SmartWay®
Transport Partnership
U.S. Environmental Protection Agency

2018 SmartWay Shipper Partner Tool: Technical Documentation

U.S. Version 2.0.17 (Data Year 2017)



EPA United States Environmental Protection Agency

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Transportation and Climate Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

EPA United States Environmental Protection Agency

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1.0 Overview

The SmartWay Shipper Tool is intended to help shippers estimate and assess their carbon, PM, and NOx emissions associated with goods movement in the U.S. freight trucking, rail, air and barge sectors[1]. Shippers can track their freight-related emissions performance from year-to-year using the Tool and assess a range of strategies to improve the emissions performance of their freight operations, including selection of low-emissions carriers and implementation of operational strategies such as (but not limited to) packaging improvements, load optimization and logistical improvements.

The SmartWay truck, barge, air, logistics and multimodal carrier emissions performance data that EPA has included in the Tool, along with industry average Class I rail CO_2 data, will allow shippers to generate accurate emissions inventories. The data will also help shippers optimize their emissions performance by allowing them to better estimate the emissions impact of individual carriers, modal shifts, and operational strategies.

2.0 Tool Inputs and Calculations

After shippers enter their company and contact information, they provide basic information about each company they operate, including the name and NAICS code for each of these companies. For these individual companies to show up on the SmartWay Partner list on the EPA website, shippers should submit separate Shipper Tools, one for each company.

For each company, shippers need to indicate their participation level. If they have annual mileage-related activity data by carrier (miles or ton-miles), they should select Way 3 or Way 4, and proceed to input activity data for each carrier. Otherwise, they must select the Way 2 option, which only requires them to report the portion of goods they move with SmartWay carrier partners based on money spent, weight shipped, packages shipped, or another custom metric.

If shippers select the Way 2 option, they will not be eligible for a SmartWay Excellence Award, nor will they be able to calculate an emissions inventory or develop emissions performance metrics (e.g. g/mile or g/ton-mile) for their freight operations.[2] All shippers – regardless of participation level – will be able to see the SmartWay Category-level emissions performance data for their truck, logistics and multimodal carriers as well as available industry average rail emissions factors. Emissions performance data for barge and air carriers are reported on a carrier-specific basis.

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[1] Future versions of the tool will help Shippers evaluate the emissions performance associated with ocean going vessels.

[2] Shipper partners are encouraged to select the Way 3 or 4Way 3 or 4 reporting option for all their companies whenever possible. When a shipper has multiple companies the participation level chosen for the % SmartWay Value calculation must be the same for all companies in order for the Tool to calculate a Partner level % SmartWay Value (Way 2).

After identifying and selecting all of their SmartWay and non-SmartWay carriers, Way 4 shippers can then identify each carrier that they use for each company and the service that the carrier provides (e.g., Inbound or Outbound hauls, International and/or Domestic service, etc.). These optional parameters serve as "tags" which allows shippers to filter their emission data as desired using the screen tools discussed below.

Emission Inventory and Performance Metric Calculations

If shippers choose the Way 3 or 4 option, the Tool will calculate their total mass emissions (i.e., an emissions inventory) based on the mileage-related activity data entered for each carrier, as well as various emission performance metrics (e.g., grams/mile and grams/ton-mile – see below).

Carrier-specific emissions are first calculated either on a ton-mile basis (as ton miles x grams per ton-mile), or on a miles basis (miles x grams per mile), depending on the category as shown in Table 1.[3] Any modes/categories not listed have a limited data availability and their emissions are calculated using ton-miles.

Table 1. Emissions Calculation Basis by SmartWay Category

SmartWay Category	Activity Basis	D_{tm}	D_m
Refrigerated	Ton-miles	1	0
Mixed	Ton-miles	1	0
TL/Dry Van	Ton-miles	1	0
Flatbed	Miles	0	1
Moving	Miles	0	1
Dray	Miles	0	1
Non-SW Truck General	Ton-Miles	1	0
Specialized	Miles	0	1
Expedited	Miles	0	1
Auto	Miles	0	1
Tanker	Miles	0	1
Heavy/Bulk	Miles	0	1

The Shipper partner's mass emissions are calculated by summing the individual carrier emissions. Then, fleet average emission factors are calculated by dividing mass emissions by total ton-miles and total miles to obtain grams per ton-mile and grams per mile, respectively. The fleet average payload is calculated by dividing total ton-miles by total miles.

Overall, carrier emissions are calculated using the following equations, where D_{tm} and D_m are dummy variables with values of either 0 or 1, as shown in Table 1 above.

[3] Note that the Tool doesn't need shippers to enter a payload or ton-mile estimate for SmartWay Categories whose emissions are based on miles, as the payload estimate will not affect the overall emissions footprint. However, the calculated emission factors and average payload estimate are affected by the assigned payload.

$$E_c = D_{tm} * TonMiles * gtm + D_m * Miles * gm$$

Total emissions:

$$E_{tot} = \sum_c E_c$$

Emission factors and average payload (APL):

$$gtm = \frac{E_{tot}}{\sum_c TonMiles_c}$$

$$gm = \frac{E_{tot}}{\sum_c Miles_c}$$

$$APL = \frac{\sum_c TonMiles_c}{\sum_c Miles_c}$$

The emissions inventory for each carrier/mode combination displayed on the **Emissions Summary, Carrier Performance** and **SmartWay Category Details** screens is calculated using the equations show above. To calculate composite emissions and associated performance metrics on the **Carrier Performance** screens (i.e., overall g/mile and g/ton-mile performance), the Tool weights simply sums the emissions, miles and ton-miles for the associated group ((e.g. all Inbound carriers) and divides the total emissions by total miles and ton-miles as appropriate.

Ton-Mile Calculation

Correctly calculating Ton-Miles is critically important for the accurate determination of your carbon footprint. You can calculate your company's ton-miles as follows.

Determine the ton-miles hauled per year attributable to each carrier. A ton-mile is one ton moving one mile. DO NOT ESTIMATE TON-MILES BY SIMPLY MULTIPLYING TOTAL MILES BY TOTAL TONS - this calculation effectively assumes your entire tonnage is transported on EACH AND EVERY shipment, and will clearly overstate your ton-miles.

Many companies track their ton-miles and can report them directly without further calculation. For example, shipper company systems are often set up to associate a payload with the mileage traveled on each trip by carrier, and are then summed at the end of the year. If such information is not available, there are two ways to calculate ton-miles:

1) Companies can determine their average payload per carrier, multiply the average payload by the total miles per carrier, and sum the results for all carriers for the

reporting year; or

2) Set ton-miles per carrier = $\frac{\text{(total miles per carrier x total tons per carrier)}}{\text{total \# of trips per carrier}}$

NOTE: In both ton-mile calculations, empty miles are not factored in while the fuel used to drive those empty miles is factored in.

To check your estimate, divide ton-miles by miles. The result is your fleet-average payload. If this number is not reasonable, (e.g., typically between 15 and 25 tons for Class 8b trucks), please check your data.

Carrier Emissions Performance Data

The current SmartWay program provides CO_2, NOx and PM gram per mile, and gram per ton-mile emission factors for truck, rail, multimodal, logistics, air and barge freight transport providers. These data are provided in the SmartWayCarrierData2017ST.xls file, which is downloaded to the user's computer using the button on the Tool's Home screen.

It is envisioned that SmartWay will incorporate emission factors ocean-going vessel transport providers in the future.

Truck Carrier Performance

Truck carrier performance data utilized by the current Shipper Tool is based on 2018 Truck Partner Tool submittals for activity in 2017. Performance data includes g/mile and g/ton-mile for each truck carrier. Note that g/mile and g/ton-mile values represent midpoints for the appropriate SmartWay Category, rather than exact performance levels for a given carrier. Truck SmartWay Categories include:

- TL Dry Van
- LTL Dry Van
- Refrigerated
- Flatbed
- Tanker
- Dray
- Package
- Auto Carrier
- Expedited
- Heavy/Bulk
- Moving
- Specialized
- Mixed

The following provides an overview of the process used to estimate the carrier-specific performance ranges.

Truck Performance Categories

In the 2018 SmartWay Truck Tool, data is collected at the individual company fleet level. Fleets are characterized by a) business type: for-hire or private, b) operational

type: truckload/expedited, less than truckload, dray, expedited, or package delivery, and c) equipment type: dry van, refrigerated van, flatbed, tanker, chassis (container), heavy/bulk, auto carrier, moving, or specialized (e.g., hopper, livestock, others.)

The possible categories are shown below.

For-Hire									
	Dry Van	Reefer	Flatbed	Tanker	Chassis	Heavy/Bulk	Auto Carrier	Moving	Specialized
TL									
LTL									
Dray									
Expedited									
Package									
Private									
	Dry Van	Reefer	Flatbed	Tanker	Chassis	Heavy/Bulk	Auto Carrier	Moving	Specialized
TL									
LTL									
Dray									
Expedited									
Package									

Note that while Specialized fleets have disparate operations/equipment types and thus do not compare well, they are also unlikely to compete with one another, so it was deemed acceptable to aggregate these disparate fleets into one category.

For-hire and private fleets are combined in the SmartWay Categories. There are relatively few private fleets compared to for-hire fleets. Because owners of private fleets generally hire their own fleets exclusively, it was determined that grouping for-hire and private fleets together would not be detrimental to for-hire fleets, and the simplicity of one for-hire and private category outweighed the benefits of listing fleets separately. Grouping for-hire and private separately would have doubled the number of SmartWay Categories. Therefore, fleets can thus be categorized as shown below.

