postal Service, courier, private truck, for-hire truck, rail, water, pipeline, air, and other modes. Please note that for this survey:
>
> 'A full or partial truckload can be considered **one** shipment **only** if all the commodities are destined for one buyer/receiver at one location. If the truck makes multiple deliveries on a route, **each stop is considered (at least) one shipment.**'" (*emphasis in the original*)

Appendix Figure C1: SHIPMENT and MOVEMENT SCHEMATICS *

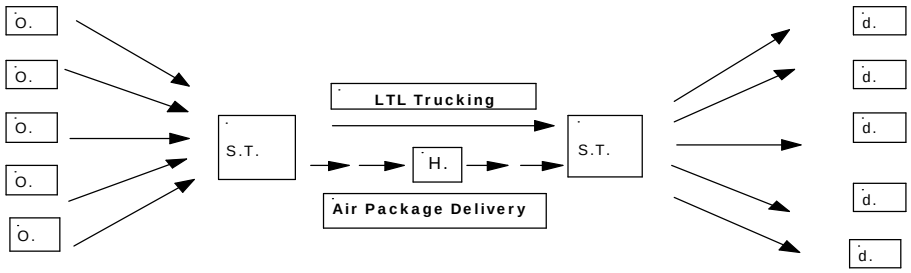


* This figure is identical to Figure 1 in the text of the report and is reshown here to facilitate the Appendix C discussion.

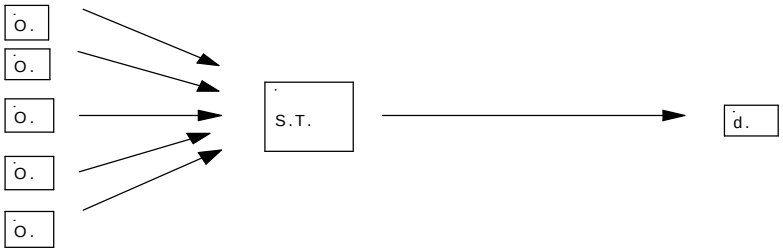
NOTES: Shp = shipments Mov = movements Tr = truck.

Appendix Figure C2: CONSOLIDATED SHIPMENT SCHEMATICS

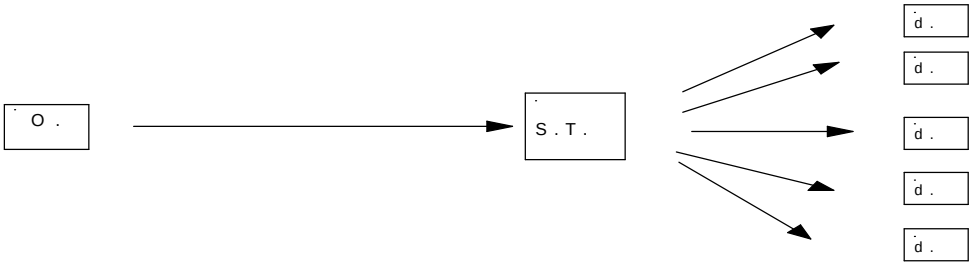
Schematic #9: Multi-origins, Multi-destinations, e.g., LTL Trucking or Air Package Delivery



Schematic #10: Multi-origins, Single Destination

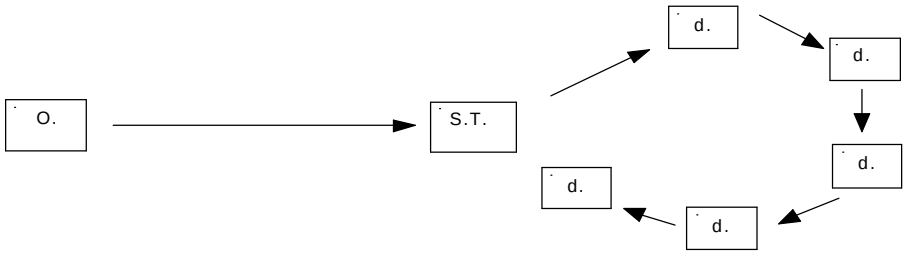


Schematic #11: Single Origin, Mutli-destinations by Multiple Delivery Vehicles



Schematic #12: Single Origin, Multi-destinations by One Delivery Vehicle

(Note similarity to Schematics #7 and #8)



O = Origin Point
ST = Sort Terminal
H = Air Cargo Hub
d = Destination (customer delivery point)

APPENDIX D
MODAL SHARES OF DAILY HAZMAT SHIPMENTS AND MOVEMENTS

Appendix Table D1 is identical in content to Table 2 in the text portion of this report. It is reintroduced here to facilitate analysis of various figures and assumptions, particularly material presented elsewhere in these appendices.

Because of the nature of the materials in "Other Hazmat," as well as the fact that the air mode hazmat share displayed in the Chemicals & Allied Products portion of Table D1 is presumed to include all air hazmat shipments, the vast majority of "Other Hazmat" shipments, movements, etc. are assumed to be captured by the truck mode. This predominance of the truck mode is assumed to apply even to products, such as those discussed in Appendix G, for which data gaps still exist.

It may also be noted that the 10,000 shipment figure ("at least 10,000") for the *Other Hazmat* commodity group assumes the 7,180 component estimate for waste hazardous materials and that medical waste, other medical industry, and various other product category shipments would bring the daily total to well over 10,000. As indicated in Appendix Table G2, if the average medical waste shipment is any size smaller than 200 pounds per shipment, that category alone would contribute more than 4,000 additional shipments to the daily total.

