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Improvements in BTS Estimation of Ton-Miles

Scott M. Dennis

ABSTRACT

Ton-miles (one ton of freight shipped one mile) is the primary physical measure of freight transportation output. This paper describes improved measurements of ton-miles for air, truck, rail, water, and pipeline modes. Each modal measure contains a discussion of the data sources used and methodology employed, presents a comparison with other well-known measures for reference purposes, and discusses the limitations of the data used. The resulting measures provide more comprehensive and more reliable coverage of transportation activity than do existing measures, especially with respect to trucking and natural gas pipelines.

KEYWORDS: *Freight transportation measurement, ton-miles*

You can obtain a copy of the full text of this working paper in PDF format by contacting Scott.Dennis@BTS.gov, or by calling the BTS Information service at 1-800-853-1351, or by emailing your request to answers@BTS.gov.

The Bureau of Transportation Statistics (BTS) is considering improvements to some of its basic measures of transportation activity. This report describes proposed ton-mile measures for air, truck, rail, water, and pipeline modes. Each modal measure contains a discussion of the data sources used and methodology employed, presents a comparison with other well-known measures for reference purposes, and discusses the limitations of the data used. This report should be viewed as part of a continuing series of steps forward. Additional work will allow BTS to further improve its basic measures of transportation activity.

CONCEPT

Ton-miles is the primary physical measure of freight transportation output. A ton-mile is defined as one ton of freight shipped one mile, and therefore reflects both the volume shipped (tons) and the distance shipped (miles). Ton-miles provides the best single measure of the overall demand for freight transportation services, which in turn reflects the overall level of industrial activity in the economy. There does not presently appear to be any complete, reliable estimate of this basic transportation measure. In addition, a ton-mile measure is necessary in order to construct other measures of transportation system performance, such as energy efficiency and accident, injury, and fatality rates.

DATA SOURCES

Measures of domestic ton-miles (traffic within and between the 50 States, District of Columbia, Puerto Rico, and the United States Virgin Islands) were developed in order to maintain compatibility with other DOT Strategic Plan data. Ton-mile measures were estimated

on an annual basis in order to illustrate long-term trends. In order to provide comprehensive coverage, the ton-mile measures are a combination of reported data from established sources, estimates from surveys, and calculations based on certain assumptions. Table 1 provides a brief comparison of the scope of the improved BTS ton-mile measures with two other well-known measures: estimates currently published by BTS in *National Transportation Statistics* (NTS) [10], and estimates published by the Eno Transportation Foundation (Eno) [2]. Figure 1 presents the improved BTS ton-mile measures for all modes, as well as the other well-known ton-mile measures.

Air

Air freight ton-mile measures are presented in Figure 2. Annual air freight data were taken from *Air Carrier Traffic Statistics Monthly* [12], which presents the results of the T-100 reporting system, supplemented with special tabulations of data on domestic all-cargo operators from the Federal Aviation Administration (FAA).

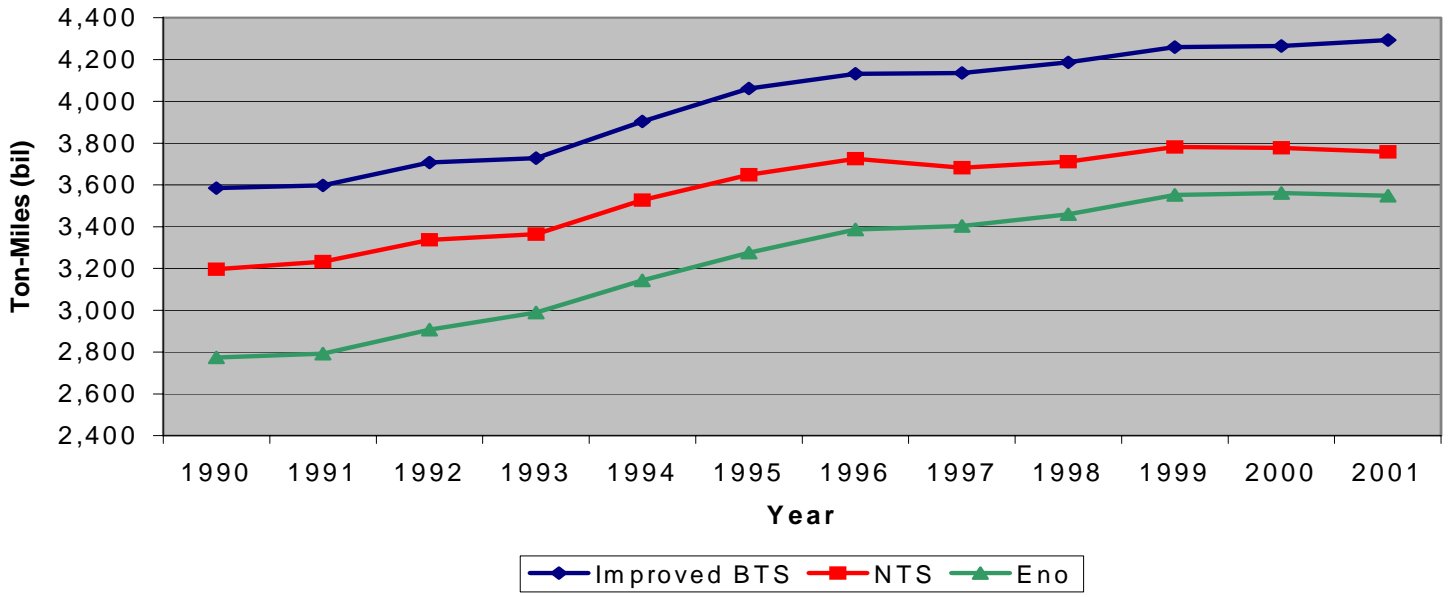
The T-100 data represent the population of all domestic freight traffic for Section 401 carriers, which operate planes with a passenger seating capacity of more than 60 seats, or a maximum payload capacity of more than 18,000 pounds. These data include the vast majority of all domestic air freight traffic. As a result of a BTS rulemaking, data for smaller carriers will be