For-Hire and Private									
	Dry Van	Reefer	Flatbed	Tanker	Chassis	Heavy/Bulk	Auto Carrier	Moving	Specialized
TL									
LTL									
Dray									
Expedited									
Package									

To be categorized in a particular category, a fleet must have at least 75% of its mileage in a single category, otherwise it is classified as a “Mixed” fleet. Fleets may be mixed via their operational or equipment type. Fleets are generally segregated by their operational type, but some mixing does occur via equipment type, especially with smaller carriers that do not differentiate their fleet. Fleets that do not have 75% of their operations in a specific SmartWay Category are placed in the Mixed category.

Individual fleets were then placed into SmartWay Categories. The following shows the relative number of fleets for the various category intersections, with darker shadings indicating more fleets.

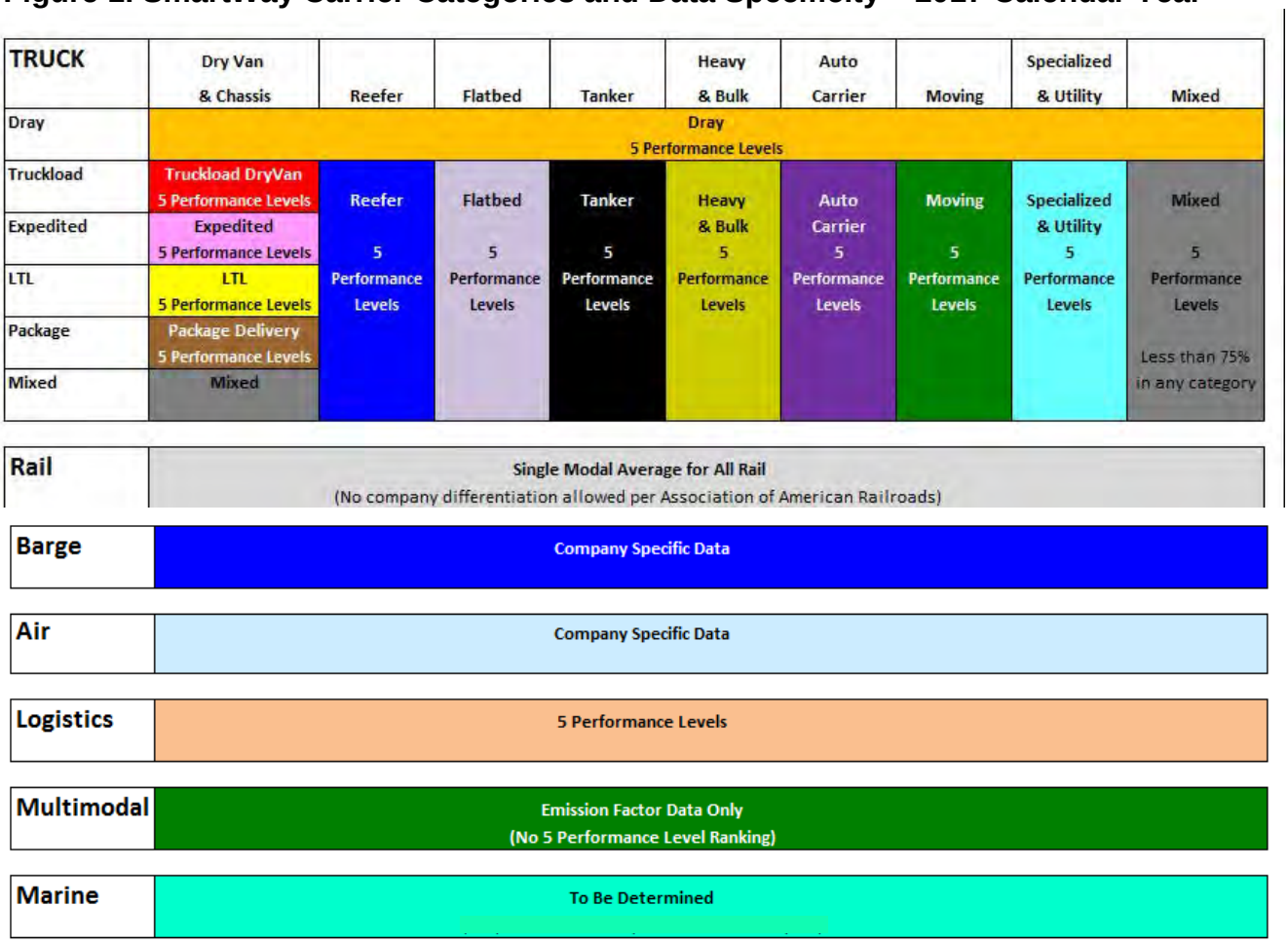
	Dry Van	Reefer	Flatbed	Tanker	Chassis	Heavy/Bulk	Auto Carrier	Moving	Specialized	Mixed
TL										
LTL				-	-	-			-	
Dray			-	-		-	-	-		
Expedited		-	-	-	-		-	-	-	
Package		-	-	-	-	-	-			-
Mixed				-		-		-	-	-

SmartWay then considered combining categories with similar characteristics for simplification purposes. One prerequisite was that there needed to be a minimum number of fleets in each category. SmartWay determined that a category needed a minimum of 25 fleets to be created. It was also determined that dry van and chassis (i.e. intermodal container) groups functioned primarily as dry van transport, so these categories were combined. While most refrigerated carriers were truckload, a few less than truckload refrigerated fleets exist, so these categories were combined. Although no expedited or package refrigerated fleets were identified, these categories were also combined into one overall refrigerated category so that no operation and equipment type intersections would be left undefined. A similar situation was identified with flatbed, tanker, heavy/bulk, auto carrier, moving, and specialized fleets. All dray fleets were collapsed into one category. Any fleet that had mixed operation and/or mixed equipment was placed into a single mixed category. Finally, logistics and multimodal fleets were also included and retained as unique categories.

The final performance categories for 2017 are illustrated below. The solid colors indicate how operation and equipment type assignments vary by performance category. For example, if 75% or more of a fleet’s mileage is associated with reefer trucks, the fleet is assigned to the Reefer category *regardless* of the operation percentage across truckload, expedited, LTL, and package categories. However, the Reefer category assignment is overridden if the operation category is greater than or equal to 75% dray, logistics, or multimodal. Similar assignment rules apply to flatbed, tanker, heavy/bulk, auto carrier, moving, and specialized equipment types. Only the Dry Van/Chassis equipment category is subdivided by the truckload, expedited, LTL, and package operation categories, meaning that the 75% threshold must be met for *both* equipment

and operation type in these cases. All other equipment/operation type percentage distributions are assigned to the Mixed category.

Figure 1. SmartWay Carrier Categories and Data Specificity – 2017 Calendar Year



It is possible that SmartWay will expand these categories in the future based on in-use experience or as a result of further data analysis, and/or requests from industry.

Fleets *within a SmartWay Category* have been ranked from lowest emission factor (best) to highest emission factor (worst) for each of the following metrics: CO_2 g/mile, CO_2 g/ton-mile, NOx g/mile, NOx g/ton-mile, PM_{10} g/mile and PM_{10} g/ton-mile. When SmartWay Categories are first established, fleets within a category are separated into 5 ranges such that an equal number of fleets were in each range. Each range thus represents a group of emission factors. These ranges, and associated ranking "cutpoints" (transition points from one rank to the next) were then modified so that each range had an equal difference between upper and lower bounds, and the new cutpoints remained as close to the originals as possible. The new range cutpoints are displayed as numbers with significant digits appropriate to emission factors in that range. The midpoint of the range is used as the emission factor for all fleets in that range.

It would be simpler and more straightforward to use fleet-specific emission factors, however the trucking industry expressed concern that revealing exact data could be used to back-calculate mile per gallon numbers. The above described methodology prevents a determination of an exact mpg figure, while at the same time attributing an emission factor much more precisely than a modal default number. Given the large number of trucking fleets, and thus opportunity for fleets to be very close to each other in performance, SmartWay believes it is acceptable and appropriate to break truck fleets into 5 performance ranges for each SmartWay Category.

The table below illustrates the ranges in the For Hire/Private Truckload/Expedited Dry Van SmartWay Category, using 2013 Truck Partner data as an example.

Table 2. Emission Factor Ranges for One Performance Category (2013 Data)

For-Hire/Private Truckload/ Dry Van CO_2 g/mile						
Group ID	**Fleets Per Bin**	**Grams Per Mile Min**	**Grams Per Mile Max**	**Grams Per Mile Avg**	**Grams Per Mile Midpoint**	**Grams Per Mile Std Dev**
1	186	944	1,549	1,452	1,500	118
2	227	1,551	1,650	1,601	1,600	28
3	194	1,651	1,749	1,692	1,700	29
4	140	1,751	1,848	1,798	1,800	29
5	115	1,851	5,090	2,010	1,900	359

Similar tables have been developed for all performance SmartWay Categories. The midpoint of each performance range is the data that a shipper downloads into their SmartWay Shipper Tool to represent the emission performance of a specific fleet that is in the associated range. Once the categories and ranges have been established, the fleets of any new companies joining SmartWay will fall into one of the predefined categories/ranges. SmartWay expects to update the category/range structure periodically.

Performance estimates for non-SmartWay truck carriers were calculated based on the lowest performing truck partners. Since no data exists to define non-SmartWay fleets, SmartWay believes the prudent approach is to assign conservative emission factors to non-SmartWay companies. Also, this policy makes it likely that any company joining SmartWay will see better emission factors displayed than the non-SmartWay default emission factors.

