

Performance Measure Evaluation of Port Truck Trip Reduction Strategies

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Abstract

The Ports of Long Beach and Los Angeles are the largest container port complex in North America and fifth largest in the world. Growth in U.S. Pacific Rim trade has put pressure on the landside transportation systems serving these two ports. In order to address this growth and mitigate environmental impacts, the ports are implementing new operational strategies and infrastructure improvements. Recently, the ports evaluated the prospective performance improvements that an aggressive program of truck trip reduction strategies can achieve. Strategies that have been evaluated include extended gate hours, virtual container yards, expanded on-dock rail facilities, a new near-dock rail intermodal terminal, and an inland rail shuttle service. This paper describes the approach taken to forecast several of the performance measures that were used to evaluate the strategies. These performance measures are change in truck trips generated at the ports, changes in port truck vehicle miles traveled (VMT), changes in weekday port truck traffic by time period on Interstate 710 (the principal access road to the port), and changes in port-related air pollutant emissions.

The evaluations relied heavily on the use of the QuickTrip truck trip generation model developed as part of the port's travel demand model. QuickTrip is a spreadsheet model that estimates truck trips by truck type on an hourly basis. The trips generated are a function of inputs such as monthly container cargo volumes, mix of import vs. export cargo volumes, mix of local vs. intermodal cargo, distribution of pickup and delivery activity by labor shift, the

amount of on-dock vs. off-dock rail, and the amount of empty container re-use that occurs without returning empties to the port storage areas. The port travel demand model was used to estimate VMT reductions and impacts on key access roads. Detailed analysis of on-dock rail terminal and line capacities were also conducted in order to determine potential opportunities to increase rail activity. Standard emission modeling methodologies for truck and rail modes were used to evaluate environmental benefits of the strategies, taking into account the age and emissions characteristics of the trucking fleet serving the ports and the early introduction of Tier II locomotives in the South Coast Air Basin. The evaluation shows that while all of the strategies can positively contribute to increased efficiency of landside transportation systems, the relative ranking of the measures depends on the specific objectives of the program (i.e., emissions reductions, congestion relief on regional roadways, or localized congestion relief).

Introduction

The Ports of Long Beach and Los Angeles are the largest container ports in the United States and together, rank third among port complexes in the world. Over the last decade, several trends have combined to create extremely rapid growth in cargo volumes moved through the twin port complex. The growth in global sourcing of industrial supply chains, the expanding appetite of U.S. consumers for goods manufactured more inexpensively overseas, and concentration of carrier operations and warehouse and distribution facilities in load center port areas have all contributed to growth in the LA/Long Beach share of West Coast and national container cargo. Rapid growth at the ports is a two-edged sword for Southern California and the communities in immediate proximity to the ports. On the one hand, the port and related businesses supporting the international trade economy have contributed substantially to the

Southern California economy, representing one of the fast growing industry sectors and providing a source of good jobs. Nonetheless, the ports also generate much heavy truck traffic that contributes to local congestion on major access routes, is a major source of air pollution, creates significant safety challenges, and causes wear and tear on the region's highways. This situation has caused the ports to evaluate a wide range of creative strategies for accommodating the high rates of expected growth while reducing or minimizing negative impacts on the surrounding communities and the Southern California region. This paper presents an analysis of a specific program of alternatives that the ports will be undertaking over the next several years. The paper is based on a study conducted by the Ports, in partnership with the Alameda Corridor Transportation Authority (ACTA), to evaluate strategies for reducing truck trips generated by the ports and their associated impacts. The strategies that were evaluated represent realistic options for which each of the partners can play an implementation role, and that are expected to have measurable impacts on traffic and emissions. Some of these strategies are already being implemented in some form, while others have progressed to later planning and engineering phases.

Performance Measures

Performance measures are useful tools for comparing the effectiveness of different strategies in meeting program objectives. For this study, performance measures were selected that show how effective the strategies are at mitigating impacts that are believed to be some of the more negative local consequences of growth in trade. Since this is a planning study, the performance measures were also selected so that they could be implemented with existing tools and data and at reasonable cost. The measures that were evaluated in this study were:

- **Changes in port truck trips generated.** This was the easiest and most direct way to measure the impact of the strategies, and is closely related to the primary criteria for selecting the strategies to be evaluated; that is, the strategies were designed to reduce truck trips.
- **Changes in port truck Vehicle Miles Traveled (VMT).** Truck VMT is directly related to the amount of congestion, emissions, accidents, and roadway damage that can be attributed to port trucks. Depending on the types of truck trips that are eliminated, a strategy can have a larger proportional impact on changes in port truck trips as compared to port truck VMT, or vice versa.
- **Port truck trips on major access roadways.** Growth in port truck traffic has had and will continue to have measurable impacts on traffic congestion and safety on major access routes to and from the Ports and connections to the off-dock intermodal terminals. The study examined likely port truck volumes on four access routes (I-710, I-110, SR 103, and Alameda Street). Truck volumes were estimated for each of four time periods for an average weekday: AM peak (6:00 a.m. to 9:00 a.m.), midday (9:00 a.m. to 3:00 p.m.), PM peak (3:00 p.m. to 7:00 p.m.), and night (7:00 p.m. to 6 a.m.).
- **Emissions.** Growth in port truck traffic creates associated emissions of criteria air pollutants. The study estimated daily ton per day changes in emissions for the following pollutants: reactive organic gases (ROG), carbon monoxide (CO), nitrogen oxides (NO_x), and particulate matter fewer than 10 microns (PM₁₀). All emissions calculations were net emissions changes, (i.e., if truck activity was decreased but rail activity was increased the change in emissions was net of the increase in rail emissions).

The performance measures are always evaluated with reference to a set of baseline scenarios that represent current plans at the port in the absence of the strategies being evaluated. The baseline scenarios were established for three years: 2005, 2010, and 2030. The 2005 baseline is a useful starting point because when the study was initiated (2004) this was the earliest timeframe in which any of the strategies could be implemented and it also provides a benchmark based on current conditions. When evaluating the effectiveness of strategies for the future, one useful measure is at what point in the future do conditions return to where they were in 2005 when the implementation program is begun. One way of looking at this is that it provides a way of determining how much time the strategies buy before additional measure would be required to result in zero growth in emissions and congestion. The remaining two baseline years (2010 and 2030) were selected because 2010 is a year in which all of the strategies could be fully implemented and would be in their earliest stages of impact whereas by 2030 they would represent mature systems.