TABLE 1**Comparison of Annual Data Coverage**

Mode	Improved BTS	NTS	Eno
Air	Section 401 carriers Section 418 carriers Excludes private carriage, some freight forwarders	Section 401 carriers Excludes Section 418 carriers Excludes private carriage, some freight forwarders	Section 401 carriers Section 418 carriers Excludes private carriage, some freight forwarders
Truck	Excludes household, retail, service, government, and certain non-commercial freight shipments	Excludes intracity traffic	Excludes intracity traffic
Railroad	All traffic	Excludes small railroads	All traffic
Water	All domestic traffic	All domestic traffic	Excludes coastal traffic (esp. AK, HI, PR)
Pipeline	Oil and oil products pipelines Natural gas pipelines Excludes chemical and coal slurry pipelines	Oil and oil products pipelines Excludes natural gas, chemical, and coal slurry pipelines	Oil and oil products pipelines Excludes natural gas, chemical, and coal slurry pipelines

FIGURE 1

All Ton-Miles



IMPROVED BTS TON-MILES
(Billions)

Mode	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Air	10	10	11	12	12	13	14	14	14	15	16	13
Truck	854	874	896	936	996	1,042	1,071	1,119	1,149	1,186	1,203	1,216
Railroad	1,064	1,042	1,098	1,135	1,221	1,317	1,377	1,391	1,448	1,504	1,546	1,599
Water	834	848	857	790	815	808	765	707	673	656	646	622
Coastwise	479	502	502	448	458	440	408	350	315	293	284	275
Lakewise	61	55	56	56	58	60	58	62	62	57	58	51
Internal	292	290	298	284	298	306	297	294	295	305	303	295
Intraport	1	1	1	1	1	1	1	1	1	1	1	1
Pipeline	822	824	844	856	860	882	905	905	902	899	853	843
Oil & Oil Products	584	579	589	593	591	601	619	617	620	618	577	576
Natural Gas	237	245	255	263	269	281	286	288	283	281	276	267
TOTAL	3,584	3,597	3,706	3,728	3,904	4,061	4,132	4,136	4,186	4,259	4,265	4,293

