SECTION 6 HEAVY-DUTY VEHICLES

This section present emissions estimates for heavy-duty vehicles source category, including source description (6.1), geographical delineation (6.2), data and information acquisition (6.3), operational profiles (6.4) the emissions estimation methodology (6.5), and the emissions estimates (6.6).

6.1 Source Description

Trucks are used extensively to move cargo, particularly containerized cargo, to and from the terminals that serve as the bridge between land and sea transportation. Trucks deliver cargo to local and national destinations, and they also transfer containers between terminals and off-port railcar loading facilities, an activity known as draying. In the course of their daily operations, trucks are driven onto and through the terminals, where they deliver and/or pick up cargo. They are also driven on the public roads within the Port boundaries, and on the public roads outside the Port.

This report deals exclusively with diesel-fueled HDVs, as there were few, if any, gasoline-fueled or alternatively-fueled counterparts in use in 2006. The most common configuration of HDV is the articulated tractor-trailer (truck and semi-trailer) having five axles, including the trailer axles. The most common type of trailer in the study area is the container trailer, built to accommodate standard-sized cargo containers. Additional trailer types include tankers, boxes, and flatbeds. A tractor traveling without an attached trailer is called a "bobtail." A tractor pulling an unloaded container trailer chassis is known simply as a "chassis." These vehicles are all classified as heavy HDVs regardless of their actual weight because the classification is based on gross vehicle weight rating (GVWR), which is a rating of the vehicle's total carrying capacity. Therefore, the emission estimates do not distinguish among the different configurations. As examples of typical HDVs, Figure 6.1 shows a container truck transporting a container in a terminal. The equipment images shown in the figures are not photographs of actual pieces of equipment used at the surveyed terminals but are for illustrative purposes only.

Figure 6.1: Truck with Container

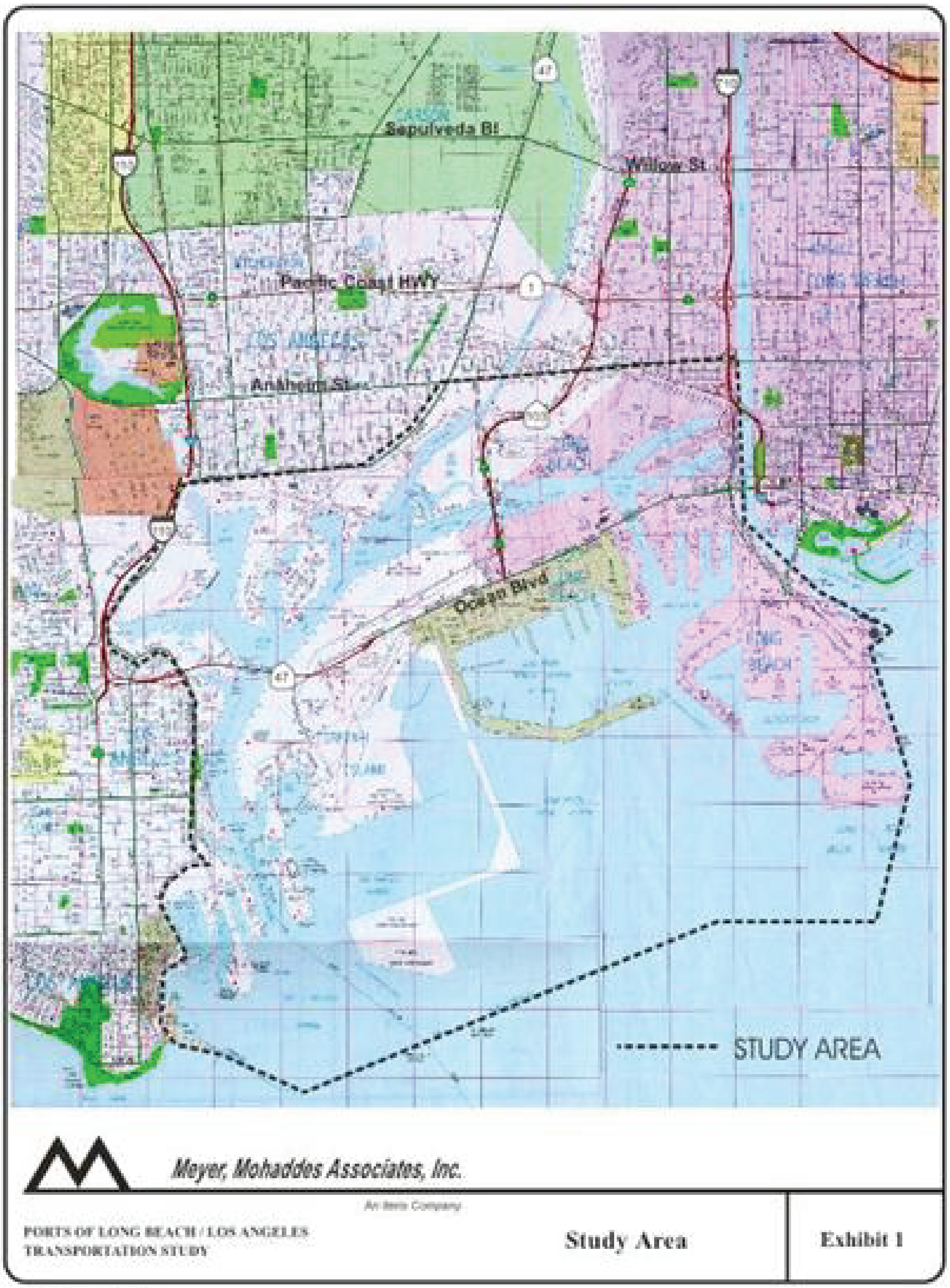
6.2 Geographical Delineation

To develop emission estimates, truck activities have been evaluated as having three components:

- On-terminal operations, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.
- Off-terminal Port operations, consisting of travel on public roads within the Port jurisdictional boundaries.
- Onroad operations outside the Port boundaries but within SoCAB. This includes travel within the boundaries of the adjacent Port of Los Angeles, because the routes many trucks take run through both ports on the way to and from Port terminals.