The non-SmartWay performance metrics were calculated by taking a standard performance range delta (max - min) for each range within each SmartWay Category, and using the delta to calculate a non-SmartWay carrier midpoint for each category. This midpoint was the midpoint for Range 5 plus the standard range delta. For example, if the Range 5 midpoint was 10.5 and the category's standard delta was 1, then the non-SmartWay midpoint was calculated to be 11.5. Once the non-SmartWay midpoints for each pollutant were calculated for all SmartWay Categories, the non-SmartWay

performance metric was calculated by using the average value of these mid-points, weighted by the number of fleets in each category. This approach does not require the shipper to identify the appropriate SmartWay Category for their non-SmartWay carrier(s), which they may not know, while still ensuring that the performance of their non-SmartWay carriers reflects the distribution of the different categories within the truck population.

As discussed in the **Shipper Tool Quick Start Guide**, depending upon the type of data available for a given carrier, the user may input ton-miles or miles, and rely on carrier data to back-calculate the other value. For example, providing ton-miles and average payload allows the Tool to estimate total miles, by dividing the former by the latter.

Logistics and Multimodal Carrier Performance

Logistic and multimodal carriers have their own performance bins based on the carrier tool submittals for the most recent available calendar year (2015 for logistics, and 2016 for multimodal). Multimodal carrier categories are also differentiated by mode combinations, including Surface;[4] Surface-Air; Surface-Marine; and Surface-Air-Marine. Multimodal composite fleets with 10% or more of their ton-miles coming from air or marine carriers are designated Surface-Air/Marine.[5] If a composite fleet does not meet the above Multimodal criteria, and if it has 75% of its ton-miles derived from one or more Logistics component fleets, it is binned as a Logistics fleet. If a composite fleet does not meet any of these criteria, it is binned as a Truck fleet.

Non-SmartWay carrier performance for the SmartWay Categories is estimated in the same way as is done for non-SmartWay Truck carriers (i.e., averaging the bin midpoints to calculate a fleet average value).

Air and Barge Carrier Performance

Barge carriers have agreed to have their actual emissions results made public, and barge performance values used in the Shipper Tool are carrier-specific. The gram per mile performance values for barge carriers correspond to individual barge (nautical) miles travelled, rather than miles travelled by a string of barges or the associated tug(s).

Non-SmartWay barge carrier gram per mile and gram per ton-mile performance is set to be 25% higher than the worst performing SmartWay barge carrier.

Since no air carrier data submittals have been approved as of this date, performance levels for non-SmartWay air freight are based on publicly available data. First upper bound estimates for grams of CO_2 per ton-mile were obtained for short and long-haul air

[4] Surface multimodal carriers utilize road and rail modes.
[5] Air and/or marine carriers may be utilized directly by the multimodal carrier, or may be utilized indirectly by logistics business units hired by the multimodal carrier.

freight (~4,236 g/t-mi and ~1,461 g/t-mi, respectively).[6,7] Values for CO_2 g/mile were calculated by multiplying the g/t-mi value by an average cargo payload value of 22.9 short tons. The average payload value was estimated by dividing total air freight tonnage in 2012 (15M tons)[8] by the total number of cargo departures in the same year (654,956 LTOs).[9] Corresponding performance metrics for NOx and PM_{10} were based on the ratio of these pollutants to CO_2 from the EDMS 5.1.4.1 model (0.009 for NOx and 0.000059 for PM_{10}).[10] The resulting performance metrics are shown in Table 3. An average cargo volume estimate was also obtained for inclusion in the SmartWay carrier data file based on the volume for a typical freight aircraft, the Boeing 747 200 series (5,123 cubic feet).[11]

Table 3. Assumed Performance Metrics for Non-SmartWay Air Carriers

	CO_2/tmi	CO_2/mi	NOx/mi	NOx/tmi	PM/mi	PM/tmi
Short-haul	4,236	96,998	873.2713	38.1341	5.743247	0.250797
Long-haul	1,461	33,448	301.1280	13.1497	1.980430	0.086482

Rail Carrier Performance

Rail carrier performance data are collected and displayed in the Shipper Tool at the industry average level derived from Class 1 rail company data. Gram per ton-mile factors were determined by dividing total fuel use by total ton-miles and multiplied by a rail diesel CO_2 factor (10,180 g CO_2/gal diesel fuel), from publicly available data submitted in the 2017 railroad R-1 reports to the Department of Transportation. 2017 R-1 data was also used to obtain total railcar-miles per year for all Class 1 carriers, in order to estimate gram per railcar-mile factors. *Industry average values are currently assumed for all rail carriers in the carrier data file, regardless of SmartWay Partnership status.* Specific rail companies may have the opportunity to provide company-specific

[6] Short haul air freight assumed to be less than 3,000 miles, covering most domestic air routes in the U.S.
[7] Estimates from Figure 8.6 in Sims R., R. Schaeffer, F. Creutzig, X. Cruz-Núñez, M. D'Agosto, D. Dimitriu, M. J. Figueroa Meza, L. Fulton, S. Kobayashi, O. Lah, A. McKinnon, P. Newman, M. Ouyang, J. J. Schauer, D. Sperling, and G. Tiwari, 2014: Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[8] U.S. DOT Bureau of Transportaion Statistics, Fregiht Facts and Figures 2013, http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/13factsfigures/pdfs/fff2013_highres.pdf (accessed 8-22-18).
[9] U.S. DOT, Bureau of Transportation Statistics, U.S. Air Carrier Traffic Statistics, https://www.transtats.bts.gov/TRAFFIC/ (accessed 8-22-18:).
[10] EDMS outputs for take-off mode, assumed to be equal to cruising mode. (Cruise emissions are not output by EDMS). Take-off mode emission rates were averaged across all aircraft/engine combinations in the Heavy (Max Takeoff Weight over 255,000 lbs) and Large (Max Takeoff Weight 41,001 to 255,000 lbs.) weight classes.
[11] Aircraft Cargo Plane Specifications, http://www.airgroup.com/standalone.php?action=air_spec (accessed 8-22-18).

data in the future. The R-1 data and corresponding CO_2 performance data are presented in Table 4 below.

Table 4. Rail Carrier Performance Metric Calculation Inputs & Results (2017 R-1 Data)

Rail Company	Gal/Yr ('000) Sch. 750 Line 4	Freight Ton-Mi/Yr ('000) Sch. 755 line 110	Railcar-Mi/Yr ('000) Sch. 755 sum of lines 30, 46, 64 & 82	g CO_2/railcar-mile	g CO_2/short ton-mile
BNSF Railway	1,353,897	665,948,516	11,606,520	1,187	20.70
CSX Transportation	426,721	208,127,221	4,713,411	922	20.87
Grand Trunk	116,986	62,708,628	1,486,205	801	18.99
Kansas City Southern	68,873	34,582,626	724,012	968	20.27
Norfolk Southern*	458,179	201,451,969	4,383,081	1,064	23.15
Soo Line	65,299	35,244,079	745,550	892	18.86
Union Pacific	1,016,161	466,721,215	10,090,926	1,025	22.16
Total - Industry Average	**3,506,116**	**1,674,784,254**	**33,749,705**	**980**	**20.72**

* and combined subsidiaries

NOx and PM emission factors for rail carriers are also based on industry averages. Please see the **"**Background on Illustrative (Modal Average) U.S. Truck and Rail Factors" section below for details regarding the calculation of industry average NOx and PM performance levels for different freight modes.

Average payloads per loaded railcar were calculated for all Class 1 carriers by dividing the value for annual ton-miles hauled by an estimate for loaded railcar-miles, based on 2008 R-1 data. The calculation uses the Total Revenue and Non-Revenue Ton-Miles as listed In the R-1 Report on line 114 of schedule 755 divided by the Total loaded Railcar-Miles (the sum of lines 30 and 64 of schedule 755) along with the factor for fuel gallons consumed for loaded freight that is created based on the percentage of loaded freight to total freight multiplied by the total diesel fuel value listed on schedule 750 Line 4. The following table summarizes the estimated average payload per railcar, by carrier.

Table 5. Rail Carrier Average Payload

Carrier	Avg Payload/Loaded Railcar (tons)
BNSF Railway	108
CSX Transportation	85
Grand Trunk	80
Kansas City Southern	91

Carrier	Avg Payload/Loaded Railcar (tons)
Norfolk Southern	76
Soo Line	77
Union Pacific	91
Industry Average	**93**

Average railcar volumes were calculated for all carriers by first estimating an average volume for each major railcar type listed in the R-1 forms (schedule 755, lines 15-81). The assumptions used to estimate these volumes are provided in Table A-1. The railcar-miles reported for each railcar type were multiplied by these average volumes to estimate annual cubic foot-miles travelled by car type for each company and for the industry average. The distribution of cubic foot-miles across car types was used as the weighting factor to estimate a single average railcar volume for each company. These values and the resulting volume estimates are presented in Table 6 below.