Appendix Table D2 provides a detailed listing of assumptions and calculations used to estimate the shipment, movement, and tonnage figures provided in Appendix Table D1.

Appendix Table D1: MODAL SHARES of DAILY HAZMAT SHIPMENTS and MOVEMENTS

		(a)		(b)		(c)		(d)	
		Shipments	**%**	**Movements**	**%**	**Tons Shipped**	**%**	**Tons Moved**	**%**
Line		**CHEMICALS & ALLIED PRODUCTS**							
1	Truck	445,218	90.30%	830,761	89.36%	808,662	55.52%	894,452	37.30%
2	Rail	3,723	0.80%	11,169	1.20%	335,070	23.00%	1,005,210	41.92%
3	Pipeline	34	0.00%	34	0.00%	127,500	8.75%	127,500	5.32%
4	Water	82	0.00%	164	0.02%	181,279	12.45%	362,558	15.12%
5	Air	43,750	8.90%	87,500	9.41%	4,049	0.28%	8,098	0.34%
6	**SUBTOTAL -- a**	**492,807**	**100%**	**929,628**	**100%**	**1,456,560**	**100%**	**2,397,818**	**100%**
7		**PETROLEUM PRODUCTS**							
8	Truck	313,689	99.50%	313,689	99.15%	2,857,470	40.04%	2,857,470	34.39%
9	Rail	448	0.10%	1,344	0.42%	40,320	0.57%	120,960	1.46%
10	Pipeline	839	0.30%	839	0.27%	3,146,250	44.09%	3,146,250	37.87%
11	Water	253	0.10%	506	0.16%	1,091,646	15.30%	2,183,292	26.28%
12	Air	-	0.00%	-	0.00%	-	0.00%	-	0.00%
13	**SUBTOTAL -- b**	**315,229**	**100%**	**316,378**	**100%**	**7,135,686**	**100%**	**8,307,972**	**100%**
14		**OTHER HAZMAT**							
15	**Truck -- c**	10,000	98.60%	10,000	95.90%	43,048	92.43%	43,048	80.27%
16	Rail	144	1.40%	432	4.10%	3,526	7.57%	10,578	19.73%
17	Pipeline	-	0.00%	-	0.00%	-	0.00%	-	0.00%
18	Water	-	0.00%	-	0.00%	-	0.00%	-	0.00%
19	Air	-	0.00%	-	0.00%	-	0.00%	-	0.00%
20	**SUBTOTAL**	**10,144**	**100%**	**10,432**	**100%**	**46,574**	**100%**	**53,626**	**100%**
21									
22		**TOTAL HAZMAT**							
23	Truck	768,907	93.98%	1,154,450	91.88%	3,709,180	42.94%	3,794,970	35.27%
24	Rail	4,315	0.53%	12,945	1.03%	378,916	4.39%	1,136,748	10.57%
25	Pipeline	873	0.11%	873	0.07%	3,273,750	37.90%	3,273,750	30.43%
26	Water	335	0.04%	670	0.05%	1,272,925	14.73%	2,545,850	23.66%
27	Air	43,750	5.35%	87,500	6.96%	4,049	0.05%	8,098	0.08%
28	**DAILY TOTALS -- d,e**	**818,180**	**100%**	**1,256,438**	**100%**	**8,638,820**	**100%**	**10,759,416**	**100%**
29									
30	**ANNUAL TOTALS -- f**	**298,635,700**		**458,599,870**		**3,153,169,300**		**3,927,186,840**	

" - " is negligible and, in some instances, may actually be zero.

-- a Daily shipment subtotal rounded to 500,000 in Table 1 and in text.

-- b Daily shipment subtotal rounded to 300,000 in Table 1 and in text.

-- c This figure is at least 10,000 and could range as high as 80,000 daily shipments or more. Waste hazmat, medical waste, various industrial products and other materials comprise this category. Virtually all "Other" hazmat are transported by truck. See Appendix G for detailed estimates within "Other" category.

-- d Daily shipment TOTAL rounded to > 800,000 in Table 1 and in text.

-- e Daily movement TOTAL rounded to: > 1.2 million in Table 1 and in text.

-- f Annual tons shipped and moved are rounded to > 3.1 billion and > 3.9 billion in Table 1 and in text.

Appendix Table D2: MODE SHARE ESTIMATES -- LINE ITEM ASSUMPTIONS

NOTE: *These line item discussions also draw upon information in Appendix Tables A1 and A2, as well as information from Appendices E and G.*

Line 1. Column A: Truck figure based on Table A1 shipments. Reflects subtraction of air hazmat shipments from each of the first five (5) weight categories. Air shipment subtractions @ 35,000; 2,188; 2,188; 2,188; and 2,188 for a total subtraction of 43,750 air shipments. First seven weight categories in Table A1 are presumed to be truck & air, or truck exclusively. The 1993 CFS figures are indexed by a 1.178 growth factor (645/545) and factored by an 80% hazmat percentage assumption.

Column B: Weight categories 25 lb. - 875 lb. are considered small package or LTL shipments and are assumed to be moved twice; 5,500 lb. category assumed to be half LTL, half TL; next two weight categories assumed to be TL shipments, each moved once. Thus (364,818*2) + (20,725*2) + 59,675*1 = 830,761 movements.

