DrayFLEET: EPA SmartWay Drayage Activity and Emissions Model and Case Studies

Prepared for the

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and the

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The Tioga Group, Inc. ♦ www.tiogagroup.com

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Overview

Purpose. Container drayage is widely recognized as a critical emissions, congestion, and capacity issue for major container ports and rail intermodal terminals. The objective of this project was to develop an emissions and activity model – DrayFLEET[1] – that accurately depicts drayage activity in terms of VMT, emissions, cost, and throughput, and can reliably reflect the impact of changing management practices, terminal operations, cargo volume, and diesel truck upgrades.

Scope. A major objective of the modeling effort was to create a comprehensive picture of port drayage movements. While meeting this objective necessarily increases model size and complexity, comprehensiveness is vital for several reasons. Ports and terminals all fulfill the same basic functions, but do so in several different ways and in many detailed variations. The project team therefore endeavored to create model options for all significant drayage functions at any port complex, even though those model options may be rarely used. The model includes:

- Drayage trips of all types to and from marine container terminals, for any reason.
- Drayage trips between rail intermodal terminals and marine terminals, and associated bobtail and chassis trips that may not begin or end at the port.
- “Cross-town” trips to reposition empty import containers for export loads, to shift empty marine containers from rail terminals to depots, or to obtain empty containers from depots for export loads.

The DrayFLEET model therefore includes a number of trips and trip types that do not begin or end at port terminals but which are necessary to support the overall port container flow. The model does not attempt to account for trips for servicing, fuel, and repair; side trips for meals, rest, or errands; and trips made on non-port assignments such as domestic rail intermodal drayage.

Because volumes vary from year to year and month to month while movement patterns tend to persist, the model relies primarily on pattern indicators and proportions to estimate drayage trips, times, and mileages. This approach facilitates forward-looking or “what if” analyses of drayage activity and emissions with growing cargo volumes.

[1]DrayFLEET: Drayage Freight Logistics Environmental and Energy Tracking Performance Model.

DrayFLEET Model

Approach. The DrayFLEET model incorporates an activity-based approach. Each significant drayage trip type or activity is assigned a time and distance value. That value may be a precise empirical measurement, a weighted average, or an industry rule of thumb, depending on the data available. The model takes the total container volume handled by the port or terminal in question and determines the volume and mix of drayage activities required or implied. The time and VMT for those activities are tallied to develop port or terminal total drayage minutes and VMT.

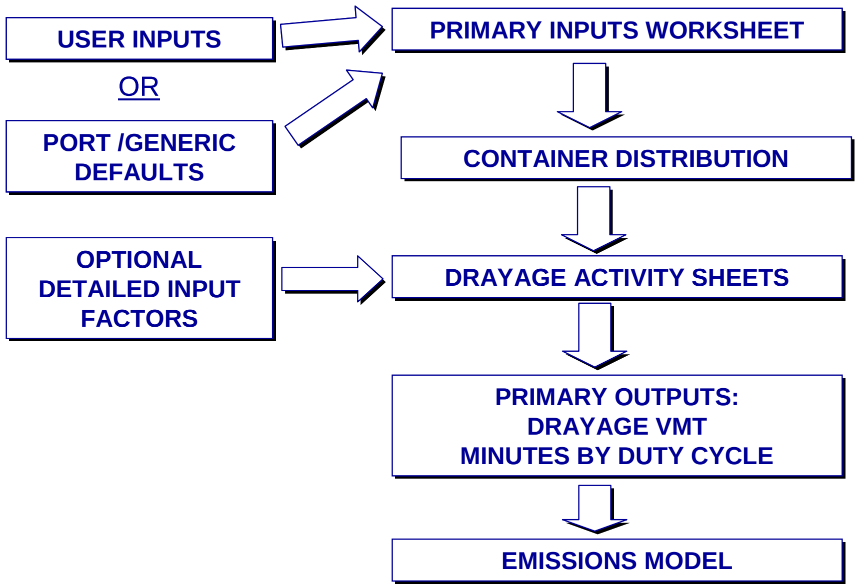
For input to the emissions model, each activity time is divided into minutes by driving cycle component: idling, creep, transient, and cruise. Drayage time and miles also become inputs to the cost and capacity portions of the model. The drayage activity cycle is made up of idling, queuing/creeping, and driving in various combinations.

The activity modeling approach includes several key features:

- Port-specific or generic default values for every variable and input
- Accommodation of user inputs that differ from defaults
- A streamlined user "front end" to facilitate primary inputs and "what if" scenarios
- An embedded flow chart of port-related container trips to account for all significant movements
- Activity tally sheets to capture default or user-specified factors for over-the-road drayage, terminal trips, etc.
- Summary activity model outputs in minutes by duty cycle to serve as emissions model inputs.

Exhibit 1 gives an overview of the model structure and the flow of information.

Exhibit 1: DrayFLEET Model Structure



The Container Distribution worksheet determines the number and nature of drayage trips implied by the Primary Inputs values. The trips are allocated among seven major activity centers, each with its own tally sheet.

- Marine Terminals
- Inter-Terminal Drayage
- Off-Dock Rail Intermodal
- Shippers and Consignees
- Container Depots
- Street Turns and Crosstowns
- Other Port Trucks

Each of these drayage activity tally sheets has its own set of secondary user-changeable default inputs. The drayage activity sheets are linked to detailed and summary output sheets. The activity model outputs become inputs for the emissions section of the model.

Input categories include:

- Port & terminal information (e.g. TEU, import/export balance)
- Default/scenario operational factors (e.g. transaction times)
- Management strategies (e.g. on-dock rail, automated gates)
- Drayage tractor fleet and technologies (e.g. diesel engine retrofits)

Outputs provided include:

- Activity outputs (e.g. trip legs and VMT)
- Duty cycle outputs (e.g. idle, creep, transition, and cruise minutes)
- Comparison charts to illustrate changes from defaults

Exhibit 2 shows the inputs worksheet. This worksheet (shown in its entirety below) has five sections covering key input values, port or terminal management initiatives, activity outputs, emissions and cost outputs, and a note section to identify the model application and scenario.