Table 6. Rail Carrier Average Volume Determination

		BNSF	
Freight Car Types (R1 - Schedule 755)	**Avg. Cu Ft.**	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	4,555	1	4,555
Box-Plain 50-Foot & Longer	7,177	9,338	67,018,826
Box-Equipped	7,177	147,226	1,056,641,002
Gondola-Plain	5,190	379,762	1,970,964,780
Gondola-Equipped	5,190	75,894	393,889,860
Hopper-Covered	4,188	758,442	3,176,355,096
Hopper-Open Top-General Service	4,220	65,077	274,624,940
Hopper-Open Top-Special Service	4,220	137,449	580,034,780
Refrigerator-Mechanical	6,202	19,272	119,524,944
Refrigerator-Non-Mechanical	6,202	32,910	204,107,820
Flat-TOFC/COFC	6,395	520,521	3,328,731,795
Flat-Multi-Level	13,625	38,624	526,252,000
Flat-General Service	6,395	357	2,283,015
Flat-All Other	6,395	71,826	459,327,270
All Other Car Types-Total	5,772	20,146	116,282,712
Average Railcar Cubic Feet			**5,811**

	CSX	
Freight Car Types (R1 - Schedule 755)	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	-	-
Box-Plain 50-Foot & Longer	6,987	50,145,699
Box-Equipped	144,631	1,038,016,687
Gondola-Plain	137,256	712,358,640
Gondola-Equipped	64,532	334,921,080
Hopper-Covered	153,315	642,083,220
Hopper-Open Top-General Service	78,412	330,898,640
Hopper-Open Top-Special Service	35,451	149,603,220
Refrigerator-Mechanical	17,117	106,159,634
Refrigerator-Non-Mechanical	11,923	73,946,446
Flat-TOFC/COFC	125,828	804,670,060
Flat-Multi-Level	29,956	408,150,500
Flat-General Service	162	1,035,990
Flat-All Other	31,913	204,083,635
All Other Car Types-Total	19,861	114,637,692
Average Railcar Cubic Feet		**6,389**

	Grand Trunk	
Freight Car Types (R1 - Schedule 755)	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	0	-
Box-Plain 50-Foot & Longer	2,119	15,208,063
Box-Equipped	66,110	474,471,470
Gondola-Plain	6,467	33,563,730
Gondola-Equipped	19,201	99,653,190
Hopper-Covered	44,239	185,272,932
Hopper-Open Top-General Service	9,114	38,461,080
Hopper-Open Top-Special Service	32,621	137,660,620
Refrigerator-Mechanical	312	1,935,024
Refrigerator-Non-Mechanical	205	1,271,410
Flat-TOFC/COFC	2,779	17,771,705
Flat-Multi-Level	4,831	65,822,375
Flat-General Service	20	127,900
Flat-All Other	31,744	203,002,880
All Other Car Types-Total	4,755	27,445,860
Average Railcar Cubic Feet		**6,309**

	Kansas City Southern	
Freight Car Types (R1 - Schedule 755)	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	0	-
Box-Plain 50-Foot & Longer	3,383	24,279,791
Box-Equipped	39,792	285,587,184
Gondola-Plain	16,628	86,299,320
Gondola-Equipped	11,150	57,868,500
Hopper-Covered	50,346	210,849,048
Hopper-Open Top-General Service	626	2,641,720
Hopper-Open Top-Special Service	943	3,979,460
Refrigerator-Mechanical	21	130,242
Refrigerator-Non-Mechanical	52	322,504
Flat-TOFC/COFC	10,736	68,656,720
Flat-Multi-Level	629	8,570,125
Flat-General Service	12	76,740
Flat-All Other	2,321	14,842,795
All Other Car Types-Total	247	1,425,684
Average Railcar Cubic Feet		**5,938**

	Norfolk Southern	
Freight Car Types (R1 - Schedule 755)	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	0	-
Box-Plain 50-Foot & Longer	7,622	54,703,094
Box-Equipped	136,745	981,418,865
Gondola-Plain	193,214	1,002,780,660
Gondola-Equipped	111,320	577,750,800
Hopper-Covered	116,848	489,359,424
Hopper-Open Top-General Service	84,557	356,830,540
Hopper-Open Top-Special Service	30,078	126,929,160
Refrigerator-Mechanical	3,512	21,781,424
Refrigerator-Non-Mechanical	5,392	33,441,184
Flat-TOFC/COFC	114,928	734,964,560
Flat-Multi-Level	20,349	277,255,125
Flat-General Service	145	927,275
Flat-All Other	24,563	157,080,385
All Other Car Types-Total	212,408	1,226,018,976
Average Railcar Cubic Feet		**6,065**

	Soo Line	
Freight Car Types (R1 - Schedule 755)	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	0	-
Box-Plain 50-Foot & Longer	725	5,203,325
Box-Equipped	17,972	128,985,044
Gondola-Plain	1,203	6,243,570
Gondola-Equipped	8,856	45,962,640
Hopper-Covered	94,146	394,283,448
Hopper-Open Top-General Service	3,077	12,984,940
Hopper-Open Top-Special Service	20	84,400
Refrigerator-Mechanical	159	986,118
Refrigerator-Non-Mechanical	742	4,601,884
Flat-TOFC/COFC	11,178	71,483,310
Flat-Multi-Level	2,973	40,507,125
Flat-General Service	12	76,740
Flat-All Other	10,068	64,384,860
All Other Car Types-Total	428	2,470,416
Average Railcar Cubic Feet		**5,667**

	Union Pacific	
Freight Car Types (R1 - Schedule 755)	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	0	-
Box-Plain 50-Foot & Longer	12,311	88,356,047
Box-Equipped	238,241	1,709,855,657
Gondola-Plain	206,370	1,071,060,300
Gondola-Equipped	91,775	476,312,250
Hopper-Covered	370,929	1,553,450,652
Hopper-Open Top-General Service	188,027	793,473,940
Hopper-Open Top-Special Service	104,969	442,969,180
Refrigerator-Mechanical	82,874	513,984,548
Refrigerator-Non-Mechanical	27,009	167,509,818
Flat-TOFC/COFC	1,026,251	6,562,875,145
Flat-Multi-Level	46,889	638,862,625
Flat-General Service	350	2,238,250
Flat-All Other	72,371	462,812,545
All Other Car Types-Total	16,769	96,790,668
Average Railcar Cubic Feet		**6,248**

	Total (for Industry Average)	
Freight Car Types (R1 - Schedule 755)	**Railcar Miles (x1K)**	**Cu Ft Miles (x1K)**
Box-Plain 40-Foot	1	4,555
Box-Plain 50-Foot & Longer	42,485	304,914,845
Box-Equipped	790,717	5,674,975,909
Gondola-Plain	940,900	4,883,271,000
Gondola-Equipped	382,728	1,986,358,320
Hopper-Covered	1,588,265	6,651,653,820
Hopper-Open Top-General Service	428,890	1,809,915,800
Hopper-Open Top-Special Service	341,531	1,441,260,820
Refrigerator-Mechanical	123,267	764,501,934
Refrigerator-Non-Mechanical	78,233	485,201,066
Flat-TOFC/COFC	1,812,221	11,589,153,295
Flat-Multi-Level	144,251	1,965,419,875
Flat-General Service	1,058	6,765,910
Flat-All Other	244,806	1,565,534,370
All Other Car Types-Total	274,614	1,585,072,008
Industry Average Railcar Cubic Feet		**6,091**

% SmartWay Value

The **% SmartWay** screen presents the portion of goods that shippers move with SmartWay Partners (expressed as a percentage between 0 and 100). Shippers select the basis for calculating the percentage shipped with SmartWay Partners, including the following options for Way 3 and Way 4 participants:

- Total annual miles (the Tool will automatically populate the **% SmartWay** screen with any carrier activity data that shippers entered in the freight **Activity Data** screen). Miles correspond to truck-miles for trucks, aircraft-miles for air, barge-miles for barge, and railcar-miles for rail;
- Total annual ton-miles (the Tool will automatically populate the **% SmartWay** screen with any carrier activity data that shippers entered on the freight **Activity Data** screen);

Shippers participating at the Way 2 level must characterize their carrier activity using one of the following metrics:

-
- Percent Spent;
- Percent Weight Shipped;
- Percent Packages Shipped;
- Other Custom Metric (as defined by Shipper).

Public Disclosure Reports

The Shipper Tool now provides a report summarizing Scope 3 emissions for public disclosure purposes. Mass emissions are presented in metric tonnes for CO_2 (biogenic and non-biogenic), NO_x, and PM[12] for all carriers NOT specifically designated as "Shipper Carriers" on the Tool's Activity screen.[13] The percent of CO_2 attributable to SmartWay Carriers is also provided, again excluding any Shipper Carriers. Biogenic CO_2 emissions estimates are assumed to equal 2 percent of total CO_2 emissions, as per U.S. requirements for biomass-based diesel from the EPA Renewable Fuel Standard program final volume requirements.[14]

3.0 Calculator Tools

In addition to estimating a shipper's emissions inventory and performance metrics, the Shipper Tool also allows shippers to estimate the emissions impact of system activity strategies as well as modal shifts, if the user provides mileage-related activity data under the Way 4 option.

Mile and Weight Improvements

The **Mile & Weight Improvements** screen is optional and is intended for reference purposes only. On this screen, shippers may estimate emission reduction benefits for the following options:

- Miles Removed from the System
    - Distribution center relocation
    - Retail sales relocation
    - Routing optimization
    - Cube optimization
    - Larger vehicles and/or multiple trailers

- Weight Removed from System
    - Product weight reduction
    - Package weight reduction
    - Vehicle weight reduction

[12] Emissions from CH_4, N_2O, HFC's, PFC's, SF_6 and NF_3 have been deemed immaterial, comprising less than 5% of overall GHG emissions and are therefore EXCLUDED for reporting purposes.

[13] "Shipper Carriers" refer to fleets directly operated by the Shippers themselves. These fleets are associated with Scope 1 emissions which are not reported in the Shipper Tool. For purposes of developing a corporate inventory using the SmartWay Shipper Tool, the relevant Scope 3 category only includes upstream transportation and distribution and therefore excludes downstream transportation and distribution as falling outside of the system boundary.

[14] As stated in the Final Rule (Table I.B.7-1 – see https://www.gpo.gov/fdsys/pkg/FR-2017-12-12/pdf/2017-26426.pdf), the volume requirements for biomass-based diesel in 2018 is 1.74%, rounded to equal 2% for calculation purposes. The percentage will be updated annually in the Tool.