Column C: Truck tonnage = no. of shipments x avg. weight per shipment/2,000 lbs. in each weight category. Most shipments are in < 1,000 lb. category, but most tonnage is in > 1,000 lb. category. Total truck tonnage = 28,795 tons + 779,867 tons = 808,662 truck tons shipped (see also Table A2).

Column D: Under 1,000 lb. tons are assumed to move twice; half the 5,500 lb. shipment tonnages are assumed to move twice (LTL), half move once (TL): Total = (28,795*2) + (56,994*2) +(722,874*1) = 894,452 truck tons moved daily.

Line 2: Column A: Rail shipments taken from AAR publication of 1996 hazmat shipments. Petroleum product shipments were subtracted from AAR total; Canadian percentage, assumed to be the same for chemicals as the Canadian percentage of petroleum product shipments, also subtracted to yield U.S. share.

Column B: All shipments assumed to move 3 times.

Column C: Average load assumed to be 90 tons -- 90 x 3,723.

Column D: Column C x 3.

Line 3: Column A: Pipeline mode estimated as residual share after subtracting rail tonnage and water tonnage from Table A1 shipments that exceed 100,000 pounds; average shipment = 3,750 tons.

Column B: Movements and shipments assumed equivalent.

Column C: 34 x 3,750 tons.

Column D: Tons shipped and tons moved assumed equivalent.

Line 4: Column A: Water figure based on Waterborne Commerce Statistics for 1996; for "Chemicals," 66,166,898 tons among 29,986 "vessel trips" implies 29,986 annual *shipments* at an average of 2,207 tons each. Daily shipments equal 29,986/365 = 82.

Column B: Movements assumed to be double the number of trips.

Column C: Tons from Waterborne Commerce Statistics (66,166,898).

Column D: Tons moved assumed to be twice number of shipments.

Line 5: Column A: Air shipments described in Appendix E.

Column B: Movements assumed to be twice number of shipments, due to consolidated loads. (See also Appendix C discussion for assumption of 2 movements per air shipment.)

Column C: Tonnage estimate taken from Table E1 and described in Appendix E; figure hinges largely upon assumption that air hazmat is 8% of total.

Column D: Tons moved assumed to be twice tons shipped.

Line 8: Column A: Truck shipment totals taken from Appendix Table B2 and Appendix Table B3. As shown in Figure 1 of the report and discussed further in Appendix C, the number of shipments, movements, and deliveries for petroleum products are assumed to be equal, with transfers along distribution chain

Appendix Table D2: MODE SHARE ESTIMATES -- LINE ITEM ASSUMPTIONS (Cont.)

assumed to denote the end of one shipment and beginning of subsequent one. Each "milk run" delivery also assumed to correspond to one shipment and one movement.

Columns C and D: Tons from Table B2 and Table B3. Tons moved equal tons shipped.

Line 9: Column A: Shipment figure taken from AAR "Annual Report of Hazardous Materials Transported by Rail," Calendar Year 1996 (November 1997).

Column B: Each rail shipment assumed to be moved 3 times.

Column C: Each loaded rail car assumed to be carrying 90 tons.

Column D: Each ton assumed to be moved 3 times.

Line 10: Column A: Pipeline shipment total based on Table B2 and B3 assumptions regarding distribution phases that utilize the oil pipeline system. "Shipment" size assumed to be 25,000 barrels.

Column B: Shipments assumed to "move" once.

Column C: Tons estimated at 42 gallons per barrel and approximately 7 pounds per gallon.

Column D: Tons *moved* assumed equal to tons *shipped*.

Line 11: Column A: Water shipments from Waterborne Commerce Statistics: Crude Petroleum @ 12,881 annual vessel trips carrying 128,089,274 annual tons for an average of 9,944 tons per vessel and 35 trips per day. Other Petroleum Products @ 79,407 annual vessel trips carrying 270,361,406 tons for an average of 3,405 tons per shipment and 218 trips (shipments) per day. Total daily shipments = 253.

Column B: Each shipment assumed to *move* twice.

Column C: Tons shipped from Waterborne Commerce Statistics.

Column D: Each shipment (vessel trip) assumed to move twice, primarily to reflect intermodal connection and subsequent modal movement.

Line 12: Air shipment of hazardous petroleum products assumed to be negligible.

Line 15: Column A: Shipment figure taken from data in Appendix G. Consists primarily of waste hazardous materials shipments. Infectious Substance (medical waste) component assumed to easily bring total over 10,000 but remains preliminary and unspecified at this time.

Column B: Because waste hazmat shipments are based on manifest count, which are supposed to correspond roughly to single movements of single shipments, and because of preliminary nature of other component estimates, a movement/shipment ratio of 1/1 assumed. (Occasional intermodal shipment implies movement/shipment ratio that slightly exceeds one.)

Column C: Tonnage figure, discussed in Appendix G and Appendix G tables, derived in part from EPA figures and 1993 Commodity Flow Survey estimates of truck and rail mode shares. Estimate in Column C is only for the 7,180 waste hazmat shipments. Other tonnage not estimated.

Column D: While intermodal shipments imply some tonnage is moved more than once, a 1/1 movement/shipment ratio is assumed for the tonnage of the 7,180 waste hazmat shipments.

Line 16: Figures contain estimate only for waste hazmat shipments, discussed in Appendix G.

Line 17: Hazmat other than chemicals and petroleum products assumed to be negligible.