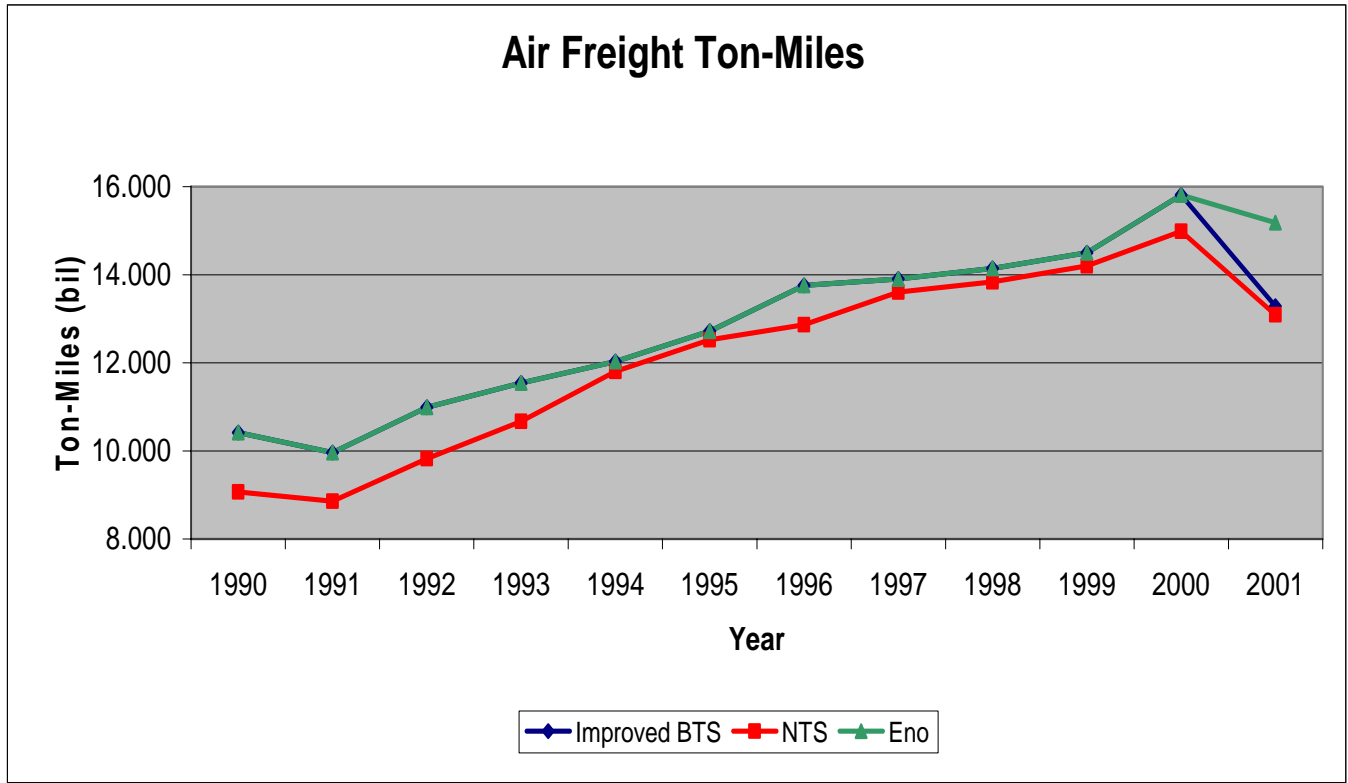
NTS TON-MILES
(Billions)

Mode	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Air	9	9	10	11	12	13	13	14	14	14	15	13
Intercity Truck	735	758	815	861	908	921	972	996	1,027	1,059	1,074	1,051
Class I Railroad	1,034	1,039	1,067	1,109	1,201	1,306	1,356	1,349	1,377	1,433	1,466	1,495
Water	834	848	857	790	815	808	765	707	673	656	646	622
Coastwise	479	502	502	448	458	440	408	350	315	293	284	275
Lakewise	61	55	56	56	58	60	58	62	62	57	58	51
Internal	292	290	298	284	298	306	297	294	295	305	303	295
Intraport	1	1	1	1	1	1	1	1	1	1	1	1
Pipeline	584	579	589	593	591	601	619	617	620	618	577	576
Oil Pipeline	584	579	589	593	591	601	619	617	620	618	577	576
Natural Gas Pipeline	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL	3,196	3,233	3,337	3,364	3,527	3,648	3,725	3,682	3,710	3,781	3,778	3,757

ENO TON-MILES
(Billions)

Mode	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Air	10	10	11	12	12	13	14	14	14	15	16	15
Intercity Truck	735	758	815	861	908	921	972	996	1,027	1,059	1,074	1,051
Railroad	1,091	1,100	1,138	1,183	1,275	1,375	1,426	1,421	1,442	1,499	1,534	1,558
Water	353	345	353	340	356	366	355	356	357	362	360	348
Rivers / Canals	292	290	298	284	298	306	297	294	295	305	303	297
Great Lakes Domestic	61	55	56	56	58	60	58	62	62	57	58	51
Pipeline	584	579	589	593	591	601	619	617	620	618	577	576
Oil Pipeline	584	579	589	593	591	601	619	617	620	618	577	576
Natural Gas Pipeline	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL	2,774	2,792	2,906	2,989	3,142	3,276	3,386	3,404	3,459	3,552	3,561	3,548

FIGURE 2



AIRLINE FREIGHT, EXPRESS, AND MAIL REVENUE TON-MILES
(Billions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Air (Improved BTS) ¹	10.420	9.960	10.990	11.540	12.030	12.720	13.760	13.900	14.140	14.500	15.810	13.288
Air (NTS) ²	9.064	8.860	9.820	10.675	11.803	12.520	12.861	13.601	13.840	14.202	14.983	13.088
Air (Eno) ³	10.420	9.960	10.990	11.540	12.030	12.720	13.760	13.900	14.140	14.500	15.810	15.180

Sources:

¹ BTS, Office of Airline Information, *Air Carrier Traffic Statistics Monthly*, p. 2; FAA supplementary statistics.

² BTS, *National Transportation Statistics*, 2003, Table 1-44.

³ Eno Transportation Foundation, *Transportation in America*, 2002, p. 42.