For each activity selected, shippers must provide an estimate of the percentage reduction in freight activity (in miles or weight), for each mode of interest, along with a detailed text description of the strategy. The Tool assumes that total mass emissions are reduced in direct proportion with the specified mileage or weight reduction.[15]

Mass emission reductions are calculated by using the appropriate emissions inventory from the **Emissions Summary** screen (based on reported activity data and associated carrier emissions performance data) as shown below:

S = EM x (1 / (1 – Reduction) - 1)

Where:

S = Savings (tons of CO_2, NOx, or PM)
EM = Emissions inventory value (tons of CO_2, NOx, or PM from Emissions Summary screen)
Reduction = the reduction in total miles or weight as a result of the strategy (expressed as fraction)

Fractional reduction estimates must be documented in the Shipper Tool. An example calculation is provided below:

A shipper changes the shape of its milk cartons from round to square. As a result, the shipper can pack 20% more milk cartons per truck trailer than the rounded milk cartons. This reduces 20% of the loads associated with that product line (corresponding to the "Cube Optimization" activity selection for the "Miles removed from system" category). However, the company sells many products, and the total truckloads associated with milk shipments is 1,000 out of 50,000 overall truckloads. The efficiency gain is thus 20% x (1,000/50,000), or a 0.4% system improvement. Therefore, the shipper would enter “0.4” in the Percent Improvement column. This assumes that all loads on average travel an equivalent distance. If milk loads were significantly shorter than other loads, then a mileage-based weighting per trip would need to be applied to arrive at a percent improvement. The burden of proof on demonstrating an accurate percent reduction and modal allocation is the shipper’s. The data sources and methodology should be briefly described in the Tool under Data Source/Methodology. The shipper should, at a minimum, keep detailed records electronically within the company to document the estimate upon EPA request. The shipper can also submit any documentation in electronic text format along with the Tool to its Partner Account Manager.

[15] This assumption should be accurate for weight reduction strategies when applied to truckload shipments that weigh out. Additional uncertainty arises in the case of LTL and package delivery shipments, where weight reductions may not result in one-to-one reductions in miles hauled. Uncertainties are even greater for non-truck modes, where the shipper commonly does not control the entire content of the container. Likewise, this assumption may not hold if shippers reduce freight by loading more products (i.e., more weight) on trucks that were previously cubing out, since the increase in payload will negatively impact the truck’s fuel economy and g/mile emissions performance.

Modal Shift Impacts

Overview

The **Modal Shift Impacts** screen in the Tool is optional and is intended for reference purposes only. Shippers should develop their carrier emissions inventories (and associated emissions factors for their companies) by inputting activity data in the **Activity Data** screen.

Shippers wishing to conduct scenario analyses can use the **Modal Shift Impacts** screen to estimate the emissions impacts associated with modal shifts by specifying the mode from which they are considering shifting their freight ("From Mode"), as well as the target mode ("To Mode"). Shippers have several options for selecting an emissions factor for both the "From Mode" and "To Mode". First, the Tool automatically calculates and displays the average emission factors for truck, barge, air and rail modes corresponding to the carrier data file values used on the **Activity Data** screen (corresponding to the "Shipper's Carrier Average" Emission Factor Source selection). In this case partners can also adjust their estimates of emission impacts from modal shifts by applying different filters for the "From" Mode (e.g., just considering inbound international freight). Second, partners may select illustrative industry average emission factors (discussed in the section below) from the drop-down menu (corresponding to the "Modal Average" selection). Third, the shipper can input a set of alternative emissions factors of their choice (corresponding to the "User Input" selection). In this instance the user must also provide a description of the source of the information used to develop the alternate factors (by selecting the "User Input Data Source" button).

Note: the emissions factors that automatically appear on the **Modal Shift Impacts** screen do not include all potential emissions impacts; for example, the factors do not include emissions associated with drayage (i.e., short-distance trips often required to move freight from one mode to another), or operations at intermodal facilities.

While EPA has populated the Tool with illustrative modal average freight emission factors, we recommend that partners use more representative emission factors to analyze scenarios whenever possible. For example, partners may wish to evaluate the emissions impact from moving freight from rail to a specific truck fleet by consulting the SmartWay Category average emissions factors associated with the fleet (available on the SmartWay website), or by inputting data that partners receive directly from a carrier. For better estimates of emission impacts from modal shifts, partners are encouraged to use a factor that reflects the full emissions impact (e.g., including anticipated drayage emissions) and that best represents the fleet equipment and operational type that they are most likely to work with for their unique freight movement.

While we have not provided modal average ocean-going vessel factors in the Tool, there are several external resources that partners can consult. We have included some selected sources of ocean-going vessel factors in the following section**.**

In order to calculate the emissions impact associated with a modal shift, shippers input the activity data corresponding with their modal shift scenario expressed in a given unit (miles or ton-miles) and the Tool combines that data with a corresponding emission factor (described above) in the same unit. The Tool then displays the change in emissions (as calculated below) in tons per year.

Total Emission Impact (tons/yr) =

[(Efficiency Before x "From Mode" Amount) –
(Efficiency After x "To Mode" Amount)] x grams to short tons conversion factor[16]

If the shipper is evaluating a mode shift between truck and rail or barge, and if the available activity units are in miles rather than ton-miles, then the activity data entered must be expressed in terms of railcar-miles or barge-miles, as appropriate in order to be consistent with the g/mile factors included in the carrier data file. Determination of railcar and barge-miles for any particular container/commodity type and route should be made in consultation with carriers or logistics service providers in order to account for volume differences compared to truck carriers.

If you need to convert truck-miles to railcar and/or barge-mile equivalents for your assessment, a railcar-to-truck equivalency factor can be calculated by first identifying the average cargo volume for a given rail carrier (see Table 5 above). These volumes estimates should be weighted by the miles associated with each rail carrier in order to estimate a single weighted-average railcar volume for the carrier company in question. Similarly, weighted average volumes can also be calculated for the different truck carriers associated with the given shipping company. (Company-specific volume data is contained within the carrier data file for SmartWay truck carriers.) The weighting calculations should involve all carriers used by the company if no filters are selected on the **Modal Shift Impacts** screen (only relevant for the "From" mode). Otherwise the weighted average calculation should only be performed for the filtered subset (e.g., inbound domestic truck carriers).

Once the weighted average volumes are determined for both rail and truck modes, you can calculate the ratio of the average railcar volume to the average truck volume (R). Using industry average volume estimates as described in Appendix A, we estimate R to equal approximately 1.41, meaning that the average railcar has 1.41 times the volume of an average truck trailer/container. Next, you can convert your truck-equivalent mile estimates to railcar equivalent miles by dividing truck miles by the ratio R.[17] Enter the corresponding railcar-mile activity estimate in the "Amounts" column.

The same process is used to convert truck-miles to barge-mile equivalents, although national average barge volume information was not identified for this analysis. In this case volume estimates may be used for specific barge carriers from the carrier data file.

[16] 1.1023×10^{-6} short tons/gram
[17] Any route mileage differences must be adjusted for separately.

In addition, the value for truck miles should also be divided by 1.15 to convert from statute to nautical miles.[18]

Background on Illustrative U.S. Modal Average Factors

Modal Average performance metrics have been estimated for rail, truck and multimodal modes (both gram per mile and gram per ton-mile), as well as for barge and air modes (gram per ton-mile only) in order to estimate emission impacts using the **Modal Shift Impacts** screen. We developed the freight **truck g/ton-mile** factors with 2014 CO_2, NO_x, and $PM_{2.5}$[19] inventory data on short-haul single unit, short-haul combination unit, long-haul single unit, and long-haul combination unit truck categories[20] in EPA's 2014a version of the Motor Vehicle Emissions Simulator (MOVES2014a) model.[21] MOVES does not contain ton-mile data, so we then divided the MOVES-based inventories by 2014 ton-mile data from the Bureau of Transportation Statistics,[22] which we determined was the most recent, comprehensive national freight truck ton-mile dataset available. For the freight **truck g/mile factors**, we used the same emissions inventory data as the g/ton-mile factors described above and divided them by the corresponding 2014 VMT data in MOVES2014a.

Table 7 presents the illustrative freight truck emissions factors in the tool, and Table 8 presents the key underlying data. (Note that the modal average factors calculated for truck carriers were assumed valid for logistics carriers as well.)

Table 7. Illustrative U.S. Freight Truck Industry Average Factors in Modal Shift

	CO_2	NO_x	$PM_{2.5}$
gram/short ton-mile	210	1.145	0.0454
gram/mile	1,546	8.45	0.335

Table 8. Underlying Emissions Inventories and Activity Data for Illustrative U.S. Freight Truck Industry Average Factors in Modal Shift

CO_2 (grams)	418,275,000,000,000
NO_x (grams)	2,286,630,000,000
$PM_{2.5}$ (grams)	90,672,929,280
short ton-miles	1,996,165,000,000
miles	270,592,000,000

We developed the freight **rail g CO_2/ton-mile and g CO_2/mile** factors with 2017 data, summarized in Table 4 above.

[18] Barge performance values are expressed in grams per nautical mile, to be consistent with barge carrier reporting practices.

[19] Corresponding PM_{10} emission factors were estimated assuming $PM_{2.5}$ values were 97% of PM_{10} values, based on MOVES model outputs for diesel fueled trucks.

[20] These four truck categories are coded as 52, 53, 61, and 62 in the MOVES model, respectively.

[21] EPA's MOVES model and accompanying resources, including technical documentation, are available at: www.epa.gov/otaq/models/moves/index.htm (accessed 8-22-18).