Figure 6.2 shows the roadways in and around the Port that the HDVs use in daily operations. The figure presents the scope of a traffic study that evaluated traffic patterns in both the Port of Los Angeles and the Port of Long Beach. That traffic study and its use in developing the HDV emission estimates presented in this report are discussed in more detail in the following subsections.

Figure 6.2: Port and Near-Port Roadways



6.3 Data and Information Acquisition

Data for the HDV emission estimates came from two basic sources: terminal interviews and computer modeling of onroad HDV volumes, distances, and speeds. These information sources are discussed below.

6.3.1 On-Terminal

The Port and their consultant collected information regarding on-terminal truck activity during in-person and telephone interviews with terminal personnel. This information included their gate operating schedules, on-terminal speeds, time and distance traveled on terminal while dropping off and/or picking up loads, and time spent idling at the entry and exit gates. Most terminals were able to provide estimates of these activity parameters, although few keep detailed records of information such as gate wait times and on-terminal turn-around time. However, the reported values appear to be reasonable and have been used in estimating on-terminal emissions, except as noted in the following text.

6.3.2 Off-Terminal

The Port retained a consultant (Iteris, previously known as Meyer Mohaddes Associates) to develop estimates of onroad truck activity inside and outside the Port. To do this, the consultant used trip generation and travel demand models they have used in previous Port transportation studies[50] to estimate the volumes (number of trucks) and average speeds on roadway segments between defined intersections.

The trip generation model was derived from a computer model designed to forecast truck volumes that was developed by Moffatt & Nichol Engineers (M&N), who were team members on the 2001 Port Transportation Study. The Port's consultant developed and validated the trip generation model using terminal gate traffic count data. They reported in their traffic study report that the model validation confirmed that the model was able to predict truck movements to within two to 10 percent of actual truck counts for all the container terminals combined, and to within 15 percent or better for the majority of individual terminals (MMA 2001). These were considered to be excellent validation results considering the variability of operating conditions and actual gate counts on any given day. The main input to the trip generation model for this study consisted of the average daily container throughput in 2006.

[50] Meyer, Mohaddes Associates, Inc. *Ports of Long Beach/Los Angeles Transportation Study*, June 2001 (MMA 2001) and Meyer, Mohaddes Associates, Inc. *Port of Los Angeles BaselineTransportation Study (April 2004).*

The results of the trip generation model were used as input to a Port-area travel demand model also developed by Iteris. This model was based on the regional model used for transportation planning by the Southern California Association of Governments (SCAG), the federally designated metropolitan planning organization for the SoCAB area. Iteris incorporated Port-specific truck travel information from the trip generation model, as well as the results of an origin/destination survey of approximately 3,300 Port-area truck drivers, into the Port-area travel demand model.

The travel demand model produced terminal-specific estimates of truck traffic volumes and speeds over defined Port roadway segments. A brief example is provided in Table 6.1. The traffic volumes and distances were combined to produce estimates of vehicle miles of travel (VMT), which in turn were used with the speed-specific EMFAC emission factors (discussed below) to estimate on-Port onroad driving emissions associated with each container terminal. The same model was used to produce estimates of Port-related truck traffic traveling through the POLB, such as toward the 710 Freeway across Terminal Island.

The roadway volumes of truck traffic outside the Port area was estimated by Iteris using a regional analysis that modeled Port-related trucks bi-directionally on highways and major thoroughfares within the greater Los Angeles area until the trucks leave the highways and enter city streets. The intent was to model Port-related trucks on their way from the Port until they make their first stop, whether for delivery of a container to a customer or to a transloading facility, or reach the boundary of the South Coast Air Basin. Transloading is the process of unloading freight from its overseas shipping container and re-packing it for overland shipment to its destination.

Table 6.1: Onroad HDV Activity Modeling Results – Example

Roadway Segment	From	To	Direction	Bobtails	Chassis	Con-tainers	Dist. miles	Speed mph
Anaheim St	Anaheim Wy	9th Street	East Bound	313	62	366	0.65	40
Santa Fe	Canal	Santa Fe	East Bound	71	-	57	0.18	20
Canal	Harbor	Canal	East Bound	95	13	131	0.21	29
Henry Ford	SR-47 SB Off Ramp	Henry Ford	East Bound	96	46	301	0.69	40

6.4 Data and Information Acquisition

Based on the data and information collected, activity profiles were developed for on-terminal and off-terminal truck traffic, as described below.

6.4.1 On-Terminal

Table 6.2 illustrates the range and average of reported characteristics of on-terminal truck activities at Port container terminals. The total number of trips was based on information provided by the terminals.

Table 6.2: Summary of Reported Container Terminal Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	15	1.5	NA	0.08	0.83	0.08
Minimum	5	0.5	NA	0.03	0.33	0.00
Average	6	0.8	NA	0.07	0.57	0.03
Total			**4,040,535**			

Table 6.3 shows the same summary data for the terminals and facilities other than container terminals. The total number of trips was based on information provided by the terminals.