In all scenarios for 2005, 2010, and 2030, it is assumed that containerized cargo will grow according to the figures in Table 1.

The assumed compound annual growth rate for TEUs between 2003 and 2010 for both Ports combined is 7.6 percent, and 4.2 percent between 2010 and 2030.

In 2010 and 2030, the baseline scenarios assume full implementation of current plans for expanded capacity and utilization of on-dock rail facilities. On-dock rail activity for both ports combined in 2005 is assumed to be approximately 18 percent of total container throughput, up from about 16 percent in 2003. The baseline scenario for 2010 assumes on-dock rail accounts for 23 percent of container throughput for both ports combined. In 2030, the baseline scenario

assumes that on-dock rail accounts for 25 percent of total container throughput. These rates of on-dock rail utilization may represent the maximum

Table Error! No text of specified style in document.1 Projected Containerized Cargo Throughput
Twenty-Foot Equivalent Units (TEUs)

	2003 Actual	2005	2010	2030
POLB	4,658,124	5,383,300	7,564,600	22,982,800
POLA	7,148,940	10,149,600	12,129,400*	21,731,100
Total	11,807,064	15,532,900	19,694,000	44,713,900

Source: Port of Long Beach and Port of Los Angeles.

*The POLA uses a 2010 forecast of 13,338,200 TEUs per year, and applies a 0.083 factor to the annual total to derive a monthly volume. POLB applied a 0.091 factor to 12,129,400 TEUs at the POLA to derive a peak month value. The resulting products are different by less than 1 percent, which results in essentially no difference in traffic volumes per weekday between the two calculation methods. The 2005 figures are forecasts generated in early 2004.

practical capacity for on-dock rail at each of the terminals given current land availability and likely operating scenarios. In order to test the benefits of the embedded increase in on-dock rail in the baseline scenarios, an alternative baseline was developed for 2010 and 2030 that caps the on-dock rail utilization at 2005 capacity levels. The baseline scenarios also assume the same gate hours of operation as in 2004 (no extended hours) and none of the truck trip reduction strategies tested in the analysis are included in the baseline.

Cambridge Systematics estimated that the ports will generate 66,367 container truck trips per weekday (41,398 to and from the Port of Los Angeles and 24,969 to and from the Port of Long Beach) under 2005 baseline conditions. These trips are comprised of loaded containers, empty containers, bobtails, and chassis. A substantial number of bobtail trips are interterminal trips that never reach the freeway or streets external to the ports. The estimated 24-hour port

container traffic volume on the I-710 freeway (the primary access route to the ports) in 2005 is 22,704. This compares favorably to truck counts taken in July 2004.

Total port container truck trips are projected to increase to 78,638 by 2010 and 167,752 by 2030, or 18.5 and 153 percent, respectively, over the 2005 baseline value of 66,367. It is also projected that by 2010 traffic volumes on the I-710 will increase to slightly over 27,000 container trucks per day, or 19 percent over the 2005 baseline value of 22,704. By 2030, I-710 traffic volumes will increase to over 65,000 container trucks, or 187 percent over the 2005 baseline.

Strategies

The strategies that were evaluated in this study would all reduce weekday, daytime truck trips generated at the ports or reduce the length of truck trips as compared to a baseline condition, in which none of the strategies would be implemented. In addition, the strategies may, to varying degrees, reduce truck vehicle miles traveled (VMT) throughout the region, reduce peak-period truck traffic on major access routes in the vicinity of the ports, and reduce emissions. Each of these strategies and the scenarios that were evaluated are described below.

Virtual Container Yard (VCY). The VCY concept is designed to reduce movements of empty containers in and out of the port gates. In many cases, after an import container is unloaded by the importer (or a transloader), it is returned to the Port or to an off-site depot for storage until an exporter calls for a container. The use of the ports as storage yards for empty containers generates extra truck traffic that could be reduced if there were a more efficient way of matching importers and exporters so that empty containers could move directly from importers to exporters. Computerized “matching” systems create a mechanism for tracking the

whereabouts of containers and making the necessary matches. While it would be impossible to always match every import container with an exporter without a storage move, this study evaluates the impacts of some plausible VCY scenarios. The ports are working with a commercial vendor to develop and implement a VCY program. This VCY will be operational by mid- 2006.

In a recent study by the Tioga Group (2002), it was estimated that approximately 2 percent of the import containers are already exchanged “on the street” with exporters. Thus, a 2 percent “import-export box reuse” factor is assumed in the 2005 and 2010 baseline scenarios. The study examined the impacts on port truck trips of increasing empty container reuse from 2 percent of import containers to 5 percent and 10 percent in 2005 and 2010, and to 10 percent in 2030.

Extended Gate Hours. These scenarios have two components: 1) switching gate activity from the daytime peak periods to off-peak periods at night, and 2) moving some weekday activity to weekends. Extended gate hour strategies do not actually reduce truck trips or truck VMT, but they can have an impact on traffic congestion. They may also reduce emissions, but this effect is not examined in this study. In 2004 at the Port of Los Angeles, it was estimated that 15 percent of weekly gate moves occurred on the weekend; and that the day, night, and hoot-owl shifts accounted for 80 percent, 10 percent, and 10 percent of weekday gate moves, respectively. The Port of Long Beach collects data on gate moves by shift and weekend moves every week from each of the container terminals. For the year to date through August 8, 2004, an average of 6 percent of the POLB weekly gate moves occurred on the weekend. The average allocation of weekday gate moves by day, night, and hoot shifts was 93 percent, 5 percent, and 2 percent. However, this distribution of traffic throughout the day and week was changed with the introduction of the PierPass program, which became operational on July 23, 2005. PierPass is a

program developed by the terminal operators with the cooperation of regional importers and exporters and is privately run. The program charges a fee for picking up containers during daytime hours and this fee is rebated to shippers who pickup their containers during the off-peak periods. During the first two weeks of operation, off-peak use increased from about 20 percent of all weekly gate moves to 30 percent.