Line 18: Hazmat other than chemicals and petroleum products assumed to be negligible.

Line 19: The amount of waste hazmat that travels by air is presumed to be negligible, if not actually zero. The amount of infectious substances, however, including diagnostic specimens, medical cultures, etc., that travels by air is not presumed negligible. Still, no reliable estimate is available at this time, and therefore such shipments are presumed included in the 43,750 daily shipments within the Chemical & Allied category.

APPENDIX E
HAZMAT SHIPMENTS BY AIR

The mode share data in Table 2 and Appendix Table D1 indicate an estimated 43,750 daily hazmat shipments by air. This figure is an extrapolation from traffic level estimates for a select number of air carriers authorized to transport hazmat by air. [2] These companies estimated their respective hazmat shipment traffic at certain levels. With an assumption that these carriers' composite share of air hazmat traffic was similar to the companies' composite share of total air cargo traffic -- based on Bureau of Transportation Statistics (BTS) 1997 air cargo data, an estimate of the total air hazmat market was generated. For example, if 7 companies handled 35,000 daily hazmat shipments and those companies also had 70% of the total air cargo market, then a similar hazmat market share would suggest a total air hazmat market of 50,000 shipments per day. Based on the carriers, hazmat shipment levels, and cargo market percentages surveyed for this analysis, the total air hazmat shipment market was estimated at 43,750 daily shipments.

Hazmat *tonnage* estimates, Table 2 and Appendix Table D1, are also derived in part from the BTS 1997 air cargo industry figures, but they also include a currently used FAA assumption from the 1986 OTA hazmat study that 8% of total air cargo tonnage is hazardous materials. These data and the 8% assumption result in an estimate of 4,049 tons of hazardous materials shipped daily by air (Appendix Table E1). That figure may be compared with the OTA estimate for 1982 of 781 hazmat tons per day. [3] When the 4,049 level is divided by 43,750 daily shipments, the result is an average air hazmat shipment size of 185 pounds.

The 4,049 daily ton figure (1997) is considerably higher than the 781 daily ton figure (1982), and the 185 pound figure may appear high for an industry in which many shipments contain only small quantities of hazardous materials. However, enormous growth in the overall air cargo industry as well as the occurrence of a relatively small number of large, all-cargo hazmat flights could explain the various numbers. Unlike combined passenger/cargo flights on which both *individual shipment size* and the *total amount of hazmat* aboard an aircraft are limited to relatively small amounts, the regulated limits for individual shipments on all-cargo flights are typically several times larger, and total tonnage aboard the aircraft is generally not limited. Thus, a relatively small number of large, all-cargo flight hazmat shipments could result in large tonnage figures and in what might appear to be a relatively large average shipment size. [4]

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[2] These companies' names, hazmat traffic levels, and respective air cargo market shares -- for confidentiality reasons -- are not identified herein.

[3] Office of Technology Assessment, Transportation of Hazardous Materials, (Washington, D.C., 1986), p 4.

[4] It is also possible that the 8% figure (hazmat air cargo/total air cargo) is too high, at least in terms of 1997 air cargo traffic levels. That OTA figure was based on the 1977 Commodity Flow Survey data. The 1977 CFS data had several shortcomings, including incomplete air traffic data.

Appendix Table E1: HAZMAT TONNAGE BY AIR

CATEGORY	MEASURE
1997 System CARGO Revenue Ton-miles (RTM) for Passenger and	
All-Cargo Carriers, both International and Domestic.	25,320,736,000
An estimated 8% of RTM = hazmat RTM [--a]	2,025,658,880
Domestic hazmat RTM for Passenger Carriers = [--b]	262,400,000
Avg trip length (miles) for Dom. hazmat Pass Carriers = [--b]	772
Annual Tons hazmat = RTM/ trip length or 262.4m/772 = [--b]	339,896
Domestic hazmat RTM for Cargo Carriers = [--b]	679,300,000
Avg trip length (miles) for Dom. hazmat Cargo Carriers = [--b]	597
Annual Tons hazmat = RTM/ trip length or 679.3m/597 = [--b]	1,137,856
Total Annual Domestic Tons of Hazmat = 339,896 + 1,137,856	1,477,752
If annual figure is divided by 365 days, daily tons =	**4,049**

[-- a] Figure used by FAA, from Office of Technology Assessment (OTA) 1985 report, "Transportation of Hazardous Materials," p. 55, citing the Bureau of Census 1977 Commodity Transportation Survey (CTS) that 8% of all air cargo tonnage is hazmat. The 1993 Commodity Flow Survey (CFS) provides negligible data on air cargo hazmat tonnage.

[-- b] FAA, Office of Aviation Policy and Plans, based on 1997 Bureau of Transportation Statistics (BTS) data.

APPENDIX F
RADIOACTIVE MATERIALS (RAM)

Appendix F contains summary data about radioactive materials shipments. The vast majority of shipments are very small in size and involve such products as radio pharmaceuticals. Because SIC 28 includes radio pharmaceutical and other radioactive materials, the Table F1 estimate of 7,671 daily shipments is already reflected in Table 1, Table 2, and Appendix Table A1 data.

Fewer than 100 shipments per year over the last decade have involved highly radioactive spent fuel shipments from the nation's and some foreign nuclear power plants. These high level spent fuel shipments could increase to 300 - 400 shipments per year, if either an interim storage or permanent repository site became available. While having considerable implications for transport safety, the actual shipment, movement, and tonnage figures would remain only nominal -- and close to negligible at that.