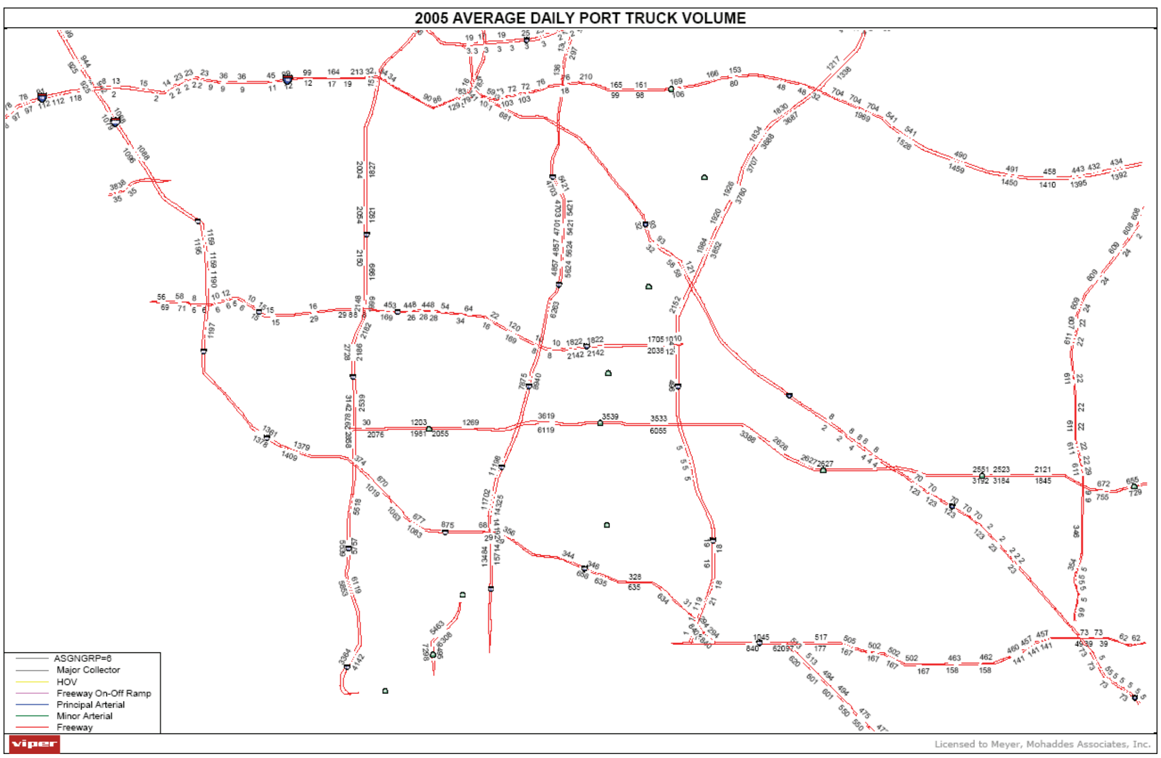
Table 6.3: Summary of Reported Non-Container Facility Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	10	0.5	NA	0.16	0.75	0.10
Minimum	5	0.0	NA	0.00	0.00	0.00
Average	6	0.2	NA	0.03	0.14	0.02
Total			**350,412**			

6.4.2 Off-Terminal

Figure 6.3 provides a graphical example of the regional analysis, a map of area roadways listing the number of trucks on each segment of road, in each direction of travel. The information on these maps was incorporated into the same calculations as used for the in-port onroad estimates described above. The daily traffic estimates are based on average week-day activity during a peak month. They have been annualized for the emission estimates presented in this inventory by adjusting for peak to average conditions on the basis of 255 weekdays of terminal operation per year, and assuming that weekend activity accounts for 15% of total annual activity. These adjustments are empirically derived factors used by the Port in their planning processes requiring annualization of daily activity measures.

Figure 6.3: Regional Traffic Volume Map



During the Technical Working Group's (TWG) review of the draft 2005 emissions inventory report the traffic modeling discussed above was extensively examined with respect to two key components: the number of truck trips to and from Port terminals and the total number of miles these trips generated within the Air Basin. The review took place over several meetings of the TWG (which included staff members from Port, consultant, CARB, SCAQMD and EPA Region 9) and primarily consisted of reconciling the trip and VMT estimates produced by the terminal and regional models with independent estimates prepared by CARB.

In comparison with the independent activity estimates developed by CARB, the model results on which this inventory is based are considerably higher. The CARB model is focused on container truck traffic and estimates considerably lower VMT than the Port models' estimates for container traffic alone. As a result of the discrepancy, the San Pedro Bay Ports and CARB, along with SCAQMD, have pledged to continue working together to understand the differences in the methodologies and to conduct the reviews and studies necessary to reconcile them to ensure the best, most supportable estimates possible for upcoming revisions to the Ports' inventories.

6.5 Methodology

This section discusses how the emission estimates used in this analysis were developed based on the data collected from terminals operators or through traffic modeling. Figure 6.4 illustrates this process in a flow diagram format for the three components of the HDV evaluation previously discussed (on-terminal, on-Port, and regional components). It is important to note that the speed specific grams per mile emission rates estimated by CARB's EMFAC 2007 model were used in support of this analysis. However, because EMFAC does not directly report the gram per hour emission rates associated with idle engine operation, CARB's published low idle emission rates, rather than the modeled output was used.

This subsection describes the specific methodology used to develop the emission estimates for HDVs in the various locations described above. The general form of the equation for estimating the emissions inventory for a fleet of onroad vehicles is:

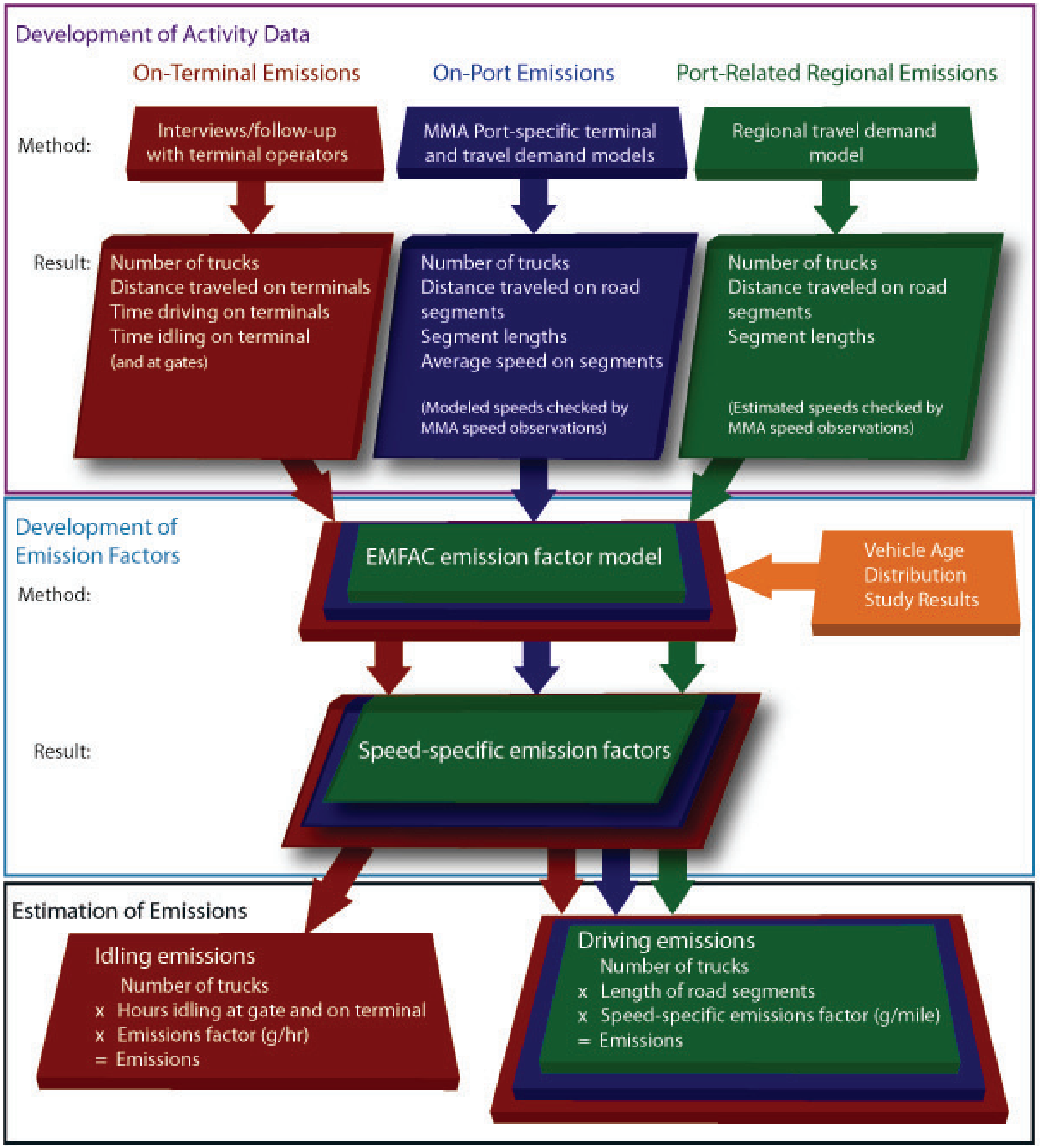
Equation 6.1

Emissions = Population x Basic Emission Rate x Activity x Correction Factor

Where:

Population = number of vehicles of a particular model year in the fleet
Basic Emission Rate = amount of pollutants emitted per unit of activity for vehicles of that model year
Activity = the average number of miles per truck
Correction Factor = adjustment to Basic Emission Rate for specific assumptions of activity and/or atmospheric conditions

Figure 6.4: HDV Emission Estimating Process



The basic emission rate is modeled as a straight line with a "zero mile rate" (ZMR) or intercept representing the emissions of the vehicle when new (well maintained and un-tampered), plus a "deterioration rate" (DR) or slope representing the gradual increase in the emission rate over time or as a function of use (mileage). For heavy duty diesel trucks the deterioration rate is expressed as grams per mile traveled per 10,000 accumulated miles.

Equation 6.2

Basic Emission Rate = ZMR + (DR x Cumulative Mileage /10,000)

In estimating the emissions from heavy-duty trucks, two types of activity can be considered: running emissions that occur when the engine is running with the vehicle moving at a given speed, and idle emissions that occur when the engine is running but the vehicle is at rest. Running emissions are expressed in grams per mile, while idle emissions are expressed in grams per hour. The emission factors (g/mi or g/hr) are multiplied by the activity estimates, VMT or hours of idle operation, to derive a gram per day (g/day) or gram per year inventory.

6.5.1 The EMFAC Model

The CARB has developed a computer model to calculate the emissions inventories of various vehicle classes in the California fleet. EMFAC 2007, the latest official version of the model, has been approved by the EPA for use in California and this model, with noted exceptions, was used to estimate the emissions of heavy-heavy-duty diesel trucks that call on the Port.

Although the EMFAC model produces ton per day estimates of emissions by vehicle class, it is generally a macro-scale model that is inappropriate for estimating inventories at a sub-county level. In order to calculate the inventory of emissions for Port-related heavy-duty trucks, the emission factors and correction factors from EMFAC were coupled with Port specific truck activity estimates.

6.5.2 Basic Emission Rates

The basic emission rates of heavy-duty diesel trucks included in EMFAC are derived from tests of vehicles randomly selected from the in-use fleet. Because CARB has imposed progressively more stringent standards for the allowable emissions from trucks over many years, different model years of trucks have been certified to specific standards and, therefore, are assumed to emit at different rates. Table 6.4 lists the emission factors used to estimate the emission of trucks visiting the Port.

Table 6.4: Emission Factors in EMFAC 2007 (ZMR in g/mi – DR in g/mi/10,000mi)

Model Years	HC		CO		NO_x		PM		CO_2	
	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR
Pre-87	1.20	0.027	7.71	0.176	23.0	0.019	1.73	0.028	2237	0.00
87-90	0.94	0.032	6.06	0.209	22.7	0.026	1.88	0.025	2237	0.00
91-93	0.62	0.021	2.64	0.090	19.6	0.039	0.78	0.014	2237	0.00
94-97	0.46	0.024	1.95	0.103	19.3	0.046	0.51	0.011	2237	0.00
98-02	0.47	0.024	1.99	0.103	18.9	0.053	0.56	0.010	2237	0.00
03-06	0.30	0.011	0.87	0.031	12.5	0.052	0.35	0.005	2237	0.00

CARB has included an update to the idle emissions rates for heavy-duty diesel trucks and their "low idle" emission rates were used in developing the emissions inventory for the Port. These factors are presented in Table 6.5.