Exhibit 2: Primary Inputs Worksheet

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0d of 06/10/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,000,000	2,000,000
Average TEU per Container	1.75	1.75
Inbound Share	50%	50%
Inbound Empty Share	5%	5%
Outbound Empty Share	25%	25%
Rail Intermodal Share	25%	25%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	10%	10%
Container Shippers/Receivers		
Weighted Average Miles from Port	25	25
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	0%	0%
Automated Gates (% of gate transactions)	0%	0%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	0%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Port	
Terminal(s)	
Scenario	
Date	

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,498,452	3,498,452	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	0.0	0.0%
Total Drayage VMT	65,706,753	65,706,753	0	0.0%
Drayage VMT per Container	57.5	57.5	0.0	0.0%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	1,869,294	1,869,294	0	0.0%
Creep Hours	994,223	994,223	0	0.0%
Transient Hours	572,700	572,700	0	0.0%
Cruise Hours	1,506,026	1,506,026	0	0.0%
Total Drayage Hours	4,942,243	4,942,243	0	0.0%
Drayage Hours per Container	4.3	4.3	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	53	53	0.00	0.0%
CO	298	298	0.00	0.0%
NOx	1,108	1,108	0.00	0.0%
PM_{10}	37	37	0.00	0.0%
$PM_{2.5}$	31	31	0.00	0.0%
CO_2	88,497	88,497	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	7,909,626	7,909,626	0.0	0.0%
Total Drayage Cost	$ 159,451,797	$ 159,451,797	$ -	0.0%
Drayage Cost per Container	$ 140	$ 140	$ -	0.0%

For each of the Primary Inputs there is a Default value and a Scenario value. The model uses the Default value unless it is superseded by a different user entry in the Scenario columns. The key port or terminal inputs specify the overall volume and pattern of trade. The model has default values for every variable. The user can replace other defaults with specific scenario information as available.

Emissions Estimates. DrayFLEET calculates emissions by combining the amount of time that trucks spend within various modes of operation (idle, creep, transient, and cruise) with EPA emissions rate data specific to those operating modes for a given fleet age distribution. Loaded and empty emissions are calculated separately. The emission rate data is already part of the DrayFLEET model and the amount of time spent within each mode comes directly from the activity module.

Four operating modes are included in the DrayFLEET model: idle, creep, transient, and cruise. The activity portions of the model yield estimates of minutes spent by drayage tractors in each of these modes. The emissions portion of the model therefore uses a mode conversion factor to bridge the gap between the detailed drayage activity model output and the emissions factors in MOBILE6.2.

The DrayFLEET activity model allocates all drayage activities to one or more of the four operating modes. Actual time spent in each mode is calculated by DrayFLEET for each terminal or port activity. The table below gives some general examples.

Exhibit 3: Examples of Mode Use in DrayFLEET

Activity	Mode
Over-the-road Operations	Four-mode cycle
Queuing	Creep mode
Loading/unloading	Idle mode
Terminal movements	Transient
Port-area arterial movements	Transient Mode
Gate Transactions	Idle mode
Trouble Window Transactions	Idle mode

Actual time spent in these different modes is calculated by DrayFLEET. Idling emissions rates are very important in the model. Idling accounts for about 35% of total drayage truck time in major ports such as Los Angeles/Long Beach. Many of the terminal management initiatives being considered have substantial impacts on the amount of idling. It was therefore critical that the model reflect idling emissions as accurately as possible.

Mode Correction Factors (MCF). To estimate emissions across these operating modes, the DrayFLEET model requires Mode Specific Emissions factors (MSEs) in grams per hour corresponding to each combination of drayage tractor model year, age (based on calendar year), and operating mode (idle, creep, transient, cruise). The DrayFLEET Model calculates mode correction factors to adjust MOBILE6.2 base speed output in grams per mile to reflect each of the four modes in grams per hour. Fuel economy data for use in the mode correction factor are based on the values assigned by EPA in MOBILE6.2 calculations, and the observed fuel economy from the four-mode test data collected during the Coordinating Research Council E55/E59 study.

The drayage activity model yields estimates of miles traveled and minutes by mode (idle, creep, transition, cruise) for tractors pulling loaded containers, for bobtails (tractors without chassis), for tractors pulling empty chassis, and for tractors pulling empty containers on chassis.

DrayFLEET emissions factors vary by tractor model year and age. The model incorporates a default fleet age distribution and a designated calendar year for this purpose. The model also allows the user to develop a custom age distribution or to create a new scenario based on one of the default choices.

Initiative and Technology Impacts

Modeling the emissions impacts of port and terminal management initiatives such as neutral chassis pools and automated gates was a major reason for developing DrayFLEET. DrayFLEET is likewise intended to estimate the impacts of truck and engine technology such as diesel particulate filters or idling controls. In general:

- Changing all (or most) of the initiative inputs together makes a substantially greater difference that treating them individually – as expected. On-dock rail makes the greatest difference, but it requires a large investment.

- The scope of the analysis makes a major difference. When the scope is restricted to the vicinity of the Port (as it would be in an emissions inventory), the same management initiatives have a much greater percentage impact.

- Port drayage activity and emissions can be dominated by long trips to and from regional customers. In those cases, the marine terminal impact is overshadowed by the much large, unchanged activity of serving customers.

- Truck and engine technology impacts vary with the application and context. Idle reduction, for example, is more important in the vicinity of the port while particulate filters provide benefits across all movement types and modes.

To illustrate the dramatic impact of port and terminal initiatives within the port area, Exhibit 4 maximizes the initiative inputs using a five-mile analysis scope to focus on the immediate vicinity of the port. In this example, the initiatives result in more than a 20% reduction in emissions and a 24% reduction is drayage costs.