Two major variations in extended gate hour operations were evaluated for this study. The first scenario examined just the impact of shifting truck arrivals and departures from the day shift to the night shift. This scenario was only evaluated for the years 2005 and 2010. The results of this scenario were primarily changes in commuter peak congestion on major facilities. The scenario assumes that traffic is distributed evenly over 5 weekdays. Weekday traffic is then allocated approximately 60 percent to day shift, 40 percent night, 0 percent hoot on three weekdays. Over five weekdays the weighted average is 68 percent, 32 percent, and 0 percent. This assumed that those terminals with hoot shifts would drop them after PierPass was implemented. Prior analyses have shown that this provides for efficient labor utilization at the terminal gates and reduces commuter peak traffic more than when a hoot shift is operated (the hoot shift tends to increase morning peak traffic on the freeways).

The second scenario included a higher level of weekend operations, shifting 20 percent of the truck activity to the weekend. This allowed for a comparison of the effects of weekend operations on average weekday traffic across all time periods.

On-Dock Rail. Approximately 50 percent of cargo moved through the ports is ultimately shipped into or out of Southern California by intermodal rail. In 2004, only 18.6 percent of all containerized cargo was loaded directly to/from rail on-dock. However, in 2005 this

percentage grew to 20.8 percent. The remaining intermodal cargo requires a drayage truck movement between the ports and one of the region's near-dock or off-dock intermodal terminals or transload centers. Increasing on-dock capacity and making other operational changes in the system could increase the amount of on-dock loading with associated reductions in drayage truck trips.

Two approaches were taken to examine the impacts of increasing on-dock rail use. The first approach recognizes that the baseline scenarios for 2010 and 2030 both include significant investment in new on-dock rail facilities. In order to demonstrate the benefits of this increased use of on-dock rail, an alternative baseline was constructed for both 2010 and 2030 that caps on-dock rail usage at 2005 capacity levels. The 2010 and 2030 baselines were then compared to these alternative baselines.

The second approach was a sensitivity test to see what the potential impacts of increased on-dock rail would be if a modest amount could be added in 2005 and 2010 (the sensitivity tests for 2030 were viewed as unrealistic in light of the significant increase in on-dock rail already expected in that timeframe). Two sensitivity tests were run for 2005:

1. One additional 25-car eastbound unit train *per week*, from all 10 terminals that currently have (or use) on-dock yards; and
2. Three additional 25-car eastbound unit trains *per week*, from all 10 terminals that currently have (or use) on-dock yards, plus one new Port of Los Angeles on-dock yard and a new small on-dock facility in the Port of Long Beach.

One sensitivity test was run for 2010. This scenario assumes one additional 25-car eastbound unit train *per day*, five days per week, from all 10 terminals that currently have (or use) on-dock yards, operation of a new on-dock yard with 5 eastbound trains per week, and a small on-dock facility with 3 trains per week.

Shuttle Trains. A number of concepts have been proposed that would move cargo directly from the ports by rail to an inland facility from which it could either be distributed to local importers near the inland facility, move to transloaders at or near the inland facility, or be involved in other types of intermodal operations away from the ports. To the extent that these movements today are made by truck, this approach could eliminate truck trips. ACTA is planning to implement a shuttle train pilot project. Two scenarios for 2005 were tested:

1. A demonstration project assuming two eastbound 10-car trains per day, five days per week. It was assumed that three major terminals, two from POLA and one from POLB would equally contribute containers to the shuttle train, and that the trains themselves would be assembled at one major terminal in POLA. The location of the inland rail yard is unknown at this time. The intersection of I-215 and I-10 in San Bernardino was assumed to be an artificial location of the inland yard for the purpose of calculating VMT. It was assumed that all containers on the train would be returned empty via train.

2. A more significant service involving four eastbound 25-car trains per day, five days per week from four major terminals, two in POLA and two in POLB. This scenario was run primarily for sensitivity testing and not for its likelihood of occurring by 2005.

For 2010 only one scenario was tested that was identical to Number 2 above, except under 2010 conditions. The 2030 scenario would double the number of eastbound trains from four per day to eight per day but would otherwise be identical to the 2010 scenario.

Near-Dock Rail. There are physical and operational constraints that make it impossible to load/unload all intermodal cargo on-dock. At the same time, current off-dock intermodal terminals are at or nearing capacity. Development of a new intermodal terminal relatively close to the Ports would reduce truck drayage trip lengths, and this could reduce future congestion and emissions associated with truck drayage trips. The Burlington Northern Santa Fe (BNSF) Railway has proposed a major new near-dock yard north of Pacific Coast Highway (Southern California International Gateway). It is expected to be operational by 2010. In 2010, the new yard is assumed to handle 1,000,000 TEUs per year (540,540 lifts per year). In 2030 it was assumed that the near-dock terminal handles 2,000,000 TEUs.

Methodology

Truck Trip Reductions (QuickTrip Model). The calculation of reductions in truck trips relies on the QuickTrip trip generation model that is part of the Port travel demand model. QuickTrip was developed by Moffatt & Nichol Engineers to estimate the number of container truck trips generated at each terminal as a function of peak monthly throughput (waterside) and various operating parameters of the terminals. Figure 1 provides an example of an input spreadsheet

for the QuickTrip Model illustrating the key parameters that can be altered to analyze a scenario. The outputs from QuickTrip are hourly truck volumes arriving and departing the terminal gates. Trucks are classified as bobtail, chassis, empty containers, or loaded containers.

In order to estimate the truck trip generation impacts of the VCY, the input to line 12a was modified to reflect the rate of empty container re-use associated with a particular scenario.