[22] Bureau of Transportation Statistics, U.S. Ton-Miles of Freight, https://www.bts.gov/content/us-ton-miles-freight. . Accessed , https://www.bts.gov/content/us-ton-miles-freight (accessed 8-22-18).

We developed the freight **rail g NO_x/ton-mile and g $PM_{2.5}$/ton-mile** factors with 2010 inventory data from Tables 3-82 and 3-83, respectively, in EPA's 2008 Regulatory Impact Analysis for a locomotive diesel engine rule.[23] This inventory data represents 2010 emission projections for all U.S. rail except for passenger and commuter rail (i.e., large line-haul, large switch, and small railroads), which we determined would very closely align with the freight rail sector. We divided this emissions inventory data by the 2007 BTS ton-mile data described above.

We developed the freight **rail g/mile** factors for NOx and $PM_{2.5}$ by using 2008 railcar mileage data from lines 15 through 81 of R-1 forms that Class I railroad companies submitted to the Surface Transportation Board.[24] We developed the NO_x and PM inventories using the average 2010 locomotive g PM_{10}/gal and g NOx/gal factors from Tables 5 and 6, respectively, in EPA's 2009 *Technical Highlights: Emissions Factors for Locomotives.*[25] To calculate g $PM_{2.5}$/gal, we assumed 95% of PM_{10} is $PM_{2.5}$, which we determined was a good approximation of the share of overall PM_{10} emissions represented by particulate matter that is 2.5 micrometers in diameter or smaller.

Table 9 presents the illustrative freight rail emissions factors in the Tool and Table 10 presents the key underlying data.

Table 9. Illustrative U.S. Freight Rail Industry Average Factors in Modal Shift

	NO_x	$PM_{2.5}$
gram/short ton-mile	0.4270	0.0120
gram/railcar mile	18.6	0.503
gram/TEU-mile	4.745	0.1284

[23] U.S. EPA, Office of Transportation and Air Quality, 2008. *Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder*, EPA420-R-08-001a, Washington DC. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/P10024CN.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2006+Thru+2010&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C06thru10%5CTxt%5C00000005%5CP10024CN.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL (accessed 8-22-18).

[24] Surface Transportation Board (STB), *Industry Data, Economic Data, Financial and Statistical Reports, Class 1 Annual Report, Form R-1*. Available at: http://www.stb.dot.gov/stb/industry/econ_reports.html (accessed 8-22-18).

[25] U.S. EPA, Office of Transportation and Air Quality, 2009. *Technical Highlights: Emission Factors for Locomotives*, EPA-420-F-09-025, Washington DC. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/P100500B.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2006+Thru+2010&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C06thru10%5CTxt%5C00000010%5CP100500B.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL (accessed 8-22-18).

Table 10. Underlying Emissions Inventories and Activity Data for Illustrative U.S. Freight Rail Industry Average Factors in Modal Shift

short ton-miles	1,819,633,000,000
Class I-only railcar miles (total)	34,611,843,000
50' and Larger Box Plain + Box Equipped	*2,223,402,000*
40' Box Plain	*22,000*
Flat TOFC/COFC, General, and Other	*5,057,466,000*
Flat Multi Level	*1,725,998,000*
Gondola Plain and Equipped	*7,893,684,000*
Refrigerated Mechanical and Non-Mechanical	*495,311,000*
Open Top Hopper General and Special Service	*5,913,012,000*
Covered Hopper	*7,210,656,000*
Tank under 22,000 gallons	*1,295,482,000*
Tank 22,000 gallons and over	*2,394,565,000*
All Other Car Types	*402,245,000*

Note that NOx and PM emission factors were not available at the carrier level for the rail mode. Accordingly, the modal average emission factors for NOx and PM were assumed to apply equally for all rail carriers.

Modal average estimates for multimodal carriers were calculated for intermodal truck/rail freight movements by estimating the average length of haul for rail freight (990 miles)[26] and truck drayage carriers (398 miles).[27] Based on these estimates we assume a "typical" intermodal container shipment will travel 71% by rail, and 29% by truck. These percentages are applied as weights to the modal average rail and truck mode values calculated above in order to estimate modal average performance metrics for intermodal shipments (see Table 11).

Table 11. Modal Average Performance Metric Estimates for Rail, Truck, and Intermodal

Mode	g/mi				g/ton-mi			
	CO_2	NOx	PM_{10}	$PM_{2.5}$	CO_2	NOx	PM_{10}	$PM_{2.5}$
Rail	1,072	18.6	0.519	0.503	22.94	0.427	0.012	0.012
Truck	1,546	8.54	0.345	0.335	210	1.145	0.047	0.045
Intermodal	1,209	15.68	0.469	0.454	77.19	0.635	0.022	0.022

NOTE: if you wish to estimate the emission impacts for other modal combinations (e.g., truck/barge) select the "User Input" option to provide the appropriate performance metric estimates.

The modal average barge emissions factors presented in Table 12 are from a study prepared by the Texas Transportation Institute (TTI) for the U.S. Maritime

[26] Class I Rail average length of haul for 2013 - https://transportgeography.org/?page_id=2735 (accessed 8-22-18).
[27] Harrison, R. et al, Characteristics of Drayage Operations at the Port of Houston, University of Texas Center for Transportation Research, Table 4, September 2008. Available at https://static.tti.tamu.edu/swutc.tamu.edu/publications/technicalreports/473700-00075-1.pdf (accessed 8-22-18).

Administration[28] and reflect inland waterway towing operations in the U.S. We converted the PM_{10} factor in the TTI study into $PM_{2.5}$ by assuming 95% of PM_{10} is $PM_{2.5}$, which we determined was a good approximation of the share of overall PM_{10} emissions represented by particulate matter that is 2.5 micrometers in diameter or smaller.

Table 12. Modal Average Barge Emission Factors

	CO_2	NO_x	$PM_{2.5}$
gram/short ton-mile	17.48	0.4691	0.0111

Estimates of average g/mi performance metrics were not identified for barge carriers.

Modal average estimates for air freight are based on EDMS outputs, presented in Table 3 above.

Outside Sources of Ocean-Going Marine Emission Factors

There are many sources of marine emission factors available in research literature and other GHG estimation tools. For reference, we have included below:

- g CO_2/ton-mile marine factors from the Business for Social Responsibility's (BSR) Clean Cargo Tool g CO_2/ton-mile marine factors from a study prepared for the International Maritime Organization (IMO).[29]

Note that the factors from BSR and IMO are published in units of kg CO_2/metric ton-km, so we converted this data into g CO_2/ton-mile by first multiplying by 1,000 (to convert from kilograms to grams), then multiplying by 0.9072 (to convert from metric tonnes to short tons), and then multiplying by 1.609 (to convert from kilometers to miles) to prepare the tables below.

BSR developed average 2009 marine emission factors for various shipping corridors, as well as global defaults that are applicable outside those corridors, based on surveys from marine carriers. The BSR marine factors in Table 13 below are from the "Emission Factors & Distances" tab in their tool.

Table 13. BSR Marine Emission Factors (g CO_2/short ton-mile)

Ship_general	International	13.0678
Ship_Barge	International	29.1937
Ship_Feeder	International	29.1937
Ship_inland_Germany	Germany	41.5280
Ship_inland_China	China	35.0578

[28] U.S. Maritime Administration and the National Waterways Foundation (U.S. MARAD), amended January 2017. *A Modal Comparison of Domestic Freight Transportation Effects on the General Public*. Prepared by Center for Ports & Waterways, Texas Transportation Institute, Table 10. Available at: http://www.portsofindiana.com/wp-content/uploads/2017/06/Final-TTI-Report-2001-2014-Approved.pdf (accessed 8-22-18).

[29] Buhaug, et al. for the International Maritime Organization (IMO), 2009. Second IMO GHG Study 2009, International Maritime Organization (IMO), London, UK, April 2009. Available at: http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/SecondIMOGHGStudy2009.pdf (accessed 8-22-18).

Ship_Asia-Africa	Asia--Africa	11.9227
Ship_Asia-South America (EC/WC)	Asia--South America (EC/WC)	13.1897
Ship_Asia-Oceania	Asia--Oceania	13.4028
Ship_Asia-North Europe	Asia--North Europe	10.8586
Ship_Asia-Mediterranean	Asia--Mediterranean	12.1358
Ship_Asia-North America EC	Asia--North America EC	12.9854
Ship_Asia-North America WC	Asia--North America WC	12.0818
Ship_Asia-Middle East/India	Asia--Middle East/India	13.5459
Ship_North Europe-North America EC	North Europe--North America EC (incl. Gulf)	14.1823
Ship_North Europe-North America WC	North Europe--North America WC	13.0642
Ship_Mediterranean-North America EC	Mediterranean--North America EC (incl. Gulf)	12.6788
Ship_Mediterranean-North America WC	Mediterranean--North America WC	10.1433
Ship_Europe (North & Med)-Middle East/India	Europe (North & Med)--Middle East/India	13.4276
Ship_Europe (North & Med)-Africa	Europe (North & Med)--Africa	15.8361
Ship_Europe (North & Med)-Oceania (via Suez / via Panama)	Europe (North & Med)--Oceania (via Suez / via Panama)	14.4056
Ship_Europe (North & Med)-Latin America/South America	Europe (North & Med)--Latin America/South America	12.6146
Ship_North America-Africa	North America--Africa	17.4549
Ship_North America EC-Middle East/India	North America EC--Middle East/India	12.8788
Ship_North America-South America (EC/WC)	North America--South America (EC/WC)	13.4379
Ship_North America-Oceania	North America--Oceania	15.0552
Ship_South America (EC/WC)-Africa	South America (EC/WC)--Africa	11.7432
Ship_Intra-Americas (Caribbean)	Intra-Americas (Caribbean)	15.9222
Ship_Intra-Asia	Intra-Asia	15.2012
Ship_Intra-Europe	Intra-Europe	17.1790

The marine factors in the IMO study reflect commonly-used equipment sizes and types. The factors in Tables 14 below come from Table 9.1 4 in the IMO study.