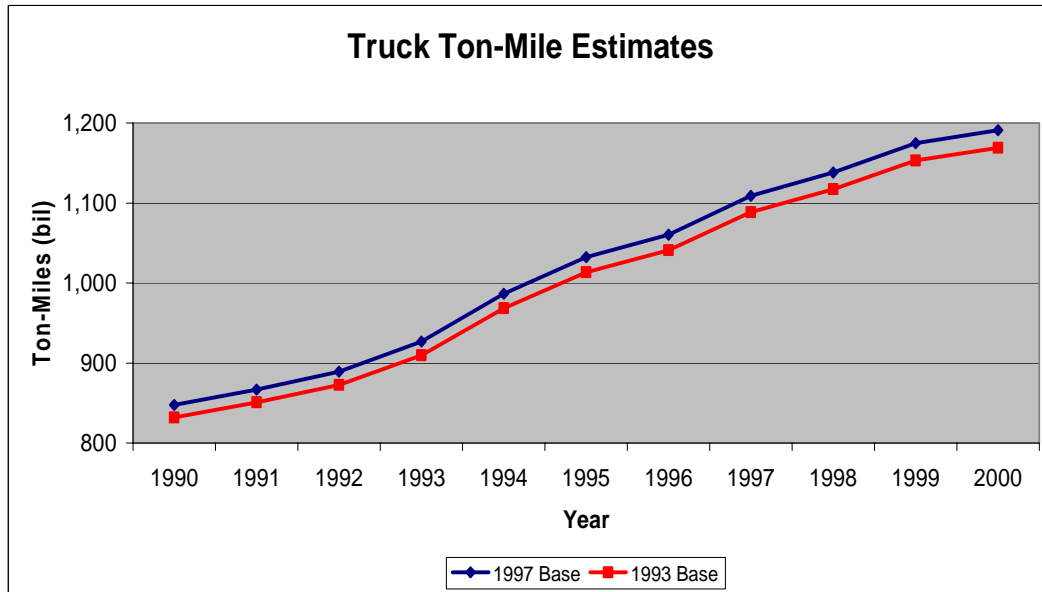
included in this source starting with the fourth quarter of 2003. The inclusion of smaller carriers is not expected to substantially affect the results. Domestic all-cargo operators (Section 418 carriers) have been gradually integrated into *Air Carrier Traffic Statistics Monthly*. The FAA data captured those carriers who had not yet reported in *Air Carrier Traffic Statistics Monthly*, thus allowing representation of the full population of domestic all-cargo operators.

The proposed measure of air-freight ton-miles is essentially the same as the Eno measure. Neither measure includes private carriage of air freight or air freight forwarders who do not use T-100 reporting carriers. These exceptions are likely to account for well under five percent of all air freight traffic. The substantial difference between the two data series in 2001 apparently is due to Eno's use of preliminary data.

Truck

Oak Ridge National Laboratory produced estimates of truck ton-miles based on the 1993 and 1997 Commodity Flow Survey (CFS) [13] and supplemented with data on farm-based shipments and imports arriving by truck from Canada and Mexico. The 1997 estimate of truck ton-miles is reported in *Transportation Statistics Annual Report* [11]. The 1993 and 1997 estimates were then updated and backdated using intercity and intracity vehicle miles traveled (VMT) for single unit and combination trucks as reported in *Highway Statistics* [14]. The resulting estimates are presented in Figure 3. The trend in both series is the same because the same VMT data were used to update both series. After making these adjustments for different time periods and population coverage, the difference between the 1993 and 1997 estimates is less than two percent.

FIGURE 3



DEVELOPMENT OF TRUCK TON-MILE ESTIMATES

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Oak Ridge National Lab Estimate (bil) ¹				909.614				1,109.000				
Single Unit Truck VMT (bil) ²	51.901	52.898	53.874	56.772	61.284	62.707	64.072	66.845	68.021	70.304	70.500	72.286
Combination Truck VMT (bil) ²	94.341	96.645	99.510	103.116	108.932	115.455	118.899	124.500	128.359	132.384	135.020	135.400
Total Truck VMT (bil)	146.242	149.543	153.384	159.888	170.216	178.162	182.971	191.345	196.380	202.688	205.520	207.686
Truck VMT Index, 1993 Base	0.915	0.935	0.959	1.000	1.065	1.114	1.144	1.197	1.228	1.268	1.285	1.299
Est. Truck Traffic, 1993 Base (bil ton-miles)	831.981	850.761	872.612	909.614	968.371	1,013.576	1,040.935	1,088.575	1,117.220	1,153.106	1,169.218	1,181.540
Truck VMT Index, 1997 Base	0.764	0.782	0.802	0.836	0.890	0.931	0.956	1.000	1.026	1.059	1.074	1.085
Est. Truck Traffic, 1997 Base (bil ton-miles)	847.591	866.723	888.985	926.681	986.540	1,032.594	1,060.466	1,109.000	1,138.182	1,174.742	1,191.156	1,203.709

Sources:

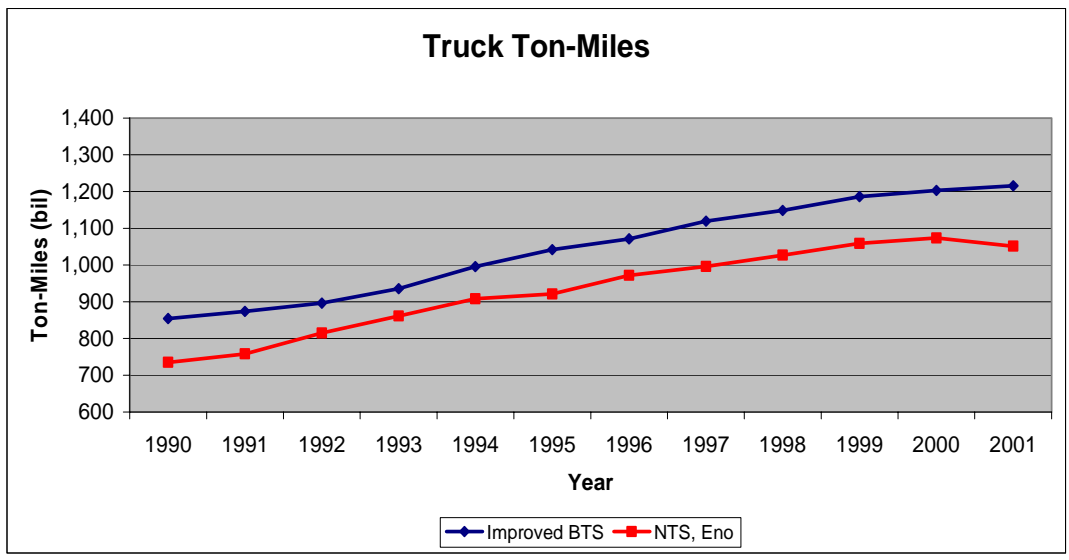
¹ BTS, *Transportation Statistics Annual Report*, 2000, p. 124.² FHWA, *Highway Statistics*, Table VM-1.

The CFS captures export movements, as well as movements of imports once they have reached their first domestic destination, such as a warehouse. In order to provide a more complete estimate of truck traffic, the data in Figure 3 were further adjusted to reflect truck ton-miles from maritime movements prior to reaching their first domestic destination. The number of loaded twenty foot equivalent unit containers (TEU's) shipped through U.S. ports is reported in *Maritime Trade and Transportation* [9]. These figures were then divided by 2.4 to convert to an equivalent number of 48 foot trucks. Estimates of the percentage of import traffic, truck share of import traffic, miles to first domestic destination, and tons per truck for east, gulf, and west coast ports were obtained through interviews with port personnel in New York, Houston, and Los Angeles respectively. The resulting estimates added between 7 and 12 billion truck ton-miles each year. This represents approximately one percent of all truck ton-miles currently estimated.

Trucking ton-mile estimates are presented in Figure 4. The improved BTS estimates are based on the Oak Ridge National Laboratory supplement to the 1997 study, which is the more recent of the two studies. The improved BTS measure is about 10 percent greater than the NTS and Eno measures, each of which reflect only intercity truck traffic. The improved BTS measure therefore provides a more comprehensive measure of truck traffic.

The CFS data used to construct the improved trucking ton-miles measure exclude shipments by households, retail, service, and government establishments (including U.S. Mail); and certain non-commercial freight shipments, such as municipal solid waste. The NTS and Eno measures do not include intracity traffic. It therefore appears that a significant percentage of truck VMT and a somewhat smaller percentage of truck ton-miles are not included in any of these measures. Clearly more work is needed in this area.

FIGURE 4



TRUCK TON-MILES
(Billions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Intercity Truck (NTS, Eno) ^{1,2}	735	758	815	861	908	921	972	996	1,027	1,059	1,074	1,051
ICC Truck	311	320	342	365	391	401	428	436	459	474	483	471
Non-ICC Truck	424	438	473	496	517	520	544	560	568	585	591	580
All Truck, 1997 base (Improved BTS)	854	874	896	936	996	1,042	1,071	1,119	1,149	1,186	1,203	1,216

Sources:

¹ BTS, *National Transportation Statistics*, 2003, Table 1-44.

² Eno Transportation Foundation, *Transportation in America*, 2002, p. 42.