Exhibit 4: Initiative Impacts - Five-Mile Scope

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0E of 06/26/2008

Port	Generic
Terminal(s)	All
Scenario	Initiative Impacts
	Five-Mile Scope
Date	6/26/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,000,000	2,000,000
Average TEU per Container	1.75	1.75
Inbound Share	50%	50%
Inbound Empty Share	5%	5%
Outbound Empty Share	25%	25%
Rail Intermodal Share	25%	25%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	10%	10%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	100%
On-Dock Rail (% of rail on-dock)	0%	100%
Automated Gates (% of gate transactions)	0%	100%
Extended Gate Hours (% off-peak, 50% max)	0%	50%
Container Info System (% used)	0%	100%
Virtual Container Yard (% available)	0%	100%
Neutral Chassis Pool (% used)	0%	100%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,235,095	-591,140	-15.4%
Drayage Trip Legs per Container	3.3	2.8	-0.5	-15.4%
Total Drayage VMT	32,188,994	26,730,130	-5,458,864	-17.0%
Drayage VMT per Container	28.2	23.4	-4.8	-17.0%
Fleet Required (FTE Tractors)	1,286	944	-343	-26.6%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,378,740	-346,738	-20.1%
Creep Hours	991,532	514,187	-477,345	-48.1%
Transient Hours	339,489	257,964	-81,526	-24.0%
Cruise Hours	755,790	645,766	-110,024	-14.6%
Total Drayage Hours	3,812,289	2,796,656	-1,015,633	-26.6%
Drayage Hours per Container	3.3	2.4	-0.9	-26.6%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	25	-7.17	-22.5%
CO	181	139	-41.37	-22.9%
NOx	637	505	-131.46	-20.6%
PM_{10}	21	17	-4.19	-20.2%
$PM_{2.5}$	18	14	-3.53	-20.2%
CO_2	79,582	63,343	-16,239	-20.4%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	5,661,443	-1,451,395.6	-20.4%
Total Drayage Cost	$ 130,800,961	$ 98,503,289	$ (32,297,672)	-24.7%
Drayage Cost per Container	$ 114	$ 86	$ (28)	-24.7%

The EPA SmartWay program offers freight carriers technical and financial information on a range of truck and engine technologies and practices designed to conserve fuel and reduce emissions. Many of the applicable options have been built into DrayFLEET, as shown in Exhibit 5. These measures have different impacts on drayage emissions and fuel use, depending on which combination of options is applied and how widely they are implemented across the fleet.

Exhibit 5: DrayFLEET Technology and Strategy Options

Drayage Fleet Technology and Strategy Inputs*		
Technology Retrofits		
☐ Particulate Filter/Trap	% of eligible fleet retrofit	50%
☐ Oxidation Catalyst	% of eligible fleet retrofit	50%
☐ Flow-Through Filter	% of eligible fleet retrofit	50%
Idle Reduction		
☐ Idling Control Strategies	% reduction in idle	50%
Fuel Conservation		
☐ Single-Wide Tires	% of fleet	50%
☐ Automatic Tire Inflation	% of fleet	50%
☐ Tare Weight Reduction	% of fleet	50%
	lbs of weight saved	2,000
☐ Low Friction Engine Lubricant	% of fleet	50%
☐ Low Friction Drive Train Lubricant	% of fleet	50%
☐ Direct Drivetrain	% of fleet	50%
☐ Single Axle Drive (vs. Dual Axle)	% of fleet	50%
☐ Speed Management Policy (55 mph)	% of fleet	50%

Los Angeles/Long Beach Case Study

Los Angeles and Long Beach together form the largest and busiest container port complex in North America. As Exhibit 6 shows, the Los Angeles/Long Beach port complex includes fourteen terminals which are served by several on-dock rail terminals.

Exhibit 6: LA/LB Container Terminals

Port drayage (highway trucking of marine containers) in Southern California poses a prominent and difficult problem within California's goods movement system. Emissions from port drayage operations endanger the health of surrounding communities and have produced a regional backlash against international trade and the growth of the State's ports. The Ports of Los Angeles and Long Beach have launched ambitious efforts to reduce emissions from drayage and are considering additional steps.

The importance of the drayage issue and the community sensitivity to port activity in Southern California have led to numerous studies of drayage and related subjects, several of which are discussed in the literature review. There is thus much more documentation available on drayage in Southern California than on drayage in other regions.

Exhibit 7 displays the primary inputs for an LALB DrayFLEET model version. Inputs values were taken from the studies and other sources cited above.

Exhibit 7: DrayFLEET Model Calibrated for LALB Drayage

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0E of 06/26/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	15,667,504	15,667,504
Average TEU per Container	1.85	1.85
Inbound Share	53%	53%
Inbound Empty Share	2%	2%
Outbound Empty Share	57%	57%
Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	14	14
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	15	15
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	40%	40%
Automated Gates (% of gate transactions)	50%	50%
Extended Gate Hours (% off-peak, 50% max)	30%	30%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Port	Los Angeles/Long Beach
Terminal(s)	All
Scenario	2007 Base Case
Date	7/23/2008

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	19,511,263	0	0.0%
Drayage Trip Legs per Container	2.3	2.3	0.0	0.0%
Total Drayage VMT	268,111,709	268,111,709	0	0.0%
Drayage VMT per Container	31.7	31.7	0.0	0.0%
Fleet Required (FTE Tractors)	7,122	7,122	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	7,707,571	7,707,571	0	0.0%
Creep Hours	4,060,244	4,060,244	0	0.0%
Transient Hours	2,708,141	2,708,141	0	0.0%
Cruise Hours	6,634,950	6,634,950	0	0.0%
Total Drayage Hours	21,110,907	21,110,907	0	0.0%
Drayage Hours per Container	2.5	2.5	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	297	297	0.00	0.0%
CO	1,735	1,735	0.00	0.0%
NOx	6,900	6,900	0.00	0.0%
PM_{10}	232	232	0.00	0.0%
$PM_{2.5}$	201	201	0.00	0.0%
CO_2	643,061	643,061	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	57,475,380	57,475,380	0.0	0.0%
Total Drayage Cost	$ 796,921,267	$ 796,921,267	$ -	0.0%
Drayage Cost per Container	$ 94	$ 94	$ -	0.0%