Table 14. IMO Marine Emission Factors

TYPE	SIZE	AVERAGE CARGO CAPACITY (metric tonne)	Average yearly capacity utilization	Average service speed (knots)	Transport work per ship (tonne NM)	Loaded efficiency (g of CO_2/ ton-mile)	Total efficiency (g of CO_2/ton-mile)
Crude oil tanker	2000,000+dwt	295,237	48%	15.4	14,197,046,742	2.34	4.23
Crude oil tanker	120,000-199,99 dwt	151,734	48%	15	7,024,437,504	3.21	6.42
Crude oil tanker	80,000-119,999 dwt	103,403	48%	14.7	4,417,734,613	4.38	8.61
Crude oil tanker	60,000-79,999 dwt	66,261	48%	14.6	2,629,911,081	6.28	10.95
Crude oil tanker	10,000-59,999 dwt	38,631	48%	14.5	1,519,025,926	7.59	13.28
Crude oil tanker	0-9,999 dwt	3668	48%	12.1	91,086,398	30.22	48.61
Products tanker	60,000+ dwt	101,000	55%	15.3	3,491,449,962	4.82	8.32
Products tanker	20,000-59,999 dwt	40,000	55%	14.8	1,333,683,350	10.51	15.03
Products tanker	10,000-19,999 dwt	15,000	50%	14.1	464,013,471	16.49	27.30

TYPE	SIZE	AVERAGE CARGO CAPACITY (metric tonne)	Average yearly capacity utilization	Average service speed (knots)	Transport work per ship (tonne NM)	Loaded efficiency (g of CO_2/ ton-mile)	Total efficiency (g of CO_2/ton-mile)
Products tanker	5,000-9,999 dwt	7,000	45%	12.8	170,712,388	21.60	42.62
Products tanker	0-49,999 dwt	1,800	45%	11	37,598,072	38.68	65.69
Chemical tanker	20,000 + dwt	32,200	64%	14.7	1,831,868,715	8.32	12.26
Chemical tanker	10,000-19,999 dwt	15,000	64%	14.5	820,375,271	10.66	15.76
Chemical tanker	5,000-9,999 dwt	7,000	64%	14.5	382,700,554	15.62	22.04
Chemical tanker	0-4,999 dwt	1,800	64%	14.5	72,147,958	27.15	32.41
LPG tanker	50,000 + m^3	46,656	48%	16.6	2,411,297,106	7.59	13.14
LPG tanker	0-49,999 m^3	3,120	48%	14	89,631,360	39.41	63.50
LNG tanker	200,00 + m^3	97,520	48%	19.6	5,672,338,333	7.88	13.58
LNG tanker	0-199,999 m^3	62,100	48%	19.6	3,797,321,655	12.26	21.17
Bulk carrier	200,000 +dwt	227,000	50%	14.4	10,901,043,017	2.19	3.65
Bulk carrier	100,000-199,999 dwt	163,000	50%	14.4	7,763,260,284	2.63	4.38
Bulk carrier	60,000-99,999 dwt	74,000	55%	14.4	3,821,361,703	3.94	5.98
Bulk carrier	35,000-59,999 dwt	45,000	55%	14.4	2,243,075,236	5.55	8.32
Bulk carrier	10,000-34,999 dwt	26,000	55%	14.3	1,268,561,872	7.74	11.53
Bulk carrier	0-9,999 dwt	2,400	60%	11	68,226,787	33.43	42.62
General cargo	10,000 + dwt	15,000	60%	15.4	866,510,887	11.09	17.37
General cargo	5,000-9,999 dwt	6,957	60%	13.4	365,344,150	14.74	23.06
General cargo	0-4,999 dwt	2,545	60%	11.7	76,645,792	15.91	20.29
General cargo	10,000+ dwt, 100+ TEU	18,000	60%	15.4	961,054,062	12.55	16.06
General cargo	5,000-9,999 dwt, 100+TEU	7,000	60%	13.4	243,599,799	20.14	25.54
General cargo	0-4,999 dwt, dwt+TEU	4,000	60%	11.7	120,938,043	22.63	28.90
Refrigerated cargo	All	6,400	50%	20	392,981,809	18.83	18.83
Container	8000+TEU	68,600	70%	25.1	6,968,284,047	16.20	18.25
Container	5,000-7,999 TEU	40,355	70%	25.3	4,233,489,679	22.19	24.23
Container	3,000-4,999 TEU	28,784	70%	23.3	2,280,323,533	22.19	24.23
Container	2,000-2,999 TEU	16,800	70%	20.9	1,480,205,694	26.71	29.19
Container	1,000-1,999 TEU	7,000	70%	19	578,339,367	42.91	46.86
Container	0-999 TEU	3,500	70%	17	179,809,363	48.61	52.99
Vehicle	4000 +ceu	7,908	70%	19.4	732,581,677	36.78	46.71
Vehicle	0-3999 ceu	2,808	70%	17.7	226,545,399	68.90	84.08
Ro-Ro	2,000 + lm	5,154	70%	19.4	368,202,021	66.12	72.25
Ro-Ro	0-1,999 lm	1432	70%	13.2	57,201,146	80.57	88.02

TYPE	SIZE	AVERAGE CARGO CAPACITY (metric tonne)	Average yearly capacity utilization	Average service speed (knots)	Transport work per ship (tonne NM)	Loaded efficiency (g of CO_2/ ton-mile)	Total efficiency (g of CO_2/ton-mile)
Note: "Loaded efficiency" is the theoretical maximum efficiency when the ship is fully loaded at service speed/85% load. Since engine load at the fully loaded condition is higher than the average including ballast and other voyages, the difference between the columns "loaded efficiency" and "total efficiency cannot be explained by differences in utilization only.							

4.0 Shipper Payloads and Data Validation

Payload Validation

The Shipper Tool also contains data validation checks designed to identify missing and potentially erroneous data. At this time the only validation involves payload checks and total ton-mile checks, on the Activity Data screen.

Payload validation cutpoints were set with the intention of identifying those payloads that are somewhat outside typical industry values (yellow flag warnings) and those that are far outside industry averages (red flag warnings). The payload check only apples to Data Availability selections a, b, and c where payloads are either entered by the user, or calculated based on other inputs. Checks are applied at the carrier (row) level.

Payload checks are specific to the Truck SmartWay Category, which is available for each carrier category from the Carrier Data File. Note that payload Ranges 1 (very low) and 5 (very high) are colored red on the Activity screen, and require explanations before proceeding. Ranges 2 (low) and (high) 4 are colored yellow, and explanations are optional.

Reported Shipper payloads were compiled for each shipper carrier for the 2014 – 2016 reporting years. The data was broken down for each SmartWay carrier category. Next, for every category a histogram was developed and the distribution of the data was reviewed. By adjusting the size of the bins outliers were identified and the histograms adjusted to exclude those points. In most cases specific cutpoints were then selected for each SmartWay category to represent 5, 10, 90, and 95 percentiles. (Certain highly skewed distributions such as that for package carriers did not define low end cutpoints). The resulting cutpoints used to establish the "red" and "yellow" validation ranges are provided below.

Table 15. Shipper Payload Validation Ranges

Carrier Category	low red	low yellow	high yellow	high red
Dray	2.90	6.47	22.00	23.00
Expedited	N/A	N/A	20.16	21.61
Specialized	1.00	4.95	24.00	28.00
LTL	N/A	N/A	16.48	19.44
Auto Carrier	0.0041	0.0046	20.95	21.83
Heavy Bulk	5.45	10.24	25.03	25.20
TL	4.003	7.334	22.00	24.00
Moving	N/A	N/A	20.13	20.54
Flatbed	4.34	7.59	23.00	26.00
Mixed	1.001	4.429	22.500	23.933
General	10.00	14.45	21.00	28.00
Package	N/A	N/A	2.20	11.00
Tanker	7.86	14.06	24.56	26.28
Reefer	3.87	9.33	22.00	24.00
Logistics	0.404	1.158	22.00	24.00

Validation cutoffs for rail and surface multimodal carriers are summarized below. The upper bound cutpoints for surface multimodal payloads are based on a qualitative review of 2011 Multimodal carrier Tool submittals. The upper bound cutpoints for rail payloads are based on the distribution of average values estimated for all Class 1 carriers (see Table 5 above).

- Average surface multimodal payloads less than 9.4 tons (error – red)
- Average surface multimodal payloads greater than 95 tons (error – red)
- Average railcar payloads less than 9.4 tons or greater than 125 tons (error – red)
- Average surface multimodal payloads between 9.4 and 15.5 tons (warning – yellow)
- Average surface multimodal payloads between 60 and 95 tons (warning – yellow)

In addition, the absolute upper bound for rail and surface multimodal carriers have both been set at 200 tons.

Multimodal carriers with an air component have their maximum average payload set to 220,000 lbs., corresponding to the maximum payload capacity for the largest aircraft make/model specified by SmartWay partners in 2017. Payloads above this amount will trigger a “red” out of range error that must be explained by the partner in order to proceed, although no value has been set for a maximum allowable payload at this time. Payloads between 110,000 and 220,000 lbs. will receive a “yellow” warning which may be explained if the partner chooses. Any payload value less than or equal to zero will be flagged as an error and must be changed.