Railroad

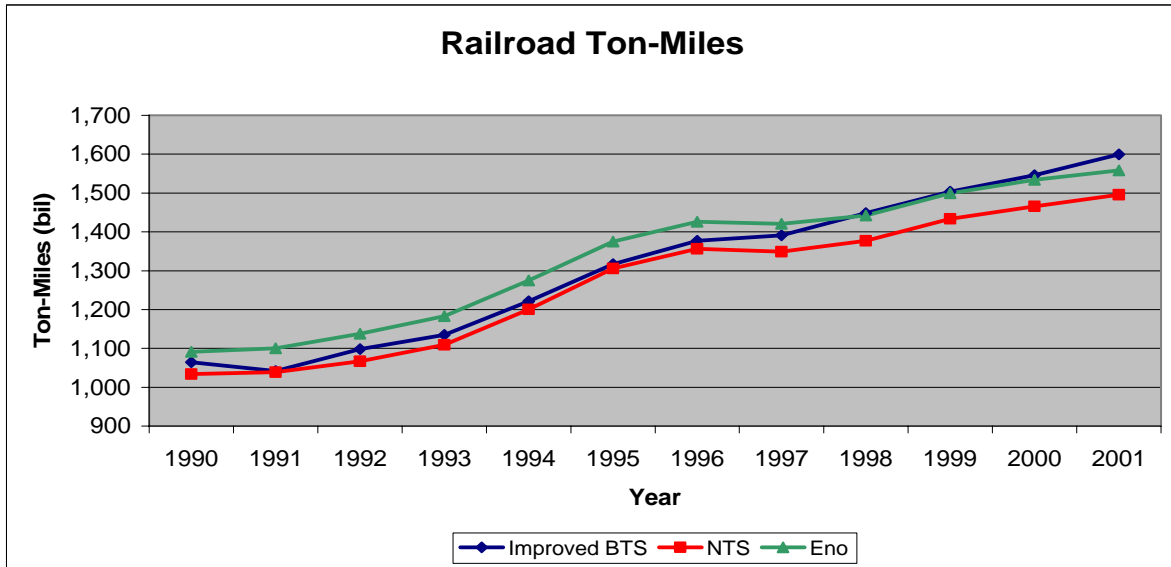
Annual railroad ton-miles were developed from the *Carload Waybill Sample* [15]. The population estimate in this source is based on a 500,000 record sample of all traffic terminating on all railroads in the United States. It is our understanding that the sample implicitly includes traffic originating on U.S. railroads and terminating on Mexican railroads, since almost all such traffic is rebilled to U.S. border crossings.

Population data on the tonnage of railroad shipments originating in the United States and terminating in Canada were obtained from *Transportation in Canada* [3]. The average length of haul for U.S. railroad shipments was applied to this tonnage to obtain an estimate of U.S. railroad ton-miles for shipments terminating in Canada. While much of this traffic originates in states bordering Canada, the amount of such traffic originating in more distant states such as California, Texas, and Georgia makes this a reasonable assumption.

Railroad ton-mile measures are presented in Figure 5. Over the last four years, the improved BTS estimates are about five percent greater than the NTS estimates, which include only Class I railroads; about one percent greater than the Waybill estimates, which do not include Canadian terminations; and almost identical to the Eno estimates, which include both non-Class I railroads and Canadian terminations. However, Eno's ton-mile estimates for non-Class I railroads are based on financial survey data. The improved BTS estimates are based on actual ton-mile data and should be considered more reliable.

Railroad ton-mile data may not include shipments which originate in Mexico and terminate in Canada. Based on data from Transport Canada, it appears that these shipments account for less than one tenth of one percent of all U.S. railroad traffic.

FIGURE 5



RAILROAD TON-MILES
(Billions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Waybill Ton-Miles, US Terminations ¹	1,055	1,033	1,089	1,124	1,208	1,303	1,362	1,374	1,433	1,490	1,530	1,581
US-Can. Term. (mil Metric Tons) ²	11.479	10.398	11.362	12.482	14.502	15.391	16.474	18.403	17.099	15.175	17.624	19.813
Convert to Short Tons (mil)	12.653	11.462	12.525	13.759	15.986	16.966	18.160	20.286	18.849	16.728	19.427	21.840
Average US Length of Haul ³	725.7	751.3	762.5	794.2	816.8	842.6	841.7	850.9	835.1	834.9	843.3	858.5
Ton-Miles, US-Can. Term. (bil)	9.18	8.61	9.55	10.93	13.06	14.30	15.28	17.26	15.74	13.97	16.38	18.75
Railroad Ton-Miles (Improved BTS)	1,064	1,042	1,098	1,135	1,221	1,317	1,377	1,391	1,448	1,504	1,546	1,599
Class I Ton-Miles (NTS) ⁴	1,034	1,039	1,067	1,109	1,201	1,306	1,356	1,349	1,377	1,433	1,466	1,495
Railroad Ton-Miles (Eno) ⁵	1,091	1,100	1,138	1,183	1,275	1,375	1,426	1,421	1,442	1,499	1,534	1,558

Sources:

- ¹ Surface Transportation Board, *Carload Waybill Sample*, various years.
- ² Transport Canada, *Transportation In Canada, Addendum*, 2002, Table A6-10.
- ³ AAR, *Railroad Facts*, various years, p. 36.
- ⁴ BTS, *National Transportation Statistics*, 2003, Table 1-44.
- ⁵ Eno Transportation Foundation, *Transportation in America*, 2002, p. 42.