Key factors in distinguishing the LALB version from other ports include:

- Volume – the ports handled over 15 million TEU in 2007, equivalent to about 8.4 million containers.
- Dramatic imbalance, with about 57% of the outbound movement being empty.
- No barge movements or transshipment, and a minimum of inter-terminal drayage.
- No separate empty lots at marine terminals (unlike the other three case studies).
- About 45% rail intermodal movement, of which 40% (18% of the total) is handled on-dock.
- Wheeled operations – draymen routinely pickup and drop containers on their chassis.
- Longer off-dock rail terminal trips – with one 4 miles away and the others 20 miles away, the weighted average distance is about 14 miles.
- Shorter average shipper/receiver drayage trips – the major local market shown in is served by truck, but the overwhelming majority of trips beyond are made by rail.

The primary outputs (Exhibit 7) suggest the enormous volume of drayage activity in the Los Angeles basin.

- Over 19 million annual drayage trip legs covering over 260 million vehicle miles.

- 21 million hours of driver and tractor time.

The emissions totals are similarly high, due to the enormous volume. Note that these estimates may not match other published estimates because of differences in the geographic scope and other modeling assumptions.

- Much greater total emissions than the other case studies, including 6,900 annual tons of NOx.
- Consumption of about 57 million gallons of diesel fuel creating 643,061 annual tons of CO_2.
- A total annual drayage cost of about $800 million.

Combined and Potential Impacts. The port terminals at Los Angeles and Long Beach have implemented a number of initiatives including automated gates, extended gate hours, and container information systems, as shown in the LALB model. The benefits of implementation thus far are substantial. Exhibit 8 shows the benefits of these initiatives by "zeroing out" the LALB initiatives, focusing on the immediate port area by setting a five-mile limit on drayage to customers or rail facilities[2]. By the results shown in Exhibit 8, the various initiatives have:

- Reduced drayage trips by 15.1% and hours by 25.5%
- Reduced 2007 emissions by 16.6% to 18.9%
- Reduced fuel use by 16.8% and cost by 22.3%

Exhibit 8: LALB Combined Initiatives Impact - Five Mile Limit

Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00
Initiative Inputs	**Default**	**Scenario**
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	40%	0%
Automated Gates (% of gate transactions)	50%	0%
Extended Gate Hours (% off-peak, 50% max)	30%	0%
Container Info System (% used)	90%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

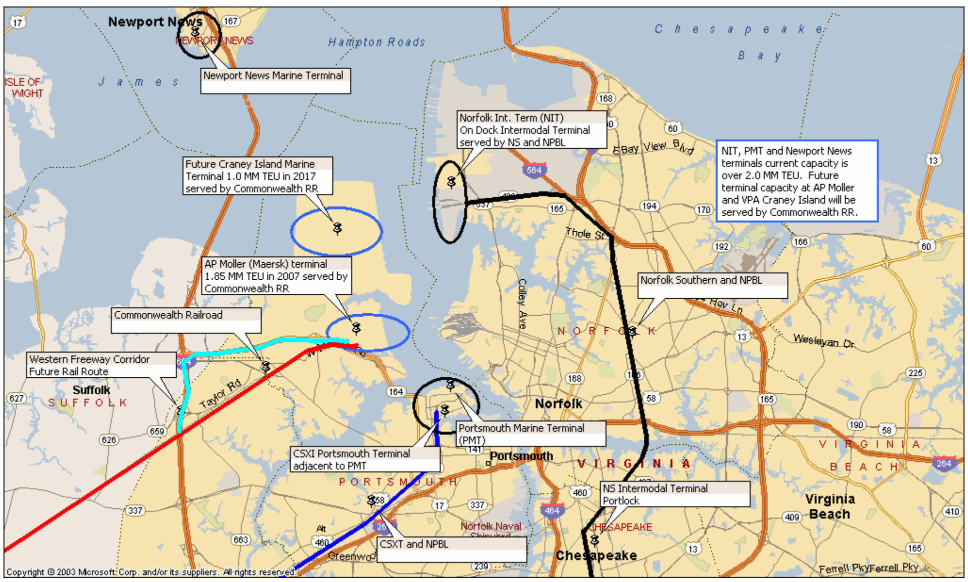
Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	22,451,777	2,940,515	15.1%
Drayage Trip Legs per Container	2.3	2.7	0.3	15.1%
Total Drayage VMT	169,539,823	193,968,171	24,428,348	14.4%
Drayage VMT per Container	20.0	22.9	2.9	14.4%
Fleet Required (FTE Tractors)	5,720	7,181	1,461	25.5%
Annual Duty Cycle Totals				
Idle Hours	7,015,578	8,596,046	1,580,468	22.5%
Creep Hours	3,768,454	5,646,815	1,878,361	49.8%
Transient Hours	1,937,722	2,285,782	348,060	18.0%
Cruise Hours	4,232,580	4,756,630	524,[illegible]	12.4%
Total Drayage Hours	16,954,334	21,285,274	4,330,939	25.5%
Drayage Hours per Container	2.0	2.5	0.5	25.5%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	208	246	38.65	18.6%
CO	1,217	1,447	229.96	18.9%
NOx	4,705	5,506	800.86	17.0%
PM_{10}	157	183	26.14	16.6%
$PM_{2.5}$	137	159	22.69	16.6%
CO_2	437,023	510,428	[illegible]	16.8%
Fuel Use and Total Cost				
Fuel Gallons	39,060,167	45,620,955	6,560,788.0	16.8%
Total Drayage Cost	$ 632,063,845	$ 773,199,816	$ 141,135,971	22.3%
Drayage Cost per Container	$ 75	$ 91	$ 17	22.3%

[2] In order to capture the emission benefits of the initiative inputs, this modeling exercise effectively "moves" the LALB rail terminals closer to the ports, since some are more than five miles away.