In order to analyze the effects of the Extended Gate Hour scenarios, inputs into the QuickTrip model are adjusted to reflect the different weekend/weekday (line 11a) split in the traffic and the different allocation of activity to the three operating shifts during the day (line 11b). It should be noted that this approach implicitly assumes that the hourly distribution of truck arrivals and departures within each shift is the same as in the base model. These distributions were based on actual gate survey data collected when QuickTrip was originally developed in 1999-2000. For the night and hoot shifts, these distributions were developed from data at several terminals that were running limited night operations at that time. It is possible that

Figure Error! No text of specified style in document. **Sample QuickTrip Input Sheet**

INPUT				
<i>Note: For Trip Generation Calculations Only, Italicized Inputs May be Ignored</i>				
1	Enter Gross Terminal Area (Acres)	91		
2	Enter Berth Length (Feet)	2,200		
3	Enter Dockside Crane Gauge (feet)	100		
	Calculated Area of Wharf (Acres)		10	
4	Enter Gate Area, (Acres)	13		
5	Enter Area of Buildings & Parking (Acres)	16		
6	Enter Railyard Area, (Acres)	0		
7	Enter Dynamic Capacity of Railyard (1=low 2=high)	1		
8	Enter Ratio (Average TEU/Container)	1.66		
	Calculated Net Container Storage Area, (Acres)		52	
9	Enter Peak Monthly Throughput, in TEU's, If Known	24,213		
10	Enter Throughput Distribution & Dwell (Over the Dock)		% of Total Throughput	Dwell (days)
10a	Local Imports	26.4%		6
10b	Local Exports	38.0%		10
10c	Empties	20.6%		15
10d	Transshipment	5.0%		5
10e	Intermodal Imports - On Dock	0.0%		2
10f	Intermodal Imports - Off Dock	5.0%		1
10g	Intermodal Exports - On Dock	0.0%		5
10h	Intermodal Exports - Off Dock	5.0%		4
	Check Total (Must = 100%)	100.0%		
11	Enter Gate Data			
11a	Number of Days Per Week Gate Will Be Open	5		
		DAY	2ND	HOOT
11b	Allocation of Gate Traffic By Shift	77%	23%	0%
				CHECK
				100%
12	Variable Factors			
12a	Percent of Import/Export (Landside) Box Re-Use	0%		Default = 10%
12b	Percent of Intermodal (Landside) Chassis Re-Use	0%		Default = 25%
12c	Peak Week / Average Week Ratio	1.00		Default = 1.08
12d	Percent Double Cycle Trucks	40%		Default = 25%
12e	Percentage of Weekly Gate Traffic Allocated to Weekend	8%		
12f	Use Day Peaking Factor? (1=Yes, 2=No)	1		
12g	Local Empty Loss Factor	10%		
12h	Intermodal Empty Return Factor, Percent	100%		

with an appointment system (which has not been implemented as part of the PierPass program), gate arrivals and departures could be managed to optimize the efficiency of terminal operations and freeway operations if this were a desired outcome. This approach to implementing extended gate hours was not modeled as part of this study. Nonetheless, the shifting of truck activity to the night shift and to weekends does have a noticeable impact on peak-period truck activity.

The basic approach to estimating truck trip reductions associated with the shuttle train is to estimate the reduction in the percent of monthly TEU throughput at the affected terminals that are allocated to local imports (line 10a). It is assumed that all of the eastbound shuttle trains leaving the Port are loaded and carry loaded import containers that are bound for the inland shuttle terminal. The containers are then lifted off the shuttle train and delivered to their final destinations nearby the inland shuttle terminal by truck. A spreadsheet model was developed that allows the user to enter the number of eastbound shuttle trains per week and the model then calculates the percent of peak monthly loaded TEUs that are handled by the shuttle train. This percentage is then subtracted from the local import percentage that is an input to the QuickTrip model. Since QuickTrip assumes that all TEUs allocated to local imports are trucked to their destination within Southern California, the reduced local import percentage results in a reduction of truck trips that would have been made had the containers on the shuttle train been delivered by truck. The QuickTrip model estimates that more than one truck trip is eliminated for each container that is moved by the shuttle train because it accounts for empty returns, repositioning of empty chassis, and bobtail truck movements.

The increased on-dock rail scenario was implemented by developing a spreadsheet model to calculate the inputs needed for QuickTrip. The spreadsheet allows the user to enter (for each affected terminal) the number of additional on-dock trains, the TEUs per rail car (including slot utilization), TEUs per lift, methods for calculation of monthly lifts from weekly rail activity data, and data on loaded and empty containers transported by rail. Entering these parameters into the spreadsheet calculates the percent of intermodal imports being diverted from off-dock to on-dock rail. This adjustment is then made automatically to increase on-dock rail and decrease off-dock rail by corresponding amounts. The output from running QuickTrip with

these inputs is the truck trips at each terminal associated with the increased on-dock rail scenario.

The new near-dock rail terminal actually has no impact on the total number of truck trips generated at the ports.

VMT Calculations. Once the number of truck trips generated at the Ports was determined using QuickTrip, the Port's travel demand model was used to develop a trip length distribution for all trips arriving and departing the Port under baseline conditions. The Port model includes a matrix of trips (trip table) showing the number of trips to and from various zones (traffic analysis zones) throughout Southern California. The model is used to estimate zone-to-zone travel distances over the roadway network, and this results in a trip length frequency distribution (number of trips of each trip length). The trip length distribution is then used to compute a weighted average trip length, and this is multiplied by the number of trips generated (QuickTrip output) to estimate total port truck VMT.

Calculation of VMT that result from the VCY scenarios involves estimating VMT by trips to and from the Port (excluding the trips eliminated by the VCY) and adding to this VMT associated with the cross-town trips between importers and exporters.

The local shuttle train is expected to reduce vehicle miles traveled by port trucks delivering to destinations in the vicinity of the inland shuttle terminal. While there would be a decrease in the port truck VMT, there would be additional vehicle miles traveled between the shuttle terminal location and the local destinations (assumed to be within a radius of 20 miles).

In the absence of information on local destinations in the 20-mile radius, trips were assumed to be distributed among traffic analysis zones (TAZs) within the 20-mile radius, in proportion to

the share of “other” employment in these zones (obtained from the Southern California Association of Governments (SCAG) regional travel demand model and assumed to be a surrogate for warehouse employment).