Water

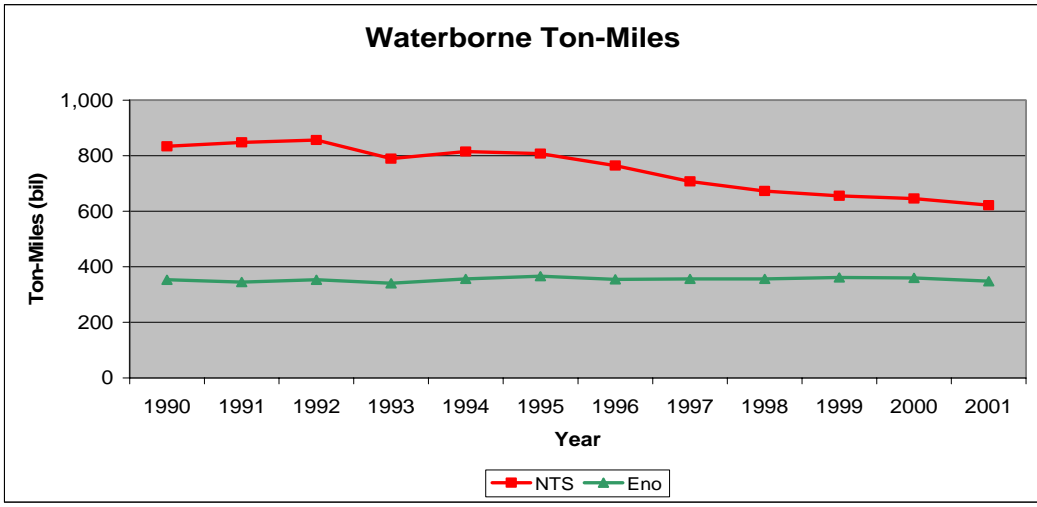
Domestic waterborne ton-mile measures are presented in Figure 6. Annual water transportation ton-miles were taken from *Waterborne Commerce of the United States* [4]. Data in this source are developed from lock data and individual trip reports which must be filed with the U.S. Coast Guard. This source therefore represents the entire population of all domestic water traffic, including inland waterways, coastwise, Great Lakes, and intraport traffic, along with traffic to and from Alaska, Hawaii, and Puerto Rico. The substantial difference between the NTS and Eno estimates reflects NTS's inclusion of coastwise (domestic ocean) traffic. The NTS measure, which is proposed for use here, is more comprehensive than Eno's estimate.

Pipeline

Pipeline ton-miles are presented in Figure 7. Annual oil and oil products pipeline ton-miles were obtained from *Shifts in Petroleum Transportation* [1]. These data represent the entire population of crude petroleum and petroleum products carried in domestic transportation by both Federally regulated and non-Federally regulated pipelines. Both NTS and Eno use this measure, which is also proposed for use here.

Natural gas pipeline ton-miles are also presented in Figure 7. The estimate of natural gas pipeline ton-miles is based on natural gas deliveries reported in *Annual Energy Review* [5]. The gas deliveries, measured in cubic feet, were converted first to metric tons and then to tons using a standard conversion factor of 48,700 cubic feet per metric ton reported in *International Energy Annual* [6]. There are no available data on length of haul for natural gas shipments, since natural gas is drawn from a common pipeline, rather than shipped to a specific consignee. Origination

