SmartWay®
Transport Partnership
U.S. Environmental Protection Agency

Logistics Company Carrier Partner 2.0.15 Tool: Technical Documentation 2015 Data Year - United States Version

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1.0 Overview

The SmartWay Logistics Tool is intended to help logistics companies estimate and assess their carbon, PM, and NOx emission performance levels as well as their total emissions associated with goods movement in the U.S. freight rail, barge, air and trucking sectors[1].

The new SmartWay truck, air and barge carrier emissions performance data that EPA has included in the Tool, along with publically available Class I rail data, will allow logistics companies to generate more accurate emissions performance estimates and mass emissions inventories. The Tool will allow logistics companies to track their freight-related emissions performance from year to year, and also help optimize their emissions performance by allowing them to better estimate the emissions impact of individual carriers.

2.0 Tool Inputs and Calculations

After logistics companies enter their company and contact information, they provide basic information about each company they operate, including name, SCAC, MCN, NSC, and US DOT Number. Logistics companies then identify each carrier that they use for each logistics business unit. Next, users proceed to input activity data for each carrier specified.

Emission Inventory and Performance Metric Calculations

After inputting the required mileage and/or ton-mile information for each carrier used, the Tool will calculate the associated total mass emissions (i.e., an emissions inventory) based on the mileage-related activity data entered, as well as various emission performance metrics (e.g., composite grams/mile and grams/ton-mile – see below) . The Tool offers two options for calculating mass emissions, based on either the annual mileage or ton-mileage data that logistics companies enter for each carrier. We encourage logistics companies to select the unit of activity data that is most appropriate for characterizing each carrier type (e.g., use grams per mile for TL and grams per ton-mile for LTL, package, and multi-modal / rail.)

[1] While this Tool is primarily focused on freight movements in the U.S. rail, air, barge and trucking freight sectors, SmartWay anticipates providing performance data for ocean-going marine freight in the future as well.

The emissions inventory for each carrier/mode combination displayed on the **Emissions Summary**, **Carrier Performance**, and **SmartWay Category Details** screens is calculated by multiplying the appropriate unit of activity data (i.e., truck, air or barge miles, railcar-miles, or ton-miles) by the corresponding carrier emissions performance data. To calculate composite, business unit-wide emissions performance metrics on the **Carrier Performance** screen (i.e., overall g/mile and g/ton-mile performance), the Tool weights the emissions performance of each of the logistics business unit's carriers by the percentage of the business unit's overall freight activity that the carrier moves. An example composite performance calculation is provided below.

Table 1. Example Compositing Calculation

	CO_2 g/mi	Mi/yr	Weighting Factor	Weighted CO_2 g/mi
Carrier 1	1,700	2,000,000	0.667	1,134 (0.667 x 1,700)
Carrier 2	1,500	1,000,000	0.333	500 (0.333 x 1,500)
		Weighted composite g/mi		**1,633 (1,134 + 500)**

This compositing process proceeds in an identical fashion for ton-miles.

Note that the composite emissions performance values are the numbers that will be used to place logistics partners into performance bins within the logistics category.

Ton-Mile Calculation

Correctly calculating Ton-Miles is critically important for the accurate determination of your carbon foot-print. You can calculate your business unit'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 truck, railcar, aircraft, or barge, and will clearly overstate your ton-miles.

Many companies track their ton-miles and can report them directly without further calculation. For example, logistics company systems are typically 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

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

NOTE: Empty miles are not included in the ton-mile calculation, but the fuel used to move those empty miles are included in the overall g/ton-mile calculations.

To check your estimate, divide ton-miles by miles. The result is your fleet-average payload. If this number is not reasonable, please check your calculations.

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, barge, air, and rail freight transport providers. These data are provided in the SmartWayCarrierData2015.xls file, which should be downloaded to the user's computer using the appropriate button on the Tool's Home page. Performance data for truck, barge, air,[2] and multi-modal partners correspond to data submittals for the 2015 calendar year, while current Logistics partner performance may correspond to submittals for 2014, depending on whether the 2015 data year performance information for logistics companies has been released at the time of tool download. (Within a given data year, logistics tools are released *after* the multi-modal tool.) Performance for Rail companies are modal averages, based on publicly available R-1 data.