Thus, the total vehicle miles traveled in this scenario was calculated as follows:

$$\text{VMT} = \text{Port Truck VMT} + \text{Additional VMT between shuttle terminal and destination}$$

where:

Additional VMT between Shuttle Terminal and Destination =

$$\sum \text{Port Trucks Eliminated} \times [\text{Percent of other employment}] \times [\text{Distance between terminal and geographic centroid}]$$

The calculation of VMT reduction associated with increased on-dock rail required estimation of the average trip length to the off-dock rail facilities. Data were obtained from the Union Pacific and BNSF railroads, indicating the percent of loads from the ports to each of the off-dock terminals and the distance between the port terminals and each of the off-dock terminals was computed from the port travel demand model. These data were used to compute the weighted average trip length to the off-dock terminals, which was determined to be 14 miles. Multiplying this average trip length by the number of trips to off-dock terminals that are eliminated by increased on-dock rail provides the VMT estimate.

The new near-dock rail terminal actually has no impact on the total number of truck trips generated at the ports. However, it does reduce traffic that would otherwise be traveling to Hobart Yard (a major downtown intermodal terminal); and this impacts port truck VMT, traffic

on the 1-710 freeway, and emissions. In order to capture these effects it was necessary to run the QuickTrip model as if trips to the new near-dock rail yard were reductions in off-dock trips. This allows for the calculation of the number of trips that are no longer traveling to Hobart Yard. As noted above, it was assumed that the trips would be diverted from each terminal in proportion to the amount of off-dock rail traffic they generate in the base case. To calculate the change in VMT, the change in truck trip outputs from the QuickTrip model is first multiplied by the distance to Hobart Yard. To this is added the amount of VMT associated with these trips going instead to the CalCartage site (2.97 miles from the Port).

Calculation of Port Truck Trips on Major Access Routes. Using information about the number of truck trips generated at each terminal and the origin-destination patterns represented by the trip table, the port travel demand model assigns truck trips to the roadway network in order that each trip uses the least time path between origin and destination, and taking into account local traffic conditions (congestion). The software used to conduct the traffic assignments has a feature called “selected link assignment” that can be used to analyze the origin-destination characteristics of the traffic on any desired segment of the roadway system. This feature was used to identify the trips with origins and destinations at each of the marine terminals that are present on each of the four major access routes. This allows the user to determine what fraction of the total truck traffic at these locations is associated with the ports. In this study, the selected link assignments were conducted for roadway segments just north of the Pacific Coast Highway (PCH). The fractions calculated by the selected link assignments were then applied to the QuickTrip results to determine the volumes of port truck traffic on each roadway for each of the desired time periods.

Emissions Calculations (Trucks). Two different emission calculation procedures were necessary for the analysis: one for trucks and one for rail. It is important to note that the procedure for calculating emissions must be considered accurate only in the relative sense. Factors such as the impact of changes in vehicle speeds associated with changes in congestion levels and local effects are not considered in this analysis. However, the results are still useful for comparing the relative emissions performance of different alternatives.

The approach to estimating reductions in truck emissions was to apply emission factors (grams per mile) to estimates of reductions in truck VMT that result from each scenario. The emission factors were calculated using EMFAC2002, the latest version of the California Air Resources Board's (ARB) on-road mobile source emission factor model.

The use of EMFAC for emissions analysis for a corridor or an area requires a VMT weighted average speed. Since no travel demand model runs were conducted for this study, there were no average speed forecasts available for the truck trips that are being reduced in each of the subject scenarios. *The Port of Long Beach Emission Inventory* by Starcrest Consulting Group (2004) and *The Alameda Corridor Air Quality Benefits Report* by Weston Solutions (2005) used average speeds in the 35 to 40 mph range for their analyses. In the case of the Starcrest report, this average speed was based on model results prepared by Meyer Mohaddes Associates, and reflects on-road operations in the port area. The source of the Weston estimates was not provided. The scenarios that are being examined in this study eliminate trips that would reflect a higher proportion of freeway driving than would those in the port area, suggesting that a higher average speed than used in the Starcrest report would be appropriate. Port travel demand model runs recently conducted by Cambridge Systematics for the Gerald Desmond Bridge toll study estimated midday average speeds on the I-710 and SR 60 freeways to be

between 45 to 55 mph in 2010, depending on the location and direction of travel. Based on these data and the nature of truck trips eliminated in the port truck trip reduction scenarios, Cambridge Systematics assumed average truck speeds of 45 mph.

EMFAC can be run with default values for the vehicle age distribution or with values provided by the user. In the current analysis, Cambridge Systematics used a vehicle age distribution provided by the ports that was obtained from gate surveys at both ports. As compared to the default values (which are based on truck registration records for all trucks in the South Coast Air Basin), the port truck age distribution has a much lower percentage of trucks that are 0 to 6 years old, a higher percentage of trucks that are 6 to 20 years old, and a lower percentage of trucks that are more than 20 years old. The same age distribution was used for the 2005 and the 2010 analyses.

EMFAC was run for the South Coast Air Basin for the years 2005 and 2010. Emissions analysis was not conducted for 2030, because of uncertainty regarding future rail emissions (as discussed below).

Table 2 provides the emission factors that were used in this analysis.

Emissions Calculations (Rail). The approach used to estimate rail emissions borrowed much from the *Alameda Corridor Air Quality Benefits Report* by Weston. The Weston approach is consistent with the U.S. Environmental Protection Agency (EPA) guidance documents for estimation of locomotive emissions and the most recent ARB “OFFROAD Modeling Change Technical Memorandum.” The latter is particularly important because it provides guidance for incorporation of the effects of early introduction of Tier II emission standards for locomotives operating in the South Coast Air Basin. Tier II standards will achieve substantial reductions in

Table 2 Truck Emission Factors (in Grams Per Mile)

Pollutants	Year	
	2005	2010
Reactive Organic Gases (ROG)	0.70	0.55
Carbon Monoxide (CO)	2.64	1.86
Nitrogen Oxide (NO _x)	17.18	13.13
Particulate Matter (PM ₁₀ - 10 microns or smaller)	0.30	0.19

Source: EMFAC 2002 – Port truck fleet age distribution from Starcrest’s Emission Inventory Report, Temperature: 70 degrees Fahrenheit; relative humidity: 50 percent; and speed: 45 mph.

locomotive emissions, particularly in NO_x.