Table 6.5: Idle Emission Rates in EMFAC 2007 (g/hr)

Model Years	HC	CO	NO_x	PM	CO_2
Pre-1987	25.9	28.4	45.7	4.76	4,640
1987-90	15.2	23.4	70.2	2.38	4,640
1991-93	12.1	21.5	78.4	1.78	4,640
1994-97	9.68	19.8	85.3	1.33	4,640
1998-02	7.26	17.8	92.1	0.92	4,640
2003-06	5.97	16.6	95.5	0.72	4,640

A more in-depth explanation of CARB's heavy-duty diesel inventory estimation methodology can be found in their document "*Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors*"[51] 3 April 2006.

[51] See *http://www.arb.ca.gov/msei/supportdocs.html#onroad*.

While most emissions from heavy-heavy duty diesel trucks are estimated on a per-mile or per-hour basis, the inventory of SO_x was calculated based upon an estimate of the amount of fuel consumed. The following equation was used to derive the SO_x inventory.

Equation 6.3

$$SO_x \text{ emissions (tpd)} = \frac{(X \text{ g S}/1{,}000{,}000 \text{ g fuel}) \times (3{,}311.21 \text{ g/gallon}) \times (2 \text{ g } SO_x/\text{g S}) \times (Y \text{ miles/day})}{(5.268 \text{ miles/gallon}) \times (453.59 \text{ g/lb} \times 2{,}000 \text{ lbs/ton})}$$

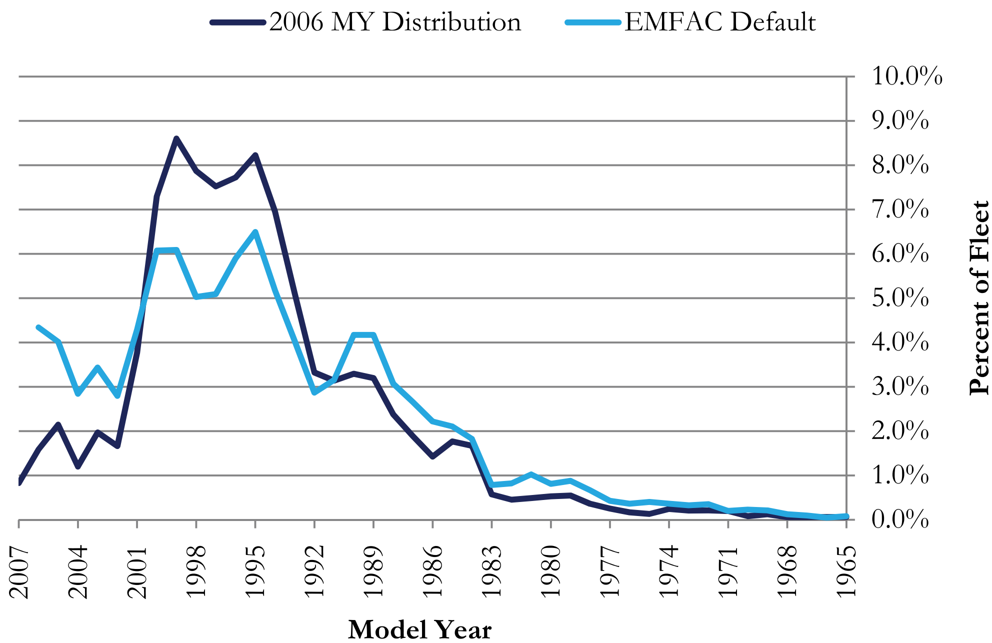
In this equation, g is grams, S is sulfur, and lb is pounds. The emission calculations have been based on the introduction of 15 ppm ULSD as commercially available onroad diesel fuel at the beginning of September 2006. The weight of a gallon of diesel fuel is assumed to be 7.3 pounds or 3,311.21 grams (7.3 lbs x 453.59 g/lb). Based on the EMFAC model, the fleet average fuel economy of the heavy-heavy duty diesel fleet is assumed to be 5.268 miles per gallon. The estimates of daily vehicle miles of travel were from the Iteris trip generation and travel demand modeling for in-Port and regional onroad travel, and were derived through tenant surveys for the on-terminal estimates.

6.5.3 Age Distribution

The age distribution (count of vehicles by model year) of trucks calling upon the Port of Long Beach was determined through evaluation of license plate numbers provided by several container terminals. This is an on-going project of the two Ports and the age distribution will be updated periodically as new data is received and evaluated.

Just over 2,000,000 records were received from the terminals, which yielded about 49,000 unique license plate numbers. Registration information was requested from the California Department of Motor Vehicles and 29,540 records were returned with model year information. The distribution of the truck population by age is presented in Figure 6.6 below. The underlying age distribution table is in Appendix D. The average age of the Port-related fleet was determined to be 11.4 years, which is in reasonable agreement with the EMFAC estimate of heavy-duty diesel trucks in operation within the South Coast Air Basin of 11.5 years. While the average age is similar, the EMFAC distribution includes a greater proportion of trucks in the newest age range (up to seven years old) and correspondingly fewer trucks in the eight to 13-year age range.

Figure 6.5: Population Distribution of the Heavy-Duty Truck Fleets



EMFAC carries an estimate of 45 model years of population within each calendar year ranging from the newest, for which the model year is the same as the current calendar year, to the oldest where the model year is the current calendar year minus 45. Therefore, EMFAC does not allow the model year to be greater than the current calendar year.