Virginia Case Study

The Port of Virginia (Exhibit 9) includes Norfolk International Terminals, Newport News Marine Terminal, Portsmouth Marine Terminal, and the Virginia Inland Port in Front Royal. Combined with a new private terminal (APM) that opened in 2007, these four facilities make up The Port of Virginia. This case study focuses on Norfolk International Terminals (NIT) and Portsmouth Marine Terminal (PMT), the two marine container terminals. Newport News Marine terminal (NNMT) is primarily a break bulk and project cargo terminal, but does handle a minimal amount of container business that is covered in this study. The Virginia Inland Port is linked to NIT by rail rather than by over-the-road drayage, and its activity is reflected in the rail intermodal share. The recently opened Maersk Terminal (APM) is not part of VPA, and not covered in this report.

Exhibit 9: Port of Virginia



The VPA/VIT container terminals at Norfolk have a distinctive operating system that is reflected in drayage movement patterns and the DrayFLEET model. In common with many Asian and European container terminals, containers at PMT and NIT are lifted on and off the chassis at designated transfer zones. The drayage drivers and tractors do not enter the container stacks in the main container yard. At PMT and NIT, this process is accomplished with straddle carriers, which shuttle between the transfer zones and the container stacks.

The Virginia marine terminals serve a substantial market beyond the immediate urban area. The population of the Norfolk metropolitan area is approximately 1.6 million, but the port also provides primary marine facility access for the Commonwealth of Virginia's 7.6 million people as well as for much of Eastern North Carolina and Maryland. The port also records significant truck volume moving to Western North Carolina, Tennessee and Kentucky. Norfolk port drayage operations are therefore characterized by a greater frequency of medium range (100-250 mile) movements than a more compact hinterland such as urban New York/New Jersey.

Primary inputs for the DrayFLEET model calibrated for the Port of Virginia (NIT, PMT, NNIT) are shown in Exhibit 10.

Exhibit 10: Virginia DrayFLEET Primary Inputs

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0d of 06/10/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,128,366	2,128,366
Average TEU per Container	1.74	1.74
Inbound Share	49%	49%
Inbound Empty Share	0%	0%
Outbound Empty Share	50%	50%
Rail Intermodal Share	27%	27%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	24	24
Rail Terminals		
Weighted Average Miles from Port	11	11
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	147	147
Weighted Average Crosstown Trip Miles	12	12
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	100%	100%
On-Dock Rail (% of rail on-dock)	89%	89%
Automated Gates (% of gate transactions)	100%	100%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	100%

Port	Virginia
Terminal(s)	NIT/PMT/NNIT
Scenario	Base Case
Date	6/16/2008

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	2,683,241	2,683,241	0	0.0%
Drayage Trip Legs per Container	2.2	2.2	0.0	0.0%
Total Drayage VMT	233,284,181	233,284,181	0	0.0%
Drayage VMT per Container	190.7	190.7	0.0	0.0%
Fleet Required (FTE Tractors)	3,494	3,494	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	2,491,249	2,491,249	0	0.0%
Creep Hours	894,677	894,677	0	0.0%
Transient Hours	1,727,351	1,727,351	0	0.0%
Cruise Hours	5,243,436	5,243,436	0	0.0%
Total Drayage Hours	10,356,714	10,356,714	0	0.0%
Drayage Hours per Container	8.5	8.5	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	167	167	0.00	0.0%
CO	968	968	0.00	0.0%
NOx	4,465	4,465	0.00	0.0%
PM_{10}	110	110	0.00	0.0%
$PM_{2.5}$	93	93	0.00	0.0%
CO_2	263,796	263,796	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	23,577,530	23,577,530	0.0	0.0%
Total Drayage Cost	$ 339,205,428	$ 339,205,428	$ -	0.0%
Drayage Cost per Container	$ 277	$ 277	$ -	0.0%

Virginia Port and Terminal Initiatives

The Port of Virginia and its constituent terminals have undertaken several initiatives designed to increase capacity and throughput while reducing cost and emissions. There has been a particularly strong emphasis on the use of information systems.

- **Gate and Terminal Cameras.** Gate and container yard/transfer zone cameras are in place at the Port of Virginia terminals, enabling drayage dispatchers and drivers to avoid congestion where possible.

- **eModal.** The eModal port community information system has been implemented at all of the VPA terminals. As noted elsewhere, eModal was designed to improve efficiency and decrease congestion by providing a single point of contact for multiple terminals.

- **Neutral Chassis Pool.** VIT, the private non-stock operating company of the Virginia Port Authority, and OCEMA, the Ocean Carrier Equipment Management Association, teamed up to create the Hampton Roads Chassis Pool II (HRCP II), which includes Norfolk International Terminals, Newport News Marine Terminal, and Portsmouth Marine Terminal. The chassis pool, resulted in a 23 percent reduction in the equipment inventory and a 27 percent increase in asset utilization.

- **Virtual Container Yard**. Off Terminal Container Solutions is an Internet based program that facilitates street turns. OTCS is a Virtual Container Yard (VCY) that gives participating motor carriers the ability to post and view containers that are available for street turns. This VCY is viewed as less than completely successful to date.

- **VIT Container Tracking.** VIT offers multiple access points to its container tracking and information systems. The VIT Container Inventory information is updated every fifteen (15) minutes and represents the current inventory of VIT's host system. A key tool in managing and communicating the preferred routing and disposition of empty containers is the Empty Return Matrix. This matrix is available on-line, and is updated daily.

- **Virginia Inland Port.** Norfolk Southern (NS) railroad provides an intermodal service between Norfolk International Terminal (NIT) and the Virginia Inland Port (VIP). VIP's operations are beyond the scope of DrayFLEET, but the rail trips to and from VIP account for any of the inter-terminal drays within the VPA complex at Norfolk.