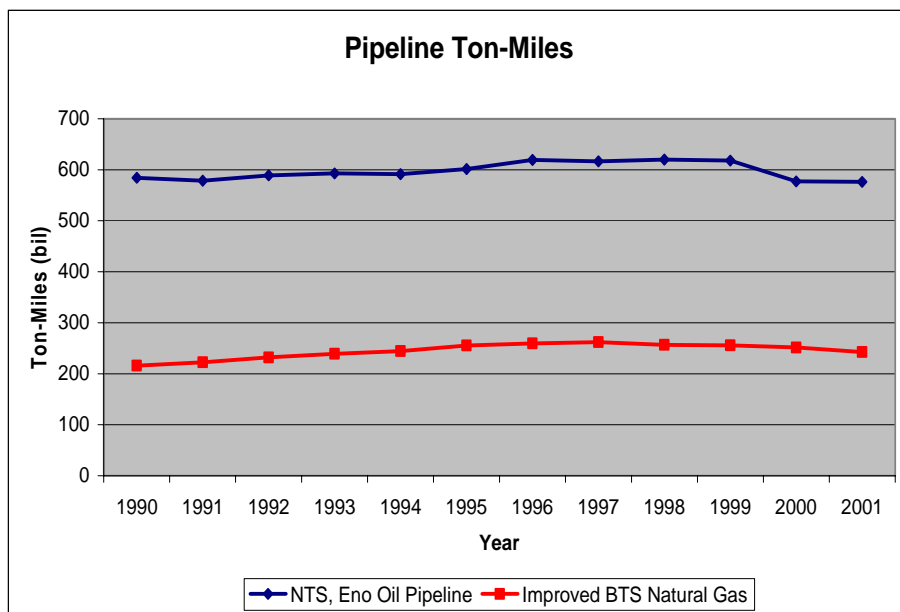
FIGURE 6



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water (NTS, Improved BTS)¹	834	848	857	790	815	808	765	707	673	656	646	622
Coastwise	479	502	502	448	458	440	408	350	315	293	284	275
Lakewise	61	55	56	56	58	60	58	62	62	57	58	51
Internal	292	290	298	284	298	306	297	294	295	305	303	295
Intraport	1	1	1	1	1	1	1	1	1	1	1	1
Water (Eno)²	353	345	353	340	356	366	355	356	357	362	360	348
Rivers / Canals	292	290	298	284	298	306	297	294	295	305	303	297
Great Lakes, Domestic	61	55	56	56	58	60	58	62	62	57	58	51

Sources:
¹ BTS, *National Transportation Statistics*, 2003, Table 1-44.
² Eno Transportation Foundation, *Transportation in America*, 2002, p. 42.

FIGURE 7



OIL AND OIL PRODUCTS PIPELINE TON-MILES
(Billions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Oil Pipeline (NTS, Improved BTS, Eno) ^{1,2}	584	579	589	593	591	601	619	617	620	618	577	576

NATURAL GAS PIPELINE TON-MILES
(Billions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total Consumption, cuFt (tril) ³	19.16	19.56	20.23	20.79	21.25	22.21	22.61	22.74	22.24	22.40	23.46	22.64
Lease and Plant Fuel ³	1.24	1.13	1.17	1.17	1.12	1.22	1.25	1.20	1.17	1.08	1.13	1.16
Pipeline Fuel ³	0.66	0.60	0.59	0.62	0.69	0.70	0.71	0.75	0.64	0.65	0.64	0.61
Gas to Consumers, cuFt (tril)	17.26	17.83	18.47	19.00	19.44	20.29	20.65	20.79	20.43	20.67	21.69	20.87
Gas to Consumers, Tons (bil) ⁴	0.391	0.404	0.418	0.430	0.440	0.459	0.467	0.471	0.462	0.468	0.491	0.472
Oil Pipeline Ton-Miles ¹	584	579	589	593	591	601	619	617	620	618	577	576
Oil Pipeline Tons ²	1.057	1.048	1.061	1.067	1.064	1.081	1.114	1.108	1.116	1.131	1.127	1.123
Length of Haul	553	552	555	556	556	556	556	556	555	546	512	513
Gas Transmission Pipeline Ton-Miles (bil)	216	223	232	239	245	255	260	262	257	256	251	242
Gas Gathering Pipeline Ton-Miles (est.) (bil) ⁵	11	11	12	12	12	13	13	13	13	13	13	12
Gas Distribution Pipeline Ton-Miles (est.) (bil) ⁵	11	11	12	12	12	13	13	13	13	13	13	12
Total Gas Pipeline Ton-Miles (bil) (Improved BTS)	237	245	255	263	269	281	286	288	283	281	276	267

Sources:

¹ BTS, *National Transportation Statistics*, 2003, Table 1-44.² Eno Transportation Foundation, *Transportation in America*, 2002, p. 42.³ USDOE, EIA, *Annual Energy Review*, 2001, Table 6.5.⁴ Conversion factor from USDOE, EIA, *International Energy Annual*, 2001, Table C1.⁵ Estimated at five percent of transmission ton-miles.

and termination data from the U.S. Department of Energy, Energy Information Administration [7, 8] indicate that natural gas has a distribution pattern similar to oil and oil products.

Therefore, the length of haul for oil and oil products was applied to the tonnage of natural gas to estimate natural gas ton-miles in transmission lines. Natural gas ton-miles in distribution lines (i.e., local utilities) were estimated using five percent of transmission length of haul, which is approximately half the diameter of a major metropolitan area. Natural gas ton-miles in gathering lines (i.e., from well to processing plant) were estimated using the same length of haul as in distribution lines. The ton-miles for gathering, transmission, and distribution lines were then summed to provide an estimate of total natural gas ton-miles. Natural gas ton-miles, which have not to our knowledge been previously estimated, represent nearly as much traffic as carried on the inland waterway system. These new estimates fill a substantial gap in the existing ton-mile data.

The natural gas pipeline data do not include gas used to repressurize gas fields or power the pipeline itself, since these uses do not represent gas carried in revenue transportation. The pipeline data also exclude coal slurry, ammonia, and other types of pipelines. There are only a few such pipelines, which tend to have either short haul or low volume, and appear to account for well under one percent of all pipeline ton-miles.

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