6.5.4 Mileage Accrual Rates/Cumulative Mileage

For purposes of this analysis, 2007 model year trucks that were in the sample of license plates provided by the terminals were assumed to have the same activity as 2006 model year trucks. Since no data were available to estimate the actual mileage of each truck visiting the Ports, the mileage accrual rates from EMFAC were used. The mileage accrual rates are the estimates of the miles traveled each year by vehicles of a specific age and type of vehicle. When vehicles are new, the mileage accrual rates are assumed to be at their highest. The miles per year tend to decline as the truck ages.

CARB has also modified the mileage accrual rates used in EMFAC as discussed in their document entitled *Redistribution of Heavy-Heavy Duty Diesel Truck Vehicle Miles Traveled in California,* 13 September 2006.[52] The mileage accrual rates included in the EMFAC 2007 update and used in this analysis are shown in Table 6.6.

[52] See: *http://www.arb.ca.gov/msei/supportdocs.html#onroad.*

Table 6.6: Mileage Accrual Rates Heavy-Heavy Duty Diesel Trucks in EMFAC 2007 (mi/yr)

Truck Age (years)	Miles/Year	Truck Age (years)	Miles/Year	Truck Age (years)	Miles/Year
1	80,705	13	43,854	25	16,662
2	85,152	14	39,965	26	15,164
3	86,460	15	36,504	27	13,653
4	85,386	16	33,452	28	12,136
5	82,571	17	30,772	29	10,629
6	78,547	18	28,417	30	9,159
7	73,755	19	26,335	31	7,759
8	68,546	20	24,469	32	6,467
9	36,199	21	22,764	33	5,324
10	57,926	22	21,171	34	4,369
11	52,881	23	19,645	35	3,363
12	48,169	24	18,150	36+	3,363

The cumulative mileage of a vehicle is assumed to be the sum of its mileage accrual rates. That is, for a three year old truck, for example, the average odometer reading would be assumed to be 252,317 miles, or 80,705 + 85,152 + 86,386. In turn, the cumulative mileage is used to assess the level of deterioration to be added to the basic emission rate (see above).

In keeping with our example of a three year old truck, the basic emission rate for NO_x would be calculated as follows:

Equation 6.4

18.9 g/mi (ZMR) + 0.053 g/mi/10K miles (DR) x 252,317 miles (Cumulative Mileage) = 20.24 g/mi

A population weighted basic emission rate for each pollutant was derived performing the calculation above for each model year; the results were then weighted by the population fraction in each model year. These fleet weighted emission rates are presented in Table 6.7.

Table 6.7: Heavy Heavy-Duty Diesel Truck Fleet Weighted Emission Rates

Pollutant	Emission Rate (g/mile)
HC	1.875
CO	13.182
NO_x	20.992
PM	1.515

6.5.5 Correction Factors

As stated earlier, correction factors are used to adjust the basic emission rates to reflect vehicle specific activity such as speed and type and quality of fuel burned, and specific ambient conditions such as temperature and relative humidity. In order to better reflect the emissions of the Port truck fleet, the basic emission rates were adjusted for both fuel and speed.

Fuel correction factors are applied to adjust for differences in the fuel used during certification or in-use testing, and the fuel used in routine operation. According to CARB's memo in which the EMFAC 2007 heavy-duty diesel emission rates are discussed, the reported emission factors represent pre-clean diesel rates. CARB diesel has a lower sulfur and aromatic hydrocarbon content compared to pre-clean diesel. According to CARB's memo entitled "*Onroad Emissions Inventory Fuel Correction Factors*," 26 July 2005, a 28 percent reduction in HC, 25 percent reduction in NO_x and a seven percent reduction in PM should be applied to the basic emission rates to reflect the benefits of CARB diesel. The fuel correction factors are applied as multiplicative modifiers to the basic emission rates. That is, a 25 percent reduction would yield a correction factor of 0.75. Table 6.8 lists the diesel fuel correction factors.

Table 6.8: CARB Diesel Fuel Correction Factors

Pollutant	Fuel Correction Factor
HC	0.72
CO	1.0
NO_x	0.93
PM	0.75

Speed is used as a surrogate for the work of the engine or load and emissions tend to increase or decrease as load increases or decreases. The basic emission rates are derived from testing vehicles over a reference cycle with a single average speed of about 20 miles per hour (the Urban Dynamometer Driving Schedule or UDDS). Speed correction factors adjust the basic emission rates for cycles or trips of differing speeds.

As running emissions are expressed in terms of grams per mile, the speed correction factors tend to be higher at the extremes of speed. At high speeds, the vehicle's engine has to work harder to overcome wind resistance and emissions tend to increase as a consequence. At low speeds, the vehicle has to overcome inertia and rolling resistance. Although emissions tend to be lower at lower speeds, as the distance approaches zero the grams/mile ratio increases. The result is a generally "U" shaped curve describing the impact of speed on emissions.

In the current version of EMFAC, at least two pollutant specific speed correction factors are needed to properly characterize the emissions of the heavy-duty truck fleet. The equation and coefficients needed to derive the speed correction factors included in EMFAC 2007 are described in CARB documentation[53].

Equation 6.5

$$\textit{Speed Correction Factor} = A + (B \times \textit{Speed}) + (C \times \textit{Speed}^2)$$

Table 6.9 lists the speed correction factor coefficients.

[53] Amendment to EMFAC Modeling Change Technical Memo, "*Revision of Heavy Heavy-duty Diesel Truck Emission factors and Speed Correction Factors*,"20 October 2006.