Exhibit 11 shows the combined estimated impact of these initiatives. In 2007, these initiatives saved:

- Nearly 600,000 drayage trip legs covering nearly 6 million miles
- Over 600,000 annual hours of driver and tractor time
- 29% to 30% of HC, NOx, CO, and particulate emissions
- Over 1 million gallons of fuel, and 11,000+ tons of CO_2
- Over $22 million in drayage costs.

Exhibit 11: Port of Virginia - Combined Initiatives Impacts - 5 Mile Scope

Rail Intermodal Share	27%	27%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	24	24
Rail Terminals		
Weighted Average Miles from Port	11	11
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	12	12
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00
Initiative Inputs	**Default**	**Scenario**
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	100%	0%
On-Dock Rail (% of rail on-dock)	89%	0%
Automated Gates (% of gate transactions)	100%	0%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	90%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	2,683,241	3,248,622	565,381	21.1%
Drayage Trip Legs per Container	2.2	2.7	0.5	21.1%
Total Drayage VMT	23,005,596	28,843,437	5,837,841	25.4%
Drayage VMT per Container	18.8	23.6	4.8	25.4%
Fleet Required (FTE Tractors)	770	986	217	28.1%
Annual Duty Cycle Totals				
Idle Hours	1,146,962	1,451,054	304,092	26.5%
Creep Hours	327,836	410,348	82,512	25.2%
Transient Hours	230,711	330,610	99,899	43.3%
Cruise Hours	576,519	731,952	155,434	27.0%
Total Drayage Hours	2,282,027	2,923,964	641,937	28.1%
Drayage Hours per Container	1.9	2.4	0.5	28.1%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	23	30	6.83	30.0%
CO	133	174	40.22	30.2%
NOx	572	739	167.08	29.2%
PM_{10}	14	18	4.04	29.0%
$PM_{2.5}$	12	15	3.41	29.0%
CO_2	36,311	47,695	11,385	31.4%
Fuel Use and Total Cost				
Fuel - Gallons	3,245,362	4,262,888	1,017,525.4	31.4%
Total Drayage Cost	$ 78,836,518	$ 101,490,898	$ 22,654,380	28.7%
Drayage Cost per Container	$ 64	$ 83	$ 19	28.7%

Houston Case Study

The Port of Houston Authority (PHA) owns and operates the public facilities located on the Houston Ship Channel. Prior to 2007 the only container terminal on property owned by PHA was Barbours Cut Container Terminal. The new Bayport container terminal opened in 2007. The modeling effort in this project focused on Barbours Cut, as Bayport does not yet have performance or throughput data.

Based on local terminal and operations features the study team developed a default DrayFLEET model for Barbours Cut. Exhibit 12 shows the primary input and outputs.

Exhibit 12: Barbours Cut DrayFLEET Model Primary Inputs

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0E of 06/25/2008

Port	Houston
Terminal(s)	Barbours Cut
Scenario	Base Case
Date	6/25/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2006	2006
Annual TEU	1,020,002	1,020,002
Average TEU per Container	1.61	1.61
Inbound Share	49%	49%
Inbound Empty Share	37%	37%
Outbound Empty Share	4%	4%
Rail Intermodal Share	21%	21%
Marine Terminals		
Average Inbound Gate Queue Minutes	20	20
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	25	25
Average Inbound Gate Queue Minutes	25	25
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	0%	0%
Container Shippers/Receivers		
Weighted Average Miles from Port	38	38
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 15.25	$ 15.25
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	90%	90%
On-Dock Rail (% of rail on-dock)	20%	20%
Automated Gates (% of gate transactions)	100%	100%
Extended Gate Hours (% off-peak, 50% max)	100%	100%
Container Info System (% used)	70%	70%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	100%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	1,942,493	1,942,493	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	0.0	0.0%
Total Drayage VMT	45,988,094	45,988,094	0	0.0%
Drayage VMT per Container	72.6	72.6	0.0	0.0%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	1,148,904	1,148,904	0	0.0%
Creep Hours	441,322	441,322	0	0.0%
Transient Hours	406,848	406,848	0	0.0%
Cruise Hours	1,134,690	1,134,690	0	0.0%
Total Drayage Hours	3,131,764	3,131,764	0	0.0%
Drayage Hours per Container	4.9	4.9	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	39	39	0.00	0.0%
CO	238	238	0.00	0.0%
NOx	871	871	0.00	0.0%
PM_{10}	32	32	0.00	0.0%
$PM_{2.5}$	27	27	0.00	0.0%
CO_2	101,373	101,373	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	9,060,468	9,060,468	0.0	0.0%
Total Drayage Cost	$ 124,569,558	$ 124,569,558	$ -	0.0%
Drayage Cost per Container	$ 197	$ 197	$ -	0.0%

The model version shown above accounts for the container volume moving through the common-user portion of Barbours Cut. Particular effort was required to model the unique system of on-dock chassis and container storage using a separate gate.

Port of Houston Initiatives

The Port of Houston and the terminal operators have undertaken a number of initiatives that together reduce drayage time, emissions, and cost.

- **Road Congestion.** Barbours Cut Blvd. has been a two lane road that serves not only Barbours Cut but also the container depots adjacent to the terminal, access to marine services support services companies as well as cruise ship traffic. The road is a very high density two land road that for most of 2007 has been in very bad repair. However, in late 2007 an extensive rebuilding project has been underway to repair and improve flow by adding extra long turn lanes to better accommodate the high volume of truck traffic.

- **Neutral Chassis Pools.** There are two neutral chassis pools to support drayage operations at the common user terminal and Maersk has its own pool.

- **Automated Gate.** In addition to the roadway improvements in late 2007, a new common user automated gate has been put into operation as of mid-November 2007.

- **On-Dock Rail Intermodal.** About 20% of the rail intermodal volume at Barbours Cut is reportedly handled on-dock, with the bulk of the rail intermodal handled at the Union Pacific terminal about 25 miles away.