Truck Carrier Performance

Truck carrier performance data utilized by the Logistics Tool is based on 2015 Truck Partner Tool submittals. Performance data includes g/mile and g/ton-mile for each truck carrier by SmartWay Category, with a top ranking indicating the top 20 percent performance level for a given pollutant/performance category. 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
- Heavy/Bulk

[2] As of 6-27-2016 no air carrier data had been approved by SmartWay.

- Package
- Auto Carrier
- Moving
- Specialized
- Mixed
- Expedited

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

Truck Performance Ranking

In the 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, package delivery, or expedited, and C.) equipment type: dry van, refrigerated van, flatbed, tanker, heavy/bulk, chassis (container), auto carrier, moving, utility, or specialized (e.g., hopper, livestock, other). The possible categories are shown below.

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

Private									
	Dry Van	Reefer	Flatbed	Tanker	Chassis	Heavy/Bulk	Auto Carrier	Moving	Specialized
TL									
LTL									
PD									
Expedited									
Dray									

For-hire and private fleets are combined in 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 ranking 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. Ranking for-hire and private separately would have doubled the number of categories. Fleets can thus be categorized as shown below.

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

To be categorized in a particular category, a fleet must have at least 75% of its operations by mileage in a single category, otherwise it is classified as a “Mixed” fleet. Fleets could 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 category are placed in the Mixed category.

Individual fleets were then placed into categories. The following graphic illustrates the population of the various categories. The darker the shade of the intersection, the higher the number of fleets in that category.

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

SmartWay then looked at combining categories that exhibited 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 (intermodal container) 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 two categories were combined. A similar situation was identified with flatbed, and flatbed truckload and less than truckload were combined. Although no less than truckload tanker fleets were identified, tanker truckload and less than truckload were combined into one category so that no intersections would be left undefined. Similar aggregations were made for the remaining, less common body types including heavy/bulk, auto carrier, moving and specialized. All dray was collapsed into one category, and package delivery was restricted to dry van body types. Any fleet that had mixed operation and/or mixed equipment was placed into a single mixed category. This produces the final bin categories illustrated below.

For-Hire and Private

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

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

Companies *within a 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, PM10 g/mile and PM10 g/ton-mile. Companies within a category were then separated into five groups (rankings) such that an equal number of companies were in each. Each ranking category thus represents a range of emission factors. This range, and associated cutpoints (transition points from one ranking category to the next) were then modified so that each bin had an equal range, and the new ranking category cutpoints remained as close to the originals as possible. The new range cutpoint is displayed as a number with significant digits appropriate to emission factors in that category. The midpoint of the range is used as the emission factor for all companies in a ranking category.

It would be simpler and more straightforward to use company-specific emission factors, however the trucking industry expressed concern with revealing exact data that 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 exact than a modal default number. Given the large number of trucking companies, and thus opportunity for companies to be very close to each other in performance (for example 0.001 g/mile of CO_2), SmartWay believes it is acceptable and appropriate to break truck fleets into 5 performance rankings. The table below illustrates the ranking results for the For Hire/Private Truckload/Expedited Dry Van/Container category, using 2010 truck partner data.

Table 2. Example Binning Results for One Ranking Category (2010 Data)

For-Hire/Private Truckload/Expedited Dry Van/Container CO_2 g/mile						
Rank	Fleets	Grams Per Mile Min	Grams Per Mile Max	Grams Per Mile Avg	Grams Per Mile Midpoint	Grams Per Mile Std Dev
1	159	602	1,600	1,503	1,550	141
2	241	1,601	1,699	1,654	1,650	28
3	204	1,700	1,799	1,746	1,750	28
4	139	1,800	1,899	1,853	1,850	28
5	55	1,900	3,701	2,064	2,801	302

Similar tables were developed for all categories. The midpoint of each ranking category is the data that a logistics company will download into their SmartWay Logistics Tool to represent the emission performance of a specific carrier fleet that is in the associated rank category. Once the categories and ranks have been established, the carrier fleets of any new companies joining SmartWay will fall into one of the predefined categories/ranks. SmartWay expects to update the category/ranks structure approximately every three years.