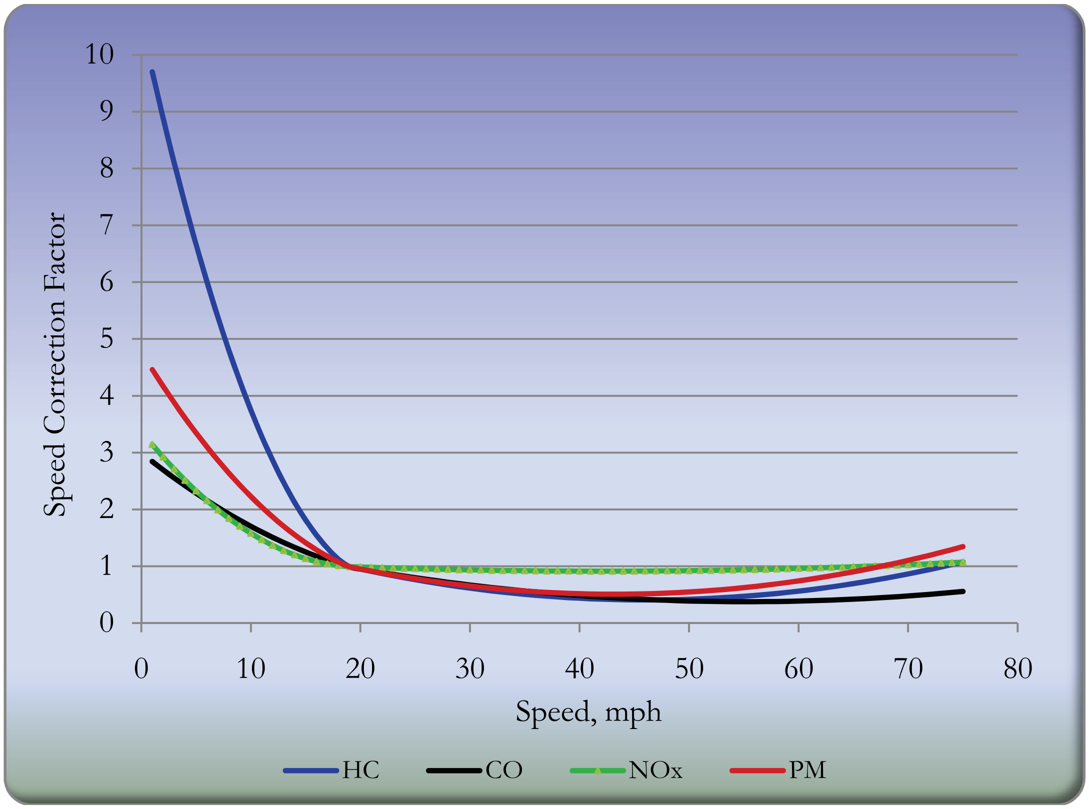
Table 6.9: CARB Speed Correction Factor Coefficients

Pollutant	Model Year Group	Speed Range	A	B	C
HC	**Pre-1991**	5.00 - 18.8	7.1195	-0.4789	0.008159
		18.8 - 65.0	1.6373	-0.04189	0.0003884
	1991-2002	5.00 - 18.8	11.614	-0.9929	0.02278
		18.8 - 65.0	2.3019	-0.08712	0.0009773
	2003+	5.00 - 18.8	10.219	-0.8937	0.02146
		18.8 - 65.0	1.6053	-0.03799	0.0002985
CO	**Pre-1991**	5.00 - 65.0	1.6531	-0.04198	0.0003352
	1991-2002	5.00 - 18.8	3.0388	-0.1511	0.002267
		18.8 - 65.0	1.8753	-0.05664	0.0005141
	2003+	5.00 - 18.8	6.2796	-0.5021	0.01177
		18.8 - 65.0	1.3272	-0.02463	0.000336
NO_x	**Pre-1991**	5.00 - 18.8	2.2973	-0.1173	0.002571
		18.8 - 65.0	1.3969	-0.02658	0.0002725
	1991-2002	5.00 - 18.8	3.7668	-0.2862	0.007394
		18.8 - 65.0	1.0771	-0.005981	0.00009271
	2003+	5.00 - 18.8	2.7362	-0.148	0.002958
		18.8 - 65.0	1.5116	-0.03357	0.0003118
PM	**Pre-1991**	5.00 - 18.8	2.6039	-0.1266	0.002198
		18.8 - 65.0	1.4902	-0.03121	0.0002733
	1991-2002	5.00 - 18.8	5.7807	-0.4032	0.007918
		18.8 - 65.0	2.2766	-0.08661	0.0009948
	2003+	5.00 - 18.8	1.4086	-0.02313	0.00007449
		18.8 - 65.0	1.4881	-0.0408	0.0007894

These speed correction factors were used to derive speed specific emission factors for each pollutant at 5 mile per hour increments for use in this analysis. This was accomplished by deriving the model year and pollutant specific speed correction factors and then weighting each factor by the population of Port trucks in each model year group. Figure 6.6 shows the fleet weighted speed correction factors for each pollutant.

The speeds used in the onroad emission calculations were estimated by the travel demand modeling discussed previously. The on-terminal speeds are those reported as average on-terminal speeds by the respective terminal operators.

Figure 6.6: Fleet Weighted Speed Correction Factors



6.6 Emission Estimates

On-terminal and onroad emissions have been estimated by terminal and are summed to represent Port-wide emissions. As discussed above, on-terminal emissions are based on terminal-specific information such as number of trucks passing through the terminal and the distance they travel on-terminal, and the Port-wide totals are the sum of the terminal-specific estimates. The on-Port onroad emissions were estimated on a terminal-specific basis for the container terminals, using the travel demand modeling results discussed above, which estimated how many trucks from each container terminal traveled along each section of road within the port. The off-Port onroad emissions were estimated for Port trucks in general (not terminal-specific) in a similar manner to the on-Port estimates, using travel demand model results to estimate how many trucks travel along defined roadways in the SoCAB on the way to their first cargo drop-off point. In most cases, emissions have been allocated to the non-container terminals using a ratio approach based on the number of trucks visiting each non-container terminal relative to the total number of container terminal truck calls. This approach was used because the in-Port travel demand model does not include terminal-specific estimates for Port terminals other than container terminals. The ratio approach assumes that the trucks servicing non-container terminals have the same general activity patterns as trucks servicing the container terminals, in terms of speed and mileage within the Port and in the region.