Appendix Table F1: RADIOACTIVE MATERIALS (RAM) SHIPMENTS: Radiopharmaceuticals, Spent Fuel, and Nuclear Wastes

	Radiopharm and Other	Commercial Spent Fuel	U.S. DOE	TOTAL
Annual Tons	na	na	na	na
Annual Shipments (a)	2,794,400	< 100	5,500	2,800,000
Daily Tons	na	na	na	na
Daily Shipments	7,656	<1	15	**7,671**
Average Shipment Size	(b)	(b)	(b)	(b)

(a) "Transporting Radioactive Materials," U.S. Department of Energy, July 1997, p. 11. The 2.8 million total and the 5,500 U.S. DOE figure are given by DOE. The DOE shipments, for fiscal year 1995, include spent fuel, low-level and mixed waste, and uranium mill tailings. The 2,794,400 figure is the difference between the 2.8 million and the 100 and 5,500 figures. Commercial fuel figure is included in total and displayed for information purposes.

Spent fuel shipments from the nation's commercial nuclear power facilities, as well as import shipments from foreign facilities, have totaled fewer than 100 per year since 1988. Completion of a permanent repository, as contemplated for the Yucca Mountain site, NV, or an interim storage site, as discussed for the Nevada Test Site, NV, could result in an additional 300-400 spent fuel shipments per year.

Opening of the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM, could result in an additional 1,000 waste shipments per year. This storage facility would receive mostly used protective clothing, rags, tools, scrap metal, etc. transported in large, lead lined, stainless steel containers. Shipment origin points would be primarily various DOE facilities.

(b) The vast majority of radiopharmaceutical and other RAM shipments are the size of small packages, often weighing less than 1 pound per shipment.

In contrast, spent fuel shipments (material only) typically weigh 0.5 - 1.0 ton for truck shipments and up to 10 tons for rail shipments. Protective lead shipping casks, used to contain the material, weigh many additional tons.

NOTE: Radioactive materials are included by Bureau of Census in the SIC 28 Chemical and Allied products category, and thus the 7,671 figure is included in Table 1 and other tables in the SIC 28 shipment group.

APPENDIX G
OTHER HAZARDOUS MATERIALS

Hazardous Wastes. Appendix Table G1 provides data on the amounts of waste tonnage produced by EPA-defined *generators;* on amounts shipped off-site; and on the number of shipments. The shipment number is assumed to be identical to EPA's estimated number of manifests associated with transporting the waste material that is shipped off-site. [5]

Information on tons generated and tons shipped off-site are from the National Biennial RCRA Hazardous Waste Report covering 1995 data and apply to amounts for *large quantity generators.* Tonnage figures for small quantity and other types of generators are not available. Shipment count or manifest data are from EPA's Office of Solid Waste, and the manifest estimates cover large, small, and other generators.

Figures regarding truck and rail mode share are taken in part from the 1993 Commodity Flow Survey data covering STCC 48 (waste hazardous materials or waste hazardous substances) and available statistics on the size of shipments for truck and rail cargoes generally.

Medical Wastes and Other Infectious Substances. Appendix Table G2 provides data on the number of medical facilities in the U.S., virtually all of which are potential generators of medical waste and other kinds of infectious substances, e.g., diagnostic specimens. Many of the materials generated by these facilities are also covered by OSHA and EPA regulations. Estimates of medical waste tonnage generated and shipped off-site are given. Depending on the size of individual shipments, various levels of daily traffic could result, and a range of possible daily shipment counts is presented in Table G2.

A more formal estimate of daily medical waste and other medical industry shipments would require clarification of data in several areas. First, the medical facility count would need to be updated. Second, because of changing EPA requirements regarding incineration of waste materials on site, amounts of medical waste shipped off-site would need reevaluation. Third, more complete information about shipping practices from these facilities is necessary. For example, it is not well understood at this time whether facilities tend to ship items on a weekly, daily, or even more frequent basis. Shipments of blood and urine samples, for example, might be sent from clinics to labs several times per day. In contrast, gloves, swabs, bandages, and other materials might be treated or at least accumulated and grouped for weekly shipment in small, medium, or large packagings. Without greater understanding of these distribution patterns, it is difficult to estimate the size of average shipments and, therefore, the number of shipments for a given tonnage of medical waste or other regulated medical industry materials.

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[5] While a single manifest generally represents a single shipment, consolidation of multiple shipments under a single manifest can occur and suggests a shipment-to-manifest ratio that would exceed 1.0. Similarly, some interlining (truck transfers) and truck-rail intermodal shipments occur within the industry. As a result, the number of waste hazmat *movements* is somewhat higher than the number of *shipments*. No attempt has been made to estimate a shipment-to-manifest or movement-to-shipment ratio, and factors of 1.0 are used for both measures.

Finally, because of the different jurisdictional roles of OSHA, EPA, and U.S. DOT, further clarification of which jurisdiction affects which types of products and product distribution phases is also warranted. Because of the current uncertainty about each of these items, the various shipment estimates provided in Table G2 have not been factored into this report's daily shipment, movement, or tonnage estimates.