The Non-SmartWay performance metrics were calculated by taking the standard performance rank range delta (min/max) for each ranking category, and using the delta to calculate a non-SmartWay carrier midpoint for each category. This midpoint was the midpoint for Rank 5 plus the standard range delta. For example, if the Rank 5 midpoint was 10.5 and the Ranking Categories 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 **Logistics Tool Data Entry and Troubleshooting 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. Alternatively, freight density and cargo volume utilization information can also be used to estimate average payloads. For this reason, average payload and volume information are provided for each carrier in the SmartWayCarrierData2015.xls file.[3] For Non-SmartWay truck carriers, the values for

[3] The Logistics Tool also calculates average payload and average volume for each logistics fleet defined by the user, weighting carrier payloads and volumes by the miles assigned on the Tool Activity screen. The resulting average payload and volume figures will be included in subsequent updates to the SmartWay Carrier file for use by Shippers and Logistics companies.

average payload (18.7 tons) and average volume (3,260 cubic feet) were derived from the average values for all Truck Partners (2011 data), weighted by miles.

Logistics and Multi-modal Carrier Performance

Logistic and multi-modal carriers have their own performance bins based on the carrier tool submittals for the most recent available calendar year (2014 for logistics, and 2015 for multi-modal). Non-SmartWay carrier performance for these 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 modal average value).

Air and Barge Carrier Performance

Air and barge carriers have agreed to have their actual emissions results made public, hence, barge performance values used in the Logistics are carrier-specific. The gram per mile performance values for barge carriers correspond to individual barge 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 freight (~4,236 g/t-mi and ~1,461 g/t-mi, respectively).[4,5] 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)[6] by the total number of cargo departures in the same year (654,956 LTOs).[7] 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}).[8] The resulting performance metrics are shown in Table 3 below. An average cargo volume estimate was also obtained for inclusion in the SmartWay carrier

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[4] Short haul air freight assumed to be less than 3,000 miles, covering most domestic air routes in the U.S.

[5] 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.

[6] U.S. DOT Bureau of Transportaion Statistics, Fregiht Facts and Figures 2013. Accessed 20 April 2015 http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/13factsfigures/pdfs/fff2013_highres.pdf

[7] U.S. DOT, Bureau of Transportation Statistics, U.S. Air Carrier Traffic Statistics, accessed April, 20, 2015: http://www.rita.dot.gov/bts/acts/customized/table?adfy=2012&adfm=1&adty=2012&adtm=12&aos=6&artd&arti&arts=3&asts&astns&astt=3&ascc=2&ascp

[8] 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.

data file based on the volume for a typical freight aircraft, the Boeing 747 200 series (5,123 cubic feet).[9]

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

All rail carriers are assumed to have the same industry modal average performance levels in the Logistics Tool, regardless of Partnership status. Rail carrier performance data are collected and displayed in the Logistics 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 (10,084 g CO_2/gal diesel fuel), from publicly available data submitted in the 2010 railroad R-1 reports to the Department of Transportation. 2010 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. Specific rail companies may have an opportunity to provide company-specific 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 and Results (2010 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	1,295,147	646,549,059	11,230,994	1,163	20.20
CSX Transportation	490,050	230,507,431	4,720,293	1,047	21.44
Grand Trunk	88,290	50,586,328	1,206,818	738	17.60
Kansas City Southern	62,354	31,025,588	609,929	1,031	20.76
Norfolk Southern*	440,159	183,104,320	4,081,893	1,087	24.24
Soo Line	65,530	33,473,544	771,033	857	19.74
Union Pacific	1,063,201	525,297,747	10,336,081	1,037	20.41
Total – Industry Average	**3,504,731**	**1,700,544,017**	**32,957,041**	**1,072**	**20.78**

* and combined subsidiaries

[9] http://www.airgroup.com/standalone.php?action=air_spec

NOx and PM emission factors for rail carriers are based on industry averages. The freight rail gNO_x/ton-mile and g$PM_{2.5}$/ton-mile factors were developed 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[10]. 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 EPA determined would very closely align with the freight rail sector. This emissions inventory data was divided by the 2007 R-1 ton-mile data.