Idling emissions were estimated separately for the on-terminal estimates, since the off-terminal traffic modeling analysis reported only volumes, distances, and average speeds, which were used to estimate VMT. This is a valid approach because the average speeds include estimates of normal traffic idling times and the emission factors are designed to take this into account. Since annual activity was used for the on-terminal analysis, emissions have been calculated as tons per year, with idling and transit activities estimated separately. Table 6.10 summarizes the two modes of on-terminal operation by terminal type.

Table 6.10: 2006 On-Terminal VMT and Idling Hours by Terminal ID

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	185,737	252,602
Container	320,047	603,822
Container	211,642	186,245
Container	869,181	424,160
Container	285,765	116,211
Container	306,317	471,728
Container	597,886	752,893
Liquid	200	167
Break bulk	5,760	5,280
Dry Bulk	4,292	5,007
Break bulk	1,948	0
Liquid	1,839	4,634
Break bulk	3,250	2,080
Dry Bulk	2,745	0
Dry Bulk	1,300	433
Dry Bulk	19,000	833
Break bulk	8,750	7,350
Dry Bulk	3,990	2,450
Dry Bulk	78	910
Break bulk	395	0
Break bulk	19,991	20,491
Liquid	2,650	2,208
Auto	9,255	23,138
Break bulk	1,950	1,248
Total	**2,863,967**	**2,883,891**

Emission estimates for HDV activity associated with Port terminals and other facilities are presented in the following tables. Tables 6.11 and 6.12 summarize emissions from HDVs associated with all Port terminals. Figure 6.7 illustrates the distribution of emissions among the on-terminal, on-port/onroad, and off-port/onroad components of HDV activity.

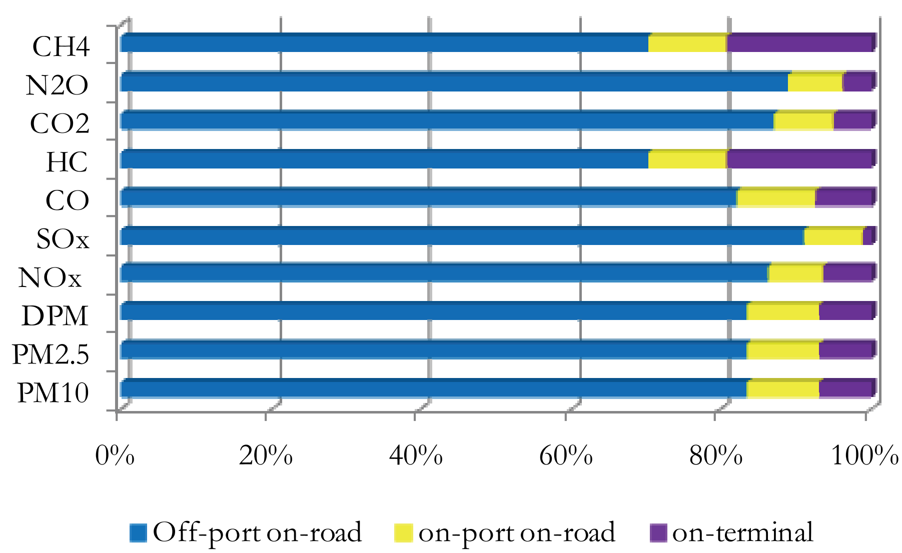
Table 6.11: HDV Emissions, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	2,863,967	21.3	19.6	21.3	419.8	0.4	156	89.8
On-Port On-Road	19,240,515	29.4	27.0	29.4	477.8	2.4	217.8	49.5
Off-Port On-Road	223,985,076	256.5	235.9	256.5	5,662.9	28.7	1,723.8	328.1
Total	**246,089,558**	**307.1**	**282.6**	**307.1**	**6,560.6**	**31.52**	**2,097**	**467.4**

Table 6.12: GHG HDV Emissions, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	2,863,967	26,570.3	2.7	4.2
On-Port On-Road	19,240,515	41,627.0	5.1	2.3
Off-Port On-Road	223,985,076	461,183.2	62.3	15.2
Total	**246,089,558**	**529,380.5**	**70.0**	**21.7**

Figure 6.7: Distribution of HDV Emissions



Tables 6.13 through 6.16 show emissions associated with container terminal activity separately from emissions associated with other Port terminals and facilities.

Table 6.13: HDV Emissions Associated with Container Terminals, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	2,776,574	20.7	19.0	20.7	408.2	0.4	151	87.2
On-Port On-Road	17,716,864	27.1	24.9	27.1	440.0	2.25	201	45.6
Off-Port On-Road	206,247,768	236.1	217.3	236.1	5,214.5	26.4	1,587	302.1
Total	**226,741,207**	**283.9**	**261.2**	**283.9**	**6,062.6**	**29.05**	**1,939**	**434.9**

Table 6.14: GHG HDV Emissions Associated with Container Terminals, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	2,776,574	25,821.6	2.6	4.0
On-Port On-Road	17,716,864	38,330.6	4.7	2.1
Off-Port On-Road	206,247,768	424,662.2	57.4	14.0
Total	**226,741,207**	**488,814.4**	**64.6**	**20.2**

Table 6.15: HDV Emissions Associated with Other Port Terminals, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	87,393	0.6	0.6	0.6	11.7	0.0	4	2.6
On-Port On-Road	1,523,650	2.3	2.1	2.3	37.8	0.2	17	3.9
Off-Port On-Road	17,737,308	20.3	18.7	20.3	448.4	2.3	137	26.0
Total	**19,348,351**	**23.3**	**21.4**	**23.3**	**498.0**	**2.48**	**158**	**32.5**

Table 6.16: GHG HDV Emissions Associated with Other Port Terminals, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	87,393	748.8	0.1	0.1
On-Port On-Road	1,523,650	3,296.4	0.4	0.2
Off-Port On-Road	17,737,308	36,521.0	4.9	1.2
Total	**19,348,351**	**40,566.1**	**5.4**	**1.5**