Rail emission factors are calculated based on an assumed duty cycle, and are provided in grams per brake horsepower-hour (g/bhp-hr). Two different duty cycles were used in the analysis: one for operations in the Alameda Corridor and one for mainline operations outside of the Corridor. The first duty cycle was used in the analysis of on-dock rail and near-dock rail scenarios. This duty cycle was provided to Weston by the railroads, and represents actual operating train hours by notch (power level) from Alameda Corridor operations. A combination of the first and second duty cycles was used for the analysis of shuttle train scenarios (The first duty cycle was used for the portion of the trip occurring in the Corridor, and the second duty cycle was used for the portion of the trip occurring on the mainline.). The second duty cycle was based on the standard EPA line-haul locomotive duty cycle. The emission factors for 2005, and 2010 were taken from the Weston report. Weston actually provides emission factors for 2012 so the 2010 emission factors had to be interpolated based on the changes between the 2005 and 2012 factors. In the case of NO_x, the emission factors in 2010 are the same as those in 2012, demonstrating the effect of early introduction of the Tier II standards. Emission factors were not calculated for 2030 because it is not clear at this time whether or not there will be a requirement for Tier III emissions standards. During the period

between 2010 and 2030, truck emissions are expected to drop significantly, and it is expected that locomotives should be able to also achieve significant reductions. In the absence of a clear emission standard that takes advantage of these technology improvements, it did not seem reasonable to compare Tier II locomotives with the lower emission trucks in 2030. The rail emission factors that were used are presented in Table 3.

Table 3 Rail Emission Factors (in Grams/BHP-Hour)

Pollutants	Year					
	Rail Emission Factors for Operations in the Alameda Corridor			Rail Emission Factors for Operations Between North End of Alameda Corridor and Rail Shuttle Terminus		
	2005	2010	2012	2005	2010	2012
ROG	0.30	0.30	0.30	0.38	0.32	0.30
CO	0.38	1.18	1.50	0.52	1.22	1.50
NO _x	10.85	5.50	5.50	11.55	5.50	5.50
PM ₁₀ (10 microns or smaller)	0.22	0.21	0.20	0.26	0.22	0.20

Source: *Alameda Corridor Air Quality Benefits Report*, Weston Solutions, Inc., Table 7 (2005) and Table 10 (2012) - Ports to End of Corridor.

Results

There is no single strategy which would meet all possible objectives for mitigating traffic and emissions impacts of port growth. The strategy that would be viewed as most effective depends on the specific objective and metric. Taken together, there are potential packages of the strategies that could have significant benefits and would go a long way towards meeting Port, industry, and community goals. Included in the analyses presented in this section are three “combined” strategies as follows:

2005

- Extended gate hours 68-32-0 day, night, hoot allocation and 20 percent weekend;
- Virtual container yard with 5 percent import-export box reuse;
- Shuttle Train demonstration project; and
- One additional eastbound on-dock train per week per on-dock terminal.

2010

- Extended gate hours 68-32-0 day, night, hoot allocation, and 20 percent weekend;
- Virtual container yard with 10 percent import-export box reuse;
- Shuttle train with four trains per day five days per week; and
- New near-dock yard with 1 million TEU capacity per year.

2030

- Extended gate hours 68-32-0 day, night, hoot allocation, and 20 percent weekend;
- Virtual container yard with 10 percent import-export box reuse;
- Shuttle train with eight trains per day five days per week; and
- New near-dock yard with 2 million TEU capacity per year.

In both the 2010 and 2030 scenarios, the effects of increased on-dock rail are already built into the baseline scenario and results with the combined scenario are compared to this baseline.

Table 4 presents a comparison of the impacts of each of the scenarios on weekday port container trips for 2005, 2010, and 2030. The extended gate hour program has a significant impact because of the potential to shift trucks from weekdays to weekends. Over the longer term, the addition of new on-dock rail capacity that is included in the baseline scenarios represents the most significant reduction in port trucks relative to a baseline without on-dock rail. The VCY has a relatively small impact on truck traffic at the ports because it only affects empty truck trips. Even with a 10 percent empty reuse level, in 2030 the reduction in total truck trips at the two ports would only be 4.2 percent. The shuttle train, produces similar percentage reductions in truck trips as the VCY. Even though the shuttle train increases its operations in each of the three forecast years, the growth in cargo volumes is faster than the growth in shuttle train operations, resulting in only 3.3 percent reduction in truck trips in 2030. The new near-dock intermodal terminal has no impact on truck trips, it simply re-directs existing off-dock truck traffic to a new terminal. The combined scenario achieves as much as a 25 percent reduction in truck trips in 2030, although growth in total truck traffic overwhelms the ability of the strategies to keep pace. However, the combined scenario could buy time before additional roadway capacity is needed, with 2010 port truck trips reduced to below the 2005 Baseline.

Table 5 presents a comparison of the impacts of each of the scenarios on I-710 traffic. The implementation of the extended gate hour program has the biggest impact on weekday peak-period truck volumes. In fact, this impact is so great that AM peak-period traffic in 2030 would be only marginally higher than the 2005 baseline. However, achieving this result would dramatically increase traffic during the night, which in the long run could prove a serious

Table 4 Summary of Impacts on Weekday Port Container Truck Trips by Scenario

	POLA	POLB	Grand Total	Percent Change (Relative to Baseline)
2005 Scenarios				
Base 2005	41,398	24,969	66,367	
VCY 5% Reuse	40,804	24,639	65,443	-1.4%
VCY 10% Reuse	39,812	24,112	63,925	-3.7%
Extended Gate Hours 68-32-0/20	36,875	21,113	57,988	-12.6%
Shuttle Train Demo	41,033	24,778	65,811	-0.8%
Shuttle Train	40,029	23,563	63,592	-4.2%
Increased On-Dock Rail (1/week)	40,775	24,320	65,095	-1.9%
Increased On-Dock Rail (3/week)	39,528	23,023	62,551	-5.7%
Combined Scenario	35,480	20,132	55,612	-16.2%
2010 Scenarios				
Base 2010	47,184	31,453	78,638	18.5%
VCY 5% Reuse	46,473	30,994	77,467	-1.5%
VCY 10% Reuse	45,288	30,229	75,517	-4.0%
Extended Gate Hours 68-32-0/20	42,229	27,431	69,660	-11.4%
Shuttle Train	45,815	30,048	75,862	-3.5%
Increased On-Dock Rail (5/week)	43,974	28,486	72,460	-7.9%
New Near-Dock Yard	47,184	31,453	78,638	0.0%
Combined Scenario	40,538	24,316	64,854	-17.5%
2030 Scenarios				
Base 2030	77,156	90,596	167,752	153.0%
VCY 10% Reuse	73,778	86,860	160,638	-4.2%
Extended Gate Hours 68-32-0/20	68,605	75,318	143,923	-14.0%
Shuttle Train	74,417	87,785	162,202	-3.3%
New Near-Dock Yard	77,156	90,596	167,752	0.0%
Combined Scenario	59,434	65,692	125,124	-25.4%

Source: Cambridge Systematics, Inc.