Alternative SIC Codes. There are many products shipped daily in the United States which, while classified as hazardous materials, would be captured by survey data in SIC or STCC code groupings that are not typically hazmat groupings. For example, automotive batteries, which are regularly shipped to automotive plants, are normally captured in STCC 37: *Transportation Equipment*. [6] Other examples exist as well. Besides for waste hazmat (for which EPA manifest data suggest shipment counts), however, this report has not attempted to estimate shipment counts for these potentially numerous products that would be itemized in commodity groupings outside Chemicals & Allied (SIC 28) or Petroleum Products (SIC 29). If and when tallies of such products became readily available, they would be included in the estimate of daily shipments.

Excluded Items. There are also several hazmat traffic categories which have been excluded from the estimates compiled in this report, not merely because of difficulty in estimating the component totals, but because of certain qualitative differences in the nature of the traffic itself. Materials of trade (MOTs), for example, include such materials as those carried by plumbers, roofers, and lawn service personnel used in application of their trade services. The MOTs category also includes items such as spare batteries and emergency starter fluids used for operation of vehicles, and items such as self contained breathing devices for the health and safety of drivers. While having certain safety implications, these materials are not quite the same as packaged, boxed or truckload (for example) goods hauled as commercial freight. Similarly, company materials (COMAT) hauled by air carriers are generally used by the crew, aircraft personnel, or for the health of passengers. Unless transported as commercial freight, these items would more closely resemble materials of trade. Finally, chemical residues in the bottom of rail cargo tanks may have important safety implications, but in terms of tonnage, commercial value, etc. the materials are quite unlike commercial shipments of packaged, boxed, or containerized goods.

[6] A strong year for automotive sales (cars and trucks) sees more than 15 million vehicles sold in the U.S., or roughly 41,000 per day. All have batteries, many of which are shipped to assembly plants, rather than "consumed" on the plant site.

Appendix Table G1: WASTE HAZARDOUS MATERIALS -- a

Material Produced & Amounts Shipped	Annual	Daily	Shipment Size (tons)
WASTE FROM LARGE GENERATORS -- b			
TONS of hazardous wastes generated (1995 annual data).	214,000,000	586,301	
TONS shipped off site (implying 5% of tons generated is amount shipped off site).	10,700,000	29,315	
MANIFESTS: EPA figure, for shipments from approximately 21,575 "Large Generators."	884,575	2,423	
SHIPMENTS: Assumed equal to the number of manifests.	884,575	**2,423**	
AVERAGE SHIPMENT SIZE: @ 10,700,000 tons / 884,575 manifests			12.1
WASTE FROM OTHER GENERATORS			
TONS of Hazardous Wastes Generated	na	na	
TONS Shipped Off site.	na	na	
MANIFESTS: EPA figure, for shipments from estimated 192,820 other generators.	1,736,012	4,756	
SHIPMENTS: Assumed equal to the number of manifests.	1,736,012	**4,756**	
AVERAGE SHIPMENT SIZE: Avg. shipment size unavailable without tonnage figure.			na
TOTAL SHIPMENTS: annual figures of 884,575 + 1,736,012 = 2,620,587	2,620,587	**7,180**	
Estimating Shipment Size & Number of Manifests for Truck and Rail Modes			
Total Number of Large Generator Manifests:	884,575	2,423	
Total Large Generator Tonnage:	10,700,000	29,315	
If 1993 CFS data relationship holds, with 91% of tonnage truck, then truck tons =	9,737,000	26,677	
If 1993 CFS data relationship holds, with 9% of tonnage rail, then rail tons =	963,000	2,638	
If average rail shipment is 5 times truck, then average truck shipment (tons) =			11.23
If average rail shipment is 5 times truck, then average rail shipment (tons) =			56.13
If tonnage and shipment size relationships hold, then truck manifests, @ 98% total =	867,053	2,375	
If tonnage and shipment size relationships hold, then rail manifests, @ 2% total =	17,522	48	
If truck tonnage share, manifest share, and shipment size for remainder of traffic is same as for large generator traffic, then total truck manifests, @ 98% =	2,568,175	7,036	
and, total rail manifests, @ 2% =	52,412	144	

-- a Waste figures correspond to EPA definitions and are not necessarily the same as Bureau of Census (STCC 48) hazardous waste definitions.

-- b Tons generated and tons shipped off-site data are from the National Biennial RCRA Hazardous Waste Report, based on 1995 data. Manifest data are from EPA's Office of Solid Waste. Tonnage estimates for small and other generators not available. EPA Office of Solid Waste internal data differ slightly from the National Biennial RCRA Report. The Report indicates 20,497 large generators as shipping 10,700,000 tons off site, while the internal figures show an estimate of 884,575 manifests coming implicitly from 21,575 large generator shippers -- but without a specific tonnage figure. Large generator figures used in table above combine manifest figure with the 10.7 million tonnage figure.

ADDITIONAL NOTES: The 1993 CFS (p. 23) cites only 813,000 tons of "hazardous wastes" shipped that year, an amount equal to only about 5% of the 17,000,000 tons estimated by EPA as shipped off-site in 1993, and equal to about only 8% of the 10,700,000 tons shipped off-site in 1995. Cause of the large discrepancy is not clear. One possibility is that many CFS surveyed shippers listed their waste tonnage under other product categories.

The 1993 CFS data also indicate that about 91% of waste tonnage is carried by truck, with 9% carried by rail.

Average rail shipment is assumed by RSPA to be 5 times larger than average truck shipment.