EPA developed the industry average freight rail g/mile factors 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[11]. The railcar miles were then converted into "truck-equivalent" railcar miles by estimating the average volume capacity of Class I railcars and dividing that by an average freight truck volume capacity. This results in a very crude estimate that does not take into consideration the utilized volume of railcars or the comparative freight truck, but EPA determined that this was the best available data and method to estimate modal average truck-equivalent railcar miles.

To estimate the industry average volume capacity of Class I railcars, the railcar miles reported by each company for each railcar type in their respective 2008 R-1 reports (lines 15-81) were multiplied by the volume-per-railcar assumptions in Table 7 below to obtain total Class I TEU-miles. EPA then divided the total railcar TEU-miles by the total railcar miles to estimate the industry average railcar volume capacity. EPA then divided this average railcar volume capacity (3.92) by the average freight truck volume capacity (2.78 TEUs) to develop the conversion factor - 1.41 railcar-miles-to-truck-miles.

EPA developed the NO_x and PM emission estimates 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*[12]. 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 5 presents the industry-average freight rail NOx and PM emissions factors in the tool and Table 6 presents the key underlying data.

Table 5. Illustrative U.S. Freight Rail Industry Average Factors

	NO_x	$PM_{2.5}$
gram/short ton-mile	0.4270	0.0120
gram/truck-equivalent mile	13.19	0.3569
gram/TEU-mile	4.745	0.1284

Table 6. Underlying Emissions Inventories and Activity Data for Illustrative U.S. Freight Rail Industry Average Factors

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*

Average payload 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 7. Rail Carrier Average Payload

Carrier	Avg Payload/Loaded Railcar (tons)
BNSF Railway	108
CSX Transportation	85
Grand Trunk	80
Kansas City Southern	91
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 8 below. 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 9 below.

Table 8. Railcar Volume Assumptions and Sources

Railcar Type	Cubic Feet	Source/Method
		Key: Norfolk Southern Railroad (NS)[13], Union Pacific Railroad (UP)[14], Burlington Northern Santa Fe Railroad (BNSF)[15], CSX Transportation Railroad (CSX)[16], World Trade Press Guide to Railcars (GTRC)[17], Chicago Rail Car Leasing (CRCL)[18], Union Tank Car Company (UTCC)[19], U.S Department of Agriculture (USDA)[20]
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)]. 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). Autoparts 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)]. Centerbeam 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*	7,428	Based on the average volumes of the flatcar types described above including multi-level as a single flat car type.

[13] http://www.nscorp.com/nscportal/nscorp/Customers/Equipment_Guide
[14] http://www.uprr.com/customers/equip-resources/cartypes/index.shtml
[15] http://www.bnsf.com/customers/how-can-i-ship/individual-railcar/#%23subtabs-3
[16] http://www.csx.com/index.cfm/customers/equipment/railroad-equipment/#boxcar_specs
[17] http://www.worldtraderef.com/WTR_site/Rail_Cars/Guide_to_rail_Cars.asp
[18] http://www.crdx.com/railcar.html
[19] http://www.utlx.com/bdd_tank.html
[20] 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: http://www.ers.usda.gov/publications/ah697/ah697.pdf

Railcar Type	Cubic Feet	Source/Method
Railcar Type	**Cubic Feet**	**Source/Method** ***Key:*** Norfolk Southern Railroad (NS)[13], Union Pacific Railroad (UP)[14], Burlington Northern Santa Fe Railroad (BNSF)[15], CSX Transportation Railroad (CSX)[16], World Trade Press Guide to Railcars (GTRC)[17], Chicago Rail Car Leasing (CRCL)[18], Union Tank Car Company (UTCC)[19], U.S Department of Agriculture (USDA)[20]
volume of "All Other Cars"]		
Gondola – all types Including equipped	5,190	Based on the average of the following gondala 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). 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).