Exhibit 13 illustrates the combined impact of the multiple initiatives undertaken at the Port of Houston, restricting scope to five miles from the Port[3]. "Backing out" the automated gates, container informational system, and neutral chassis pools while reinstating the former 40-minute queue time suggests that the combined impact of the initiatives was to:

- reduce VMT by over 2 million miles;
- reduce annual drayage hours (tractor and driver) by over 1.2 million;
- reduce emissions by 22.0% to 33.4%, including over 90 tons of NOx and almost 10,000 tons of CO2;
- reduce fuel consumption by about 888,000 gallons; and
- reduce total drayage cost by almost $32 million.

Exhibit 13: Port of Houston - Combined Impact of Initiatives – Five Mile Limit

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs

DrayFLEET Version 1.0E of 06/25/2008

Port	Houston
Terminal(s)	Barbours Cut
Scenario	Base Case - Five Mile Limit
Date	7/23/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2006	2006
Annual TEU	1,020,002	1,020,002
Average TEU per Container	1.61	1.61
Inbound Share	49%	49%
Inbound Empty Share	37%	37%
Outbound Empty Share	4%	4%
Rail Intermodal Share	21%	21%
Marine Terminals		
Average Inbound Gate Queue Minutes	20	40
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	25	25
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	0%	0%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 15.25	$ 15.25
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	90%	90%
On-Dock Rail (% of rail on-dock)	20%	20%
Automated Gates (% of gate transactions)	100%	0%
Extended Gate Hours (% off-peak, 50% max)	100%	0%
Container Info System (% used)	70%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	1,942,493	1,942,493	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	0.0	0.0%
Total Drayage VMT	17,933,015	19,966,416	2,033,401	11.3%
Drayage VMT per Container	28.3	31.5	3.2	11.3%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	945,734	1,052,731	106,997	11.3%
Creep Hours	355,652	1,484,895	1,129,243	317.5%
Transient Hours	180,651	180,701	50	0.0%
Cruise Hours	429,349	429,349	0	0.0%
Total Drayage Hours	1,911,386	3,147,676	1,236,290	64.7%
Drayage Hours per Container	3.0	5.0	2.0	64.7%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	18	24	5.72	32.1%
CO	108	144	36.12	33.4%
NOx	375	465	90.06	24.0%
PM_{10}	14	16	2.98	22.1%
$PM_{2.5}$	12	14	2.57	22.0%
CO_2	43,087	53,023	9,936	23.1%
Fuel Use and Total Cost				
Fuel - Gallons	3,850,986	4,739,055	888,068.8	23.1%
Total Drayage Cost	$ 73,078,496	$ 105,044,827	$ 31,966,331	43.7%
Drayage Cost per Container	$ 115	$ 166	$ 50	43.7%

[3] As with LALB, this modeling step "moves" the rail terminals closer to the port.

New York-New Jersey Case Study

The primary agency managing ports in the New York metropolitan area is the Port Authority of New York and New Jersey. The Port Authority is a bi-state agency which serves as a landlord for several marine terminals Exhibit 14.

Exhibit 14: Primary NYNJ Container Terminals

Terminal	Location	Stevedore	Acreage
Maher	Port Elizabeth, NJ	Maher	445
Maersk/Sealand	Port Elizabeth, NJ	APM	350
PNCT	Port Newark, NJ	Ports America	175
Howland Hook	Staten Island, NY	NYCT	187
Global	Jersey City, NJ	GTCS	100

Maher Terminals has been a major innovator and provided much of the information for this case study. Maher was sold to a new owner in 2007, but continues to operate under the Maher name. *This case study focuses on terminal operations through 2007.*

Unlike many ports in the United States, most of the cargo that uses the port of New York is consumed locally and most drayage is a local exercise. The estimated distribution is as follows.

- 15% of the cargo is handled by rail, most using on-dock rail facilities and the rest using nearby rail intermodal terminals.
- 60% of the cargo moves to the four surrounding New Jersey counties; much of this is transloaded for delivery in New York and other northeastern cities.
- 4% moves to locations within 260 miles to nearby destinations in NY, CT, PA, MA, and RI.
- 15% moves to U.S. locations beyond 260 miles such as Pittsburgh, Cleveland, and Buffalo.
- 3% moves to Canadian locations such as Montreal and Toronto.

While drayage conditions associated with highway congestion in the region have generally worsened over time, there has been a significant improvement in speed with which trucks are processed through regional marine terminals. A 1994 study[4] performed by Tioga's principals for the PA found that marine container terminal turn time in the PA's main terminals varied between two and three hours, and was the worst among competitive east coast terminals. Currently, drivers typically move through PA terminals in less than an hour. Between 1994 and 2006 container volume more than doubled and terminal turn time was cut in half.

Data from multiple sources was used to calibrate the DrayFLEET model for the port of NYNJ. Exhibit 15 shows the primary inputs used to reflect operations in 2007.

[4] "Drayage Services Improvement Study." This 1994 study was performed by Tioga's principals while engaged by Mercer Management Consulting.