Appendix Table G2: MEDICAL WASTES

TYPE OF WASTE GENERATING FACILITY	Number Of Facilities -- a		
Hospital Generating Facilities - - a			
Federal and Long-term Care Hospitals	6,201		
Non-hospital Generating Facilities - - b			
Private Physicians Offices	180,000		
Dentists Offices	98,400		
Veterinarians Offices	38,000		
Medical Clinics	15,500		
Long-term Care Facilities	12,700		
Labs	4,300		
Free Standing Blood Banks	900		
Subtotal, Non-hospital Generating Facilities	349,800		
Total Generating Facilities	**356,001**		
WASTE CATEGORY and TONS	**Annual Tons**	**Daily Tons**	**Daily Shipments**
Hospital Wastes@ 15 pounds/person/day -- b, c	2,434,550	6,670	
Amount Considered Infectious: @15% -- b	365,183	1,001	
Amount Potentially Transported: @7%-36% -- d	73,037	200	
Infectious Medical Wastes From Other, i.e., Non-Hospital, Facilities -- e	73,037	200	
Total "Infectious" Medical Wastes Transported	**146,073**	**400**	
If average shipment size is 1,000 lbs., daily shipments equal			**800**
If average shipment size is 500 lbs., daily shipments equal			**1,600**
If average shipment size is 200 lbs., daily shipments equal			**4,000**
If average shipment size is 10 lbs., daily shipments equal			**80,000**

-- a American Hospital Association, 1996 Survey of Hospitals.
-- b Society For Hospital Epidemiology Of America (SHEA) position paper, 1991. William A. Rutala, PhD, MPH; C.Glen Mayhall, MD. Based on 1987-88 data.
-- c Daily total of 6,670 tons provided; annual figures derived @ 365 days.
-- d The 7%-36% figure from SHEA; a 20% figure presently assumed by RSPA.
-- e Non-hospital level assumed equal to the hospital-generated figure.

NOTE: None of the daily shipment estimates in this table are used elsewhere in the report's totals, other than to suggest that the daily level is likely to be over 4,000 and that such a level would raise the "Other" category (Tables 1, 2 and elsewhere) to well over 10,000 shipments per day.

APPENDIX H
COMMODITY FLOW SURVEY (CFS) SHIPPER GROUPS

Appendix Table H1 lists the Bureau of Census establishment categories from which CFS shippers were sampled for survey purposes. This RSPA analysis and report captures the oil and gas extraction sector data through separate Department of Energy coverage of the petroleum products industry (relevant text and Tables B1-B6).

One important sector that has not been covered by the CFS and is briefly addressed in Appendix G of this report is the health care industry and the extent to which it generates medical wastes. The Census Bureau category that would otherwise cover the majority of these medical establishments is the "Most Retail & Services" sector listed in Table H1.

Routine operating activities of establishments in the *Construction* and *Transportation* sectors listed in Table H1 presumably also contribute to U.S. hazmat traffic flows. The CFS does not capture these establishments, however, and aside from the general discussion in Appendix G, "Alternative SIC Codes," data from these groups are not otherwise treated in this report.

Appendix Table H1: COMMODITY FLOW SURVEY SHIPPER GROUPS 1977 v. 1993

Shipper Groups (Establishments) *	1977		1993	
	Included	Excluded	Included	Excluded
Mining	x		x	
Manufacturing	x		x	
Wholesale	x		x	
Selected Retail	x		x	
Selected Service	x		x	
Auxiliary Establishments (e.g, warehouses)		x **	x	
Farms		x		x
Forestry		x		x
Fisheries		x		x
Oil & Gas Extraction		x		x
Governments		x		x
Construction		x		x
Transportation		x		x
Households		x		x
Foreign Establishments		x		x
Most Retail & Services		x		x

* Hospitals and other health facilities, which constitute a high-profile presence as medical waste generators, were excluded from both surveys.

** In the 1977 Commodity of Transportation Flow Survey, this establishment category was excluded. Because most petroleum products are shipped first from refineries and then reshipped from "regional terminals," or what would be categorized as warehouses, excluding this establishment group meant that Hazmat petroleum product shipments were greatly understated by the 1977 Survey.

SOURCE: 1993 Commodity Flow Survey, Bureau of The Census, page v.

APPENDIX I
DATA SOURCES

The following is a partial listing of data sources, reports, and other materials used to identify information and conduct the analysis contained in this report. The information is categorized by subject matter.

CHEMICALS and ALLIED PRODUCTS

1993 Commodity Flow Survey: United States, U.S. Department of Commerce, Bureau of the Census (Washington, D.C., November 1996).

U.S. Chemical Industry Statistical Handbook, 1996, Chemical Manufacturers Association (Arlington, VA, 1996).

GENERAL

Transportation of Hazardous Materials, Office of Technology Assessment (Congress of the United States, Washington, D.C., July 1986).

Transportation in America: 1995, Eno Foundation, (Landsdowne, VA, 1995).

HAZARDOUS WASTES:

A State Guide to the Uniform Hazardous Waste Manifest, National Governors' Association (Washington, D.C., 1991).

Environmental Protection Agency (EPA), Office of Solid Waste: Selected data and updates from "The National Biennial RCRA Hazardous Waste Report (Washington, D.C.)

Association of Waste Hazardous Materials Transporters (Alexandria, VA).

NUCLEAR MATERIALS

"Public Information Circular for Shipments of Irradiated Reactor Fuel," U.S. Nuclear Regulatory Commission (Washington, D.C., NUREG-0725, October 1997).