Table 9. 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
Average Railcar Cubic Feet		**6,091**

Other Carrier Modes and Metrics

SmartWay plans to incorporate emission factors for ocean-going marine freight, and gram per volume-mile emission factors for all modes, in the near future.

% SmartWay Value

The **% SmartWay** screen tracks the portion of goods that shippers move with

SmartWay Partners (expressed as a percentage between 0 and 100). You may select either ton-miles or total miles as the basis for determining your % SmartWay Value. Note that the Tool will automatically populate the % SmartWay screen with any carrier activity data entered in the Activity Data screen. In addition, the metric selected for the first business unit (miles or ton-miles) will be chosen as the basis for your other business units as well, so that a company-level % SmartWay Value can be calculated. To see your company-level % SmartWay Value, calculated across all business units, go to the % SmartWay Report in the Reports Menu via the Home page.

3.0 Data Validation

The Logistics 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

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). Checks are applied at the carrier (row) level. Both direct payload inputs and indirect payload (derived from density and load % calculators) must be checked, using the same criteria for each. If Data Availability Options 3 or 6 are used, the following equation is used to calculate inferred payload:

Payload (tons) = (density/2000) x carrier average volume x (average load percent/100)

Payload checks are specific to the truck SmartWay Category, which is specified for each carrier in the Carrier Data File. For Truck carriers, the payload checks are consistent with the Class 8b payload checks currently in the Truck Tool, and are shown below in Table 10. (See the **Truck Tool Technical Documentation** for additional information.) Note that Ranges 1 and 5 are colored red in the Tool, and require explanations before proceeding. Ranges 2 and 4 are colored yellow, and explanations are optional.

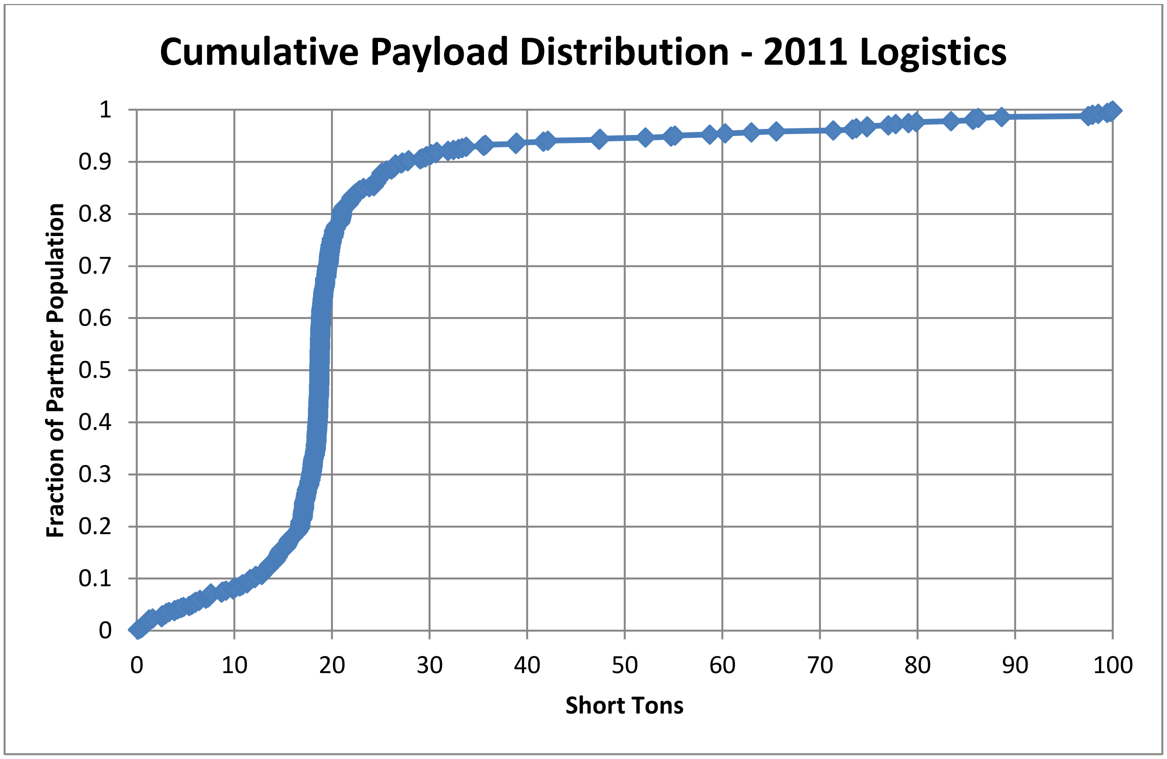
Table 10. Truck Carrier Payload Validation Ranges