Finally, barge carrier payloads are flagged for verification if their density is greater than 0.6 tons per cubic foot or less than 0.003 tons per cubic foot, consistent with the payload validation used in the Barge Tool.

Ton-Mile Validation

2011 Logistics Partner data was evaluated to establish absolute upper bounds for ton-mile inputs. The ton-mile validation applies at the carrier (row) and total fleet (summation of rows) level, with the same values applied to both. The maximum allowable ton-mile value was set to twice the observed maximum value in the 2011 data set: 209,207,446,000 ton-miles.

Appendix A
Calculation of Truck-Equivalent Mileage Factors for Rail

Truck-equivalent can be converted into railcar-miles, so that partners can more readily estimate emissions impacts from shifting freight between truck and rail modes, by estimating the average volume capacity of Class I railcars and dividing it by an average freight truck volume capacity. This results in a rough estimate that does not take into consideration the utilized volume of railcars or the comparative freight truck, but we determined that this was the best available data and method to estimate modal average railcar-equivalent miles.

To estimate the average volume capacity of railcars, we multiplied the railcar miles reported by each company for each railcar type in their respective 2008 R-1 reports (lines 15-81) by the volume-per-railcar assumptions in Table A-1 to obtain total Class I TEU-miles. We then divided the total railcar TEU-miles by the total railcar-miles to estimate the average railcar volume capacity. We then divided this average railcar volume capacity (3.92 TEUs) by the average freight truck volume capacity that we developed for the truck g/TEU-mile factor discussed above (2.78 TEUs) to develop the conversion factor - 1.41 railcar-miles-to-truck-miles. In the absence of more specific data, this factor can be used to convert truck miles to railcar miles for use on the **Modal Shift** screen of the Shipper Tool. Note that no equivalent information was identified for the estimation of industry-average barge volumes.

Table A-1: Railcar Volume Assumptions and Sources

Railcar Type	**Cubic Feet**	**Source/Method** ***Key:*** Norfolk Southern Railroad (NS)[30], Union Pacific Railroad (UP)[31], Burlington Northern Santa Fe Railroad (BNSF)[32], CSX Transportation Railroad (CSX)[33], World Trade Press Guide to Railcars (GTRC)[34], Chicago Rail Car Leasing (CRCL)[35], Union Tank Car Company (UTCC)[36], U.S Department of Agriculture (USDA)[37]
Boxcar 50 ft and longer including equipped boxcars	7,177	Based on the average of the following boxcar types: 50ft assumed to be 5694 [reflecting the average of 5355 (NS), 5431 (UP), 5238 (CSX), 6175 (BSNF), 6269 (GTRC)].

[30] Norfolk Southern Shipping Tools/Equipment Guide/Merchandise Equipment. http://www.nscorp.com/content/nscorp/en/shipping-tools/equipment-guide/merchandise-equipment.html (accessed 5-25-18).
[31] UP Rail Equipment Descriptions, UP Rail Equipment Descriptions. https://www.uprr.com/customers/equip-resources/cartypes/index.shtml (accessed 5-25-18).
[32] BNSF Individual Railcar Equipment. http://www.bnsf.com/ship-with-bnsf/ways-of-shipping/individual-railcar.html#subtabs-3 (accessed 5-25-18).
[33] CSX Railroad Equipment. https://www.csx.com/index.cfm/customers/resources/equipment/railroad-equipment/ (accessed 5-25-18).
[34] World Trade Press, World Trade Resources Guide to Railcars 2010.
[35] Chicago Freight Car Leasing Company, Railcar Types. http://www.crdx.com/Services/Railcar (accessed 5-25-18).
[36] UTLX Tank Car Designs and Descriptions. http://www.utlx.com/bdd_tank.html (accessed 5-25-18).
[37] U.S. Department of Agriculture (USDA), 1992, *Weights, Measures, and Conversion Factors for Agricultural Commodities and Their Products*, Agricultural Handbook Number 697, Economic Research Service, Washington, DC. Available at: https://www.ers.usda.gov/webdocs/publications/41880/33132_ah697_002.pdf?v=42487 (accessed 5-25-18).

Railcar Type	Cubic Feet	Source/Method ***Key:*** Norfolk Southern Railroad (NS)[30], Union Pacific Railroad (UP)[31], Burlington Northern Santa Fe Railroad (BNSF)[32], CSX Transportation Railroad (CSX)[33], World Trade Press Guide to Railcars (GTRC)[34], Chicago Rail Car Leasing (CRCL)[35], Union Tank Car Company (UTCC)[36], U.S Department of Agriculture (USDA)[37]
		60ft assumed to be 6,648 [reflecting the average of 6618 (NS), 6389 (UP), 6085 (CSX), 7500 (BNSF)]. 50ft high cube assumed to be 6,304 [reflecting the average of 6339 (NS) and 6269 (CSX)]. 60 ft. high cube assumed to be 6917 [reflecting the average of 7499 (NS) , 6646 (CSX), and 6607 (GTRC)]. 86ft assumed to be 9999 (NS). Auto parts assumed to be 7499 (NS).
Boxcar 40ft	4,555	Based on estimate of 50ft boxcar volume described above. Assumed 40ft length would result in 20% reduction in volume.
Flat car – all types except for multi-level	6,395	Based on the average of the following flat car types: 60ft assumed to be 6739 (BNSF). 89ft assumed to be 9372(BNSF). Coil assumed to be 3387(NS). Covered coil assumed to be 5294 [reflecting the average of 8328 (NS) and 2260 (BNSF)]. Center beam assumed to be 6546 [reflecting the average of 5857 (UP) and 7236 (BNSF)]. Bulkhead assumed to be 7030 (BNSF).
Multi-level flat car	13,625	Based on the average of the following multi-level flat car types: Unilevel (that carry very large cargo, such as vehicles/tractors) assumed to be 12183 (NS). Bi-level assumed to be 14381(NS). Tri-level assumed to be 14313 (based on average of 15287 (NS) and 13339 (BNSF).
Flat Car – all types-including multi-level *[not used in analysis, except for estimating volume of "All Other Cars"]*	7,428	Based on the average volumes of the flatcar types described above including multi-level as a single flat car type.
Gondola – all types Including equipped	5,190	Based on the average of the following gondola car types: 52-53ft assumed to be 2626 [based on average of 2665 (NS), 2743 (CSX), 2400 (BNSF), and 2697(CRLC)]. 60-66ft assumed to be 3372 [based on average of 3281 (NS), 3242 (CSX), 3350 (BNSF), CRCL-3670, and 3366 (GTRC)]. Municipal Waste assumed to be 7999 (NS). Woodchip assumed to be 7781[based on average of 7862 (NS) and 7700 (CRCL)]. Coal assumed to be 4170 [based on average of 3785 (NS) and 4556 (BNSF)].
Refrigerated - Mechanical /non-Mechanical	6,202	Based on the average of the following refrigerated car types: 48-72ft assumed to be 6963 [based on average of 6043 (UP) and 7883 (BNSF)]. 50ft assumed to be 5167(GTRC). 40-90 ft. assumed to be 6476 [based on average of 6952 (UP) and 6000 (BNSF)].
Open Top Hopper	4,220	Based on the average of the following open top hopper car types: 42ft assumed to be 3000 (UP). 54ft assumed to be 3700 (UP). 60ft assumed to be 5188 [based on average of 5125 (UP) and 5250 (GTRC)]. 45ft+ assumed to be 4105 [based on average of 4500 (UP) and 3710 (BNSF).

Railcar Type	Cubic Feet	Source/Method ***Key:*** Norfolk Southern Railroad (NS)[30], Union Pacific Railroad (UP)[31], Burlington Northern Santa Fe Railroad (BNSF)[32], CSX Transportation Railroad (CSX)[33], World Trade Press Guide to Railcars (GTRC)[34], Chicago Rail Car Leasing (CRCL)[35], Union Tank Car Company (UTCC)[36], U.S Department of Agriculture (USDA)[37]
		Woodchip assumed to be 7075 [based on average of 7525 (NS), 5999 (UP), and 7700 (CRCL)]. Small Aggregate assumed to be 2252 [based on average of 2150 (NS), 2106 (BNSF), and 2500 (CRCL)].
Covered Hopper	4,188	Based on the average of the following covered top hopper car types: 45ft assumed to be 5250 (GTRC). Aggregate assumed to be 2575 [based on average of 2150 (NS) and 3000 (CRCL)]. Small Cube Gravel assumed to be 2939 [based on average of 2655 (NS), 3100 (CSX), and 3063 (BNSF). Med-Large Cube Ores and Sand assumed to be 4169 [based on average of 3750 (NS) and 4589 (BNSF)]. Jumbo assumed to be 5147 [based on average of 4875 (NS), 4462 (CSX), 5175 (BNSF), and 6075 (CRCL)]. Pressure Differential (flour) assumed to be 5050 [based on average of 5124 (NS) and 4975 (CRCL)].
Tank Cars under 22,000 gallons	2,314	Assumes 1 gallon=0.1337 cubic foot (USDA). Based on small tank car average volume of 17304 gallons, which is the average of the following currently manufactured tank car volume design capacities of 13470, 13710, 15100, 15960, 16410, 17300, 19900, 20000, 20590, and 20610 gallons (GTRC).
Tank Cars over 22,000 gallons	3,857	Assumes 1 gallon=0.1337 (USDA). Based on large tank car volume of 28851 gallons, which is the average of the following currently manufactured tank car volume design capacities of 23470, 25790, 27200, 28700, 30000, 33000, and 33800 gallons (GTRC).
All Other Cars	5,014	Based on average volume presented above for each of the nine railcar types (all flatcars are represented by the line item that includes multi-level flatcars - 7428).