Note: No change in the number of trips for the 2010 and 2030 Near-Dock scenario. Percentage change for Base 2010 and 2030 is relative to Base 2005.

Table 5 Summary of Impacts on Weekday I-710 Volumes by Scenario and Percentage Change from Baseline

	AM Peak (6:00 am- 9:00 am)	Percent Change	Midday (9:00 am- 3:00 pm)	Percent Change	PM Peak (3:00 pm- 7:00 pm)	Percent Change	Day Total	Percent Change	Night (7:00 pm- 6:00 am)	Percent Change	Total	Percent Change
2005 Scenarios												
Base 2005	3,280		12,940		4,517		20,736		1,968		22,704	
VCY 5% Reuse	3,243	-1.1%	12,789	-1.2%	4,415	-2.3%	20,446	-1.4%	1,940	-1.4%	22,386	-1.4%
VCY 10% Reuse	3,178	-3.1%	12,508	-3.3%	4,291	-5.0%	19,977	-3.7%	1,895	-3.7%	21,872	-3.7%
Extended Gate Hours 68-32-0	1,617	-50.7%	8,924	-31.0%	4,127	-8.6%	14,668	-29.3%	4,879	148.0%	19,547	-13.9%
Shuttle Train Demo	3,245	-1.1%	12,826	-0.9%	4,466	-1.1%	20,537	-1.0%	1,942	-1.3%	22,479	-1.0%
Shuttle Train	3,097	-5.6%	12,240	-5.4%	4,256	-5.8%	19,593	-5.5%	1,871	-4.9%	21,464	-5.5%
Increased On-Dock Rail (1/week)	3,226	-1.6%	12,683	-2.0%	4,377	-3.1%	20,286	-2.2%	1,942	-1.3%	22,228	-2.1%
Increased On-Dock Rail (3/week)	3,077	-6.2%	12,127	-6.3%	4,187	-7.3%	19,391	-6.5%	1,890	-3.9%	21,281	-6.3%
Combined Scenario	1,548	-52.8%	8,535	-34.0%	3,931	-13.0%	14,015	-32.4%	4,662	136.9%	18,677	-17.7%
2010 Scenarios												
Base 2010	3,958	20.7%	15,314	18.4%	5,339	18.2%	24,611	18.7%	2,398	21.9%	27,009	19.0%
VCY 5% Reuse	3,904	-1.4%	15,088	-1.5%	5,253	-1.6%	24,244	-1.5%	2,363	-1.5%	26,607	-1.5%
VCY 10% Reuse	3,818	-3.5%	14,689	-4.1%	5,126	-4.0%	23,632	-4.0%	2,305	-3.9%	25,937	-4.0%
Extended Gate Hours 68-32-0	1,956	-50.6%	10,810	-29.4%	5,007	-6.2%	17,774	-27.8%	5,914	146.6%	23,688	-12.3%
Shuttle Train	3,801	-4.0%	14,585	-4.8%	5,081	-4.8%	23,467	-4.6%	2,303	-4.0%	25,770	-4.6%

Table 5 Summary of Impacts on Weekday I-710 Volumes by Scenario and Percentage Change from Baseline (continued)

	AM Peak (6:00 am- 9:00 am)	Percent Change	Midday (9:00 am- 3:00 pm)	Percent Change	PM Peak (3:00 pm- 7:00 pm)	Percent Change	Day Total	Percent Change	Night (7:00 pm- 6:00 am)	Percent Change	Total	Percent Change
2010 Scenarios (continued)												
Increased On-Dock Rail (5/week)	3,672	-7.2%	14,040	-8.3%	4,839	-9.4%	22,551	-8.4%	2,266	-5.5%	24,817	-8.1%
New Near-Dock Yard	3,707	-6.3%	14,215	-7.2%	4,919	-7.9%	22,841	-7.2%	2,237	-6.7%	25,078	-7.1%
Combined Scenario	1,800	-54.5%	9,867	-35.6%	4,563	-14.5%	16,230	-34.1%	5,396	125.0%	21,626	-19.9%
2030 Scenarios												
Base 2030	9,391	186.0%	37,367	190.0%	13,258	194.0%	60,015	189.0%	5,223	165.0%	65,238	187.0%
VCY 10% Reuse	8,993	-4.0%	38,810	-4.0%	12,707	-4.0%	57,510	-4.0%	5,009	-4.0%	62,519	-4.0%
Extended Gate Hours 68-32-0	4,438	-53.0%	24,951	-33.0%	11,760	-11.0%	41,149	-31.0%	13,758	163.0%	54,908	-16.0%
Shuttle Train	9,041	-4.0%	35,892	-4.0%	12,795	-3.0%	57,728	-4.0%	5,029	-4.0%	62,758	-4.0%
New Near-Dock Yard	8,740	-6.9%	34,833	-6.8%	12,340	-6.9%	55,914	-6.8%	4,872	-6.7%	60,786	-6.8%
Combined Scenario	3,860	-58.9%	21,731	-41.8%	10,147	-23.3%	35,738	-40.5%	11,951	128.8%	47,688	-26.9%

Source: Cambridge Systematics, Inc.