Truck Bin Category	Range 1 Low	Range 1 High / 2 Low	Range 2 High / 3 Low	Range 3 High / 4 Low	Range 4 High / 5 Low	Range 5 High (Max)
LTL Dry Van (from Dry Van Single - LTL-Moving-Package)[21]	0.0	0.0	0.0	13.5	20.8	150.0
Package (from Dry Van Single - LTL-Moving-Package)[22]	0.0	0.0	0.0	13.5	20.8	150.0
TL Dry Van (from Dry Van Single - other bins)	0.0	10.5	14.5	22.4	26.4	150.0
Refrigerated	0.0	14.5	17.3	22.9	25.7	82.5
Flatbed	0.0	14.0	18.3	26.7	31.0	99.9
Tanker	0.0	19.1	22.0	27.8	30.7	103.8
Moving (from Dry Van Single – LTL-Moving-Package)	0.0	6.9	11.0	19.1	23.2	83.7
Specialized (from Specialty - Other bins)	0.0	20.2	22.9	28.3	31.1	111.0
Dray (from Chassis)	0.0	11.2	16.5	27.1	32.4	73.5
Auto Carrier	0.0	5.7	11.0	21.4	26.6	73.5
Heavy-Bulk	0.0	2.7	16.5	44.0	57.8	120.0
Utility (from Specialty – Other bins)	0.0	20.2	22.9	28.3	31.1	111.0
Mixed (from Other - Heavy-Flatbed-Mixed bins)	0.0	14.7	21.1	33.8	40.1	99.3
Expedited (from Dry Van Single - other bins)	0.0	10.5	14.5	22.4	26.4	150.0

With the exception of the LTL and package categories (which are based on 2013 data), all other logistic carrier payload validations are based on 2011 Logistics Partner data, and use simple cutoffs from the cumulative payload distribution shown in Figure 1 below.

[21] Since LTL and package shipments can be very small, no lower-bound "red/yellow" ranges are designated for LTL and package carrier payloads. Upper bound yellow and red ranges for LTL and package (and multi-modal) carriers were set equal to the average payload (6.20) plus twice the standard deviation (7.33) for logistics companies using these carrier types (n=991 for 2013 data).

Figure 1. Logistics Partner Payload Distribution



As can be seen in the figure, the payload distribution is highly non-normal, so use of validation cutoffs based on standard deviation is not appropriate. However, rough inflection points appear at approximately 10%, 20%, 80%, and 90%. As such, these values were used to specify the following payload validation cutoffs for logistics carriers.

- Range 1 Red: 0 – 12.0 tons
- Range 2 Yellow: 12.0 – 16.7 tons
- Range 3: 16.7 – 21.0 tons
- Range 4 Yellow: 21.0 – 27.2 tons
- Range 5 Red: 27.2 – 150 tons (150 absolute max)

Validation levels for rail and multi-modal carriers are summarized below. The upper bound cutpoints for multi-modal payloads are based on a qualitative review of 2011 multi-modal carrier tool submittals. The upper bound cutpoints for rail payloads are based on the distribution of average values estimated for Class 1 carriers (see Table 6 above).

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

In addition, the absolute upper bound for rail and multi-modal carriers have both been set at 200 tons.

Finally, any payload value less than or equal to zero will be flagged as an error and must be changed.

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.