PETROLEUM PRODUCTS

Annual Energy Review 1996, U.S. Department of Energy, Energy Information Administration (Washington, D.C., July 1997).

Energy Information Administration, "Table 3: U.S. Daily Average Supply and Disposition of Crude Oil and Petroleum Products, 1996," as compiled from Monthly Reports EIA-810, 811, 812, 813, 814, 816, 817, 819M (Washington, D.C. 1997).

"1993 Residential Energy Consumption Survey," U.S. Department of Energy, Energy Information Administration/Residential and Commercial Branch (Washington, D.C.).

RAIL TRANSPORT OF HAZARDOUS MATERIALS

"Annual Report of Hazardous Materials Transported by Rail, Year 1995," Association of American Railroads (Washington, D.C., September 1996).

Hazardous Materials Flows By Rail, Beier, Hussey, and Zebe, U.S. Department of Transportation, Transportation Systems Center (Cambridge, MA, March 1990).

TRUCK TRANSPORT OF HAZARDOUS MATERIALS

Truck Transportation of Hazardous Materials, A National Overview, by Maio and Liu, U.S. Department of Transportation, Transportation Systems Center (Cambridge, MA, March 1988).

TRUCKING FLEET

"National Fleet Survey, 1996," Prepared by Star Mountain, Inc. for the U.S. Department of Transportation, Office of Motor Carriers, (Washington, D.C., March 1997).

Transportation Statistics Annual Report 1996, U.S. Department of Transportation, Bureau of Transportation Statistics (Washington, D.C., 1996).

Trucking Inventory and Use Survey (TIUS) United States, U.S. Department of Commerce, Bureau of the Census (Washington, D.C., May 1995).

APPENDIX J
OTHER RESEARCH

Following is a partial list of subjects where further research could prove beneficial.

1. HAZMAT TRUCKING FLEET. How well the TIUS figures indicate the size of the US hazmat fleet is unclear. The 1996/97 National Fleet Survey conducted by the Federal Highway Administration showed approximately 7% of the surveyed trucks as being placarded hazmat vehicles. If the 7% hazmat figure is representative of the nation's commercial fleet, and if the base number is actually 16 + million commercial vehicles, then a national hazmat fleet of 1.2 million vehicles, not 365,000, would be the more accurate estimate. These estimates should be reconciled.

2. NON-BULK DISTRIBUTION. The situation where a home heating oil (distillate) truck makes, for example, 5-20 deliveries throughout a single neighborhood or community has been discussed. Estimates of such data, including milk runs for propane and lubricants, are included in this report's *shipmen*t and *movement* figures for petroleum products. How pervasive this type of delivery is elsewhere within the hazmat industry, however, is still not well understood.

For petroleum products, for example, an assumed average delivery size of lubricants (case goods) has been provided in Appendix Tables B2 and B3. It is an assumption, however, based only on preliminary review of that market sector. RSPA is aware that thousands of retail outlets in the U.S., from 24 hour convenience stores to massive discount centers to one-pump rural gasoline stations have small inventories of motor oil (anti-freeze, and many other products) that were delivered by commercial delivery vehicles. We assume that the local convenience stores rarely receive more than a few cases of motor oil per delivery. At what point in the distribution chain the delivery amounts cease being classified as HAZMAT and instead are considered consumer quantities and what sizes the average non-bulk shipment amounts actually are represent two areas where further research could provide clarification.

3. MOVEMENTS PER SHIPMENT. As discussed in the report and in Appendix C, estimating movements per shipment is an area where more information may be needed if carefully refined estimates are desired.

4. RADIOACTIVE MATERIALS (RAM). Information on the fewer than 100 shipments per year of high level radioactive waste and spent nuclear fuel transported in the U.S. is both current and rather precise. In contrast, information on the many other, very small radioactive shipments, e.g. 1-2 pound radio-pharmaceutical shipments, is considerably less current and precise. Estimates for this report are based on 1985 levels. And while not unreasonable, the estimates for number of shipments and movements, as well as the respective mode shares for truck and air carrier, could be updated and improved with additional research.

5. MOTOR FUEL DISTRIBUTION. An estimated 80,000 shipments per day are attributed in this report to the distribution of gasoline and highway diesel fuel. This market sector, however, undergoes continuing logistical and technological change. As a result, fleet

utilization, reshipment patterns, and delivery sizes are being affected on an ongoing basis. Periodic review of Department of Energy distribution data, as well as review of industry practices, can contribute improved information in this area.

6. RESIDUE SHIPMENTS. Many trucks and rail cars, especially tank trucks and rail tank cars, return from their shipment destinations with small amounts of shipment residue. Depending upon the amount, these residues are actually regulated hazmat shipments. This report and the underlying data have not considered residue shipments as part of daily shipment or movement estimates. A closer look at the number of these shipments (movements) and whether they should be included in traditional estimates warrants consideration.

7 . MOTS AND COMAT. Materials of trade (MOTS) and company materials (COMAT) are both categories of potentially hazardous materials which fall outside the traditional regulatory definition of cargoes that are "in commerce." A 1995-96 RSPA regulatory evaluation supporting HM-200 indicated that there could be as many as 1 million vehicles per day carrying MOTS aboard small trucks, service vans, etc. Similarly, large numbers of both commercial and private aircraft carry small amounts of so-called company materials (COMAT) aboard flights every day. The size of the numbers is not insignificant, and further research in these areas may be warranted.