Note: Percentage changes for Base 2010 are relative to Base 2005.

nuisance to the community because of noise impacts. By 2030, the extended gate hour program could achieve a 53 percent reduction in AM peak hour traffic on I-710 but nighttime traffic would increase by 163 percent. It is also interesting to note that PM peak hour traffic would only be reduced by 11 percent with the extended gate hour program, as much of the shift is likely to be into the early hours of the night shift, which still puts trucks on the road in the PM peak period. After the the extended gate hour program, the increased on-dock and new near dock scenarios produce the greatest impact on I-710 truck traffic. This is because of the very high level of usage of the I-710 freeway as an access route to the existing off-dock intermodal terminals.

Table 6 presents a comparison of the impacts of each scenario on port truck VMT. Because of the length of trips it eliminates, the shuttle train scenarios are most effective in achieving VMT reductions and this means that they also have fairly significant near term emission benefits (see Table 7). While the extended gate hour scenarios have a significant impact on weekday VMT they have no impact on overall VMT. The new near-dock scenario has relatively limited impact on VMT because the trips it eliminates are relatively short and they are off-set to a limited extent by the trip to the new near-dock terminal. This is also the case for the VCY, where cross-town truck trips offset VMT reductions associated with trips that would have been taken back and forth to the ports. Again, the combined scenarios have significant effects on VMT, with 2010 VMT lower than Baseline 2005 VMT.

Table 7 shows the emissions impacts of each of the scenarios. The table focuses on NO_x emissions since these show the largest effects. Emissions reductions from the VCY are directly proportional to VMT reductions and the extended gate hours, which has no VMT reductions and therefore produces no impact on emissions. In fact it is possible that emissions could be

affected in a modest way by extended gate hours. This would be due to changes in truck operating speeds (operations in less congested periods of the day) and the ambient temperature and humidity conditions during different time periods (which could affect emission rates of the trucks). Neither of these impacts could be accounted for without more sophisticated modeling approaches than were within the scope of this study. The shuttle train has the largest impact on emissions in 2010. This is because it has the largest impact on reducing truck VMT and it replaces truck usage with relatively cleaner rail movements. In 2010, locomotive emissions already show the effect of full implementation of the Tier II locomotive emission standards. Similar impacts are seen when looking at the near dock and increased on-dock cases, although since the VMT reductions in these cases are smaller than those of the shuttle train, the net impacts are less. The combined scenario impacts on emissions are not as dramatic as are the truck trip reduction, traffic reduction, and VMT reductions seen previously, as to a large extent, truck VMT is being replaced with rail traffic, which while relatively cleaner, is still a source of pollution.

It is clear from all of the analysis, that there are a number of effective strategies, which in combination can have a significant impact on port truck traffic and emissions. In the short run these strategies may be able to mitigate growth impacts at the ports. However, in the longer run, other approaches will be necessary to address growing levels of traffic congestion on access roads and port-related truck emissions.

Table 6 Summary of Impacts on Weekday Port Container Truck Vehicle Miles of Travel and Percentage Change from Baseline

	VMT (Miles)	Percent Change
2005 Scenarios		
Base 2005	1,017,498	
VCY 5% Reuse	1,010,565	-0.7%
VCY 10% Reuse	999,178	-1.8%
Extended Gate Hours*	889,032	-12.6%
Shuttle Train Demo	989,887	-2.7%
Shuttle Train	879,791	-13.5%
Increased On-Dock Rail (1/week)	998,419	-1.9%
Increased On-Dock Rail (3/week)	960,260	-5.6%
Combined Scenario	838,241	-17.6%
2010 Scenarios		
Base 2010	1,205,617	18.5%
VCY 5% Reuse	1,196,840	-0.7%
VCY 10% Reuse	1,182,212	-1.9%
Extended Gate Hours *	1,067,979	-11.4%
Shuttle Train	1,067,909	-11.4%
Increased On-Dock Rail (5/week)	1,112,947	-7.7%
New Near-Dock Yard	1,147,665	-4.8%
Combined Scenario	861,677	-28.5%
2030 Scenarios		
Base 2030	2,571,855	153.0%
VCY 10% Reuse	2,518,501	-2.07%
Extended Gate Hours*	2,206,526	-14.2%
Shuttle Train	2,296,441	-10.71%
New Near-Dock Yard	2,430,253	-5.5%
Combined Scenario	2,105,061	-18.2%

Source: Cambridge Systematics, Inc.

Note: Percentage change for Base 2010 and Base 2030 is relative to Base 2005.

* All values in the table relate to weekday volumes. There would be no impact on VMT for extended gates measured over 7 days, because trips are being diverted to the weekend.

Table 7 Summary of Emissions Impacts of Strategies (2005 and 2010)

Scenarios	Truck VMT Per day	Change in Truck VMT Per day	NOX Net Emissions (Tons Per Day)	Percent Reductions from Base
2005 Scenarios				
Base 2005 (18% On-Dock)	1,017,498		19.2529	
Virtual Container Yard – 5% Reuse	1,010,565	-6,933	-0.1312	-0.68%
Extended Gate Hours 68-32-0/20 (n/a)				
Shuttle Train Demo (2 EB Trains/Day)	989,887	-27,611	-0.1705	-0.89%
Increased On-Dock Rail (1 EB Train per week per terminal)	999,691	-17,807	-0.2178	-1.13%
Combined Scenario (VCY-5% + Shuttle Train Demo + Increased On-Dock Rail)	967,972	-49,526	-0.4660	-2.42%
2010 Scenarios				
Base 2010 (22% On-Dock)	1,205,617		17.4363	
Virtual Container Yard – 10% Reuse	1,182,212	-23,405	-0.3385	-1.94%
Extended Gate Hours 68-32-0/20 (n/a)				
Shuttle Train (4 EB Trains/Day)	1,067,909	-137,708	-1.3110	-7.52%
New Near-Dock Yard	1,147,665	-57,952	-0.7193	-4.13%
Combined Scenario w/o SR 47	990,339	-215,278	-2.3140	-13.27%
Revised 2010 Baseline with On-Dock Capacity capped at 2005	1,277,919		2.6206	
On-Dock Rail Base 2010 Comparison with Revised 2010 Baseline		-72,302	-0.9156	-4.95%

Source: Cambridge Systematics, Inc.

References

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