Exhibit 15: NYNJ DrayFLEET Model

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0d of 06/10/2008

Port	New York - New Jersey
Terminal(s)	All
Scenario	Base Case
Date	6/16/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	5,299,105	5,299,105
Average TEU per Container	1.71	1.71
Inbound Share	50%	50%
Inbound Empty Share	1%	1%
Outbound Empty Share	44%	44%
Rail Intermodal Share	15%	15%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	14	14
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	45	45
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	80%	80%
On-Dock Rail (% of rail on-dock)	80%	80%
Automated Gates (% of gate transactions)	90%	90%
Extended Gate Hours (% off-peak, 50% max)	20%	20%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	80%	80%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	8,469,920	8,469,920	0	0.0%
Drayage Trip Legs per Container	2.7	2.7	0.0	0.0%
Total Drayage VMT	274,696,007	274,696,007	0	0.0%
Drayage VMT per Container	88.6	88.6	0.0	0.0%
Fleet Required (FTE Tractors)	4,971	4,971	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	4,458,614	4,458,614	0	0.0%
Creep Hours	1,848,985	1,848,985	0	0.0%
Transient Hours	2,155,504	2,155,504	0	0.0%
Cruise Hours	6,269,823	6,269,823	0	0.0%
Total Drayage Hours	14,732,926	14,732,926	0	0.0%
Drayage Hours per Container	4.8	4.8	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	251	251	0.00	0.0%
CO	1,454	1,454	0.00	0.0%
NOx	6,010	6,010	0.00	0.0%
PM_{10}	204	204	0.00	0.0%
$PM_{2.5}$	177	177	0.00	0.0%
CO_2	337,555	337,555	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	30,169,896	30,169,896	0.0	0.0%
Total Drayage Cost	$ 489,629,685	$ 489,629,685	$ -	0.0%
Drayage Cost per Container	$ 158	$ 158	$ -	0.0%

Exhibit 15 also shows the corresponding primary outputs. The DrayFLEET model estimates that a total of 4,971 FTE tractors would be needed to travel 274.7 million miles over 14.7 million hours to make the 8.5 million trip legs required to handle 5.3 million TEU in 2007.

NYNJ Drayage Initiatives and Impacts

Faced with the need to handle ever-increasing demand while improving in-terminal drayage times to levels that would be competitive with other east coast ports, there developed a very strong level of cooperation within the port community in New York. This collaboration has resulted in a number of individual initiatives by terminal operators which in the aggregate produced a dramatic improvement in motor carrier productivity and a reduction in drayage idling. While it is difficult to assess the precise impact of so many interrelated initiatives implemented simultaneously, in the aggregate more than an hour of driver time per turn has been gained by these efforts over the past 12 years.

- **Co-op Chassis Pools.** Maher was one of the early innovators in the establishment of a co-op neutral chassis pool in 1995. In a co-op neutral chassis pool each steamship line participant contributes their chassis to the pool and then is able to use any chassis in the pool as needed to meet ordinary and extraordinary demands.

- **Container Terminal Information System.** Each terminal has an information system that maintains container status and availability information. The practical value of accurate information is that it permits motor carrier dispatchers to plan work efficiently and to avoid "dry runs" – moves made with the goal of picking up a container that is not available for some unforeseen reason. The information system and associated operating discipline has had the further benefit of reducing visits truckers make to the “trouble window” for exceptional or difficult movements.

- **Automated Gates.** All the NYNJA marine terminals have been continuously improving gate technology. In particular, Maher was a leader in the implementation of Optical Character Recognition (OCR) technology at marine terminal gates.

- **Port ID Card.** NYNJ was one of the first ports to implement a uniform truck driver identification card, called SEALINK®. The uniform ID was one of the building blocks that is used to simplify business processes at marine gates and reduce the time taken to process trucks.

- **Extended Gate Hours.** Maher extended gate hours to 6 am-10 pm without penalty charges and had been almost as successful as PierPASS at increasing gate capacity by spreading the demand for gate services over a longer period of time.

- **Staggered Lunch Breaks.** ILA work rules now permit staggered shifts over the lunch hour. In the past it was possible for truckers to get caught in the terminal and be forced to sit idle for an hour while the gates closed for lunch.

- **Gate Web Cameras.** Gate Web Cameras help level the demand for gate services over the available time by giving motor carrier dispatchers and drivers real time information regarding gate congestion.

- **Terminal and Gate Capacity.** Another way to reduce trucker turn times is to increase terminal capacity. At NYNJ, Howland Hook Marine Terminal was reopened in 1996 after a period of dormancy. The terminal’s 187 acres added approximately 17% to marine container facilities. During this period, Maher's two separate terminal operations were consolidated into a single more efficient 445-acre terminal and the APM terminal was expanded from 266 to 350 acres. Concurrently the ExpressRail Elizabeth on-dock rail terminal was relocated and expanded from 32 to 70 acres.

- **On-Dock Rail.** NYNJ’s first on-dock rail terminal, ExpressRail, began operation in 1991. ExpressRail is now a system of three on dock rail terminals which handled 358,043 lifts in 2007. The cargo shipped using on-dock rail terminals typically avoids all the marine gate processes and queues as well as the dray to the customer or off dock facility.

The combined impact of these multiple NYNJ terminal initiatives has been substantial.

Exhibit 16: Combined NYNJ Terminal Initiatives Impact - Five Mile Limit

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0d of 06/10/2008

Port	New York - New Jersey
Terminal(s)	All
Scenario	Base Case
	Five-Mile Limit
Date	7/23/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	5,299,105	5,299,105
Average TEU per Container	1.71	1.71
Inbound Share	50%	50%
Inbound Empty Share	1%	1%
Outbound Empty Share	44%	44%
Rail Intermodal Share	15%	15%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	60
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	80%	0%
On-Dock Rail (% of rail on-dock)	80%	0%
Automated Gates (% of gate transactions)	90%	0%
Extended Gate Hours (% off-peak, 50% max)	20%	0%
Container Info System (% used)	90%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	80%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	8,469,920	9,174,216	704,295	8.3%
Drayage Trip Legs per Container	2.7	3.0	0.2	8.3%
Total Drayage VMT	70,049,637	77,054,647	7,005,010	10.0%
Drayage VMT per Container	22.6	24.9	2.3	10.0%
Fleet Required (FTE Tractors)	2,314	3,731	1,417	61.2%
Annual Duty Cycle Totals				
Idle Hours	3,147,653	6,400,242	3,252,589	103.3%
Creep Hours	1,296,196	1,987,109	690,913	53.3%
Transient Hours	695,967	820,577	124,610	17.9%
Cruise Hours	1,718,603	1,850,191	131,589	7.7%
Total Drayage Hours	6,858,419	11,058,120	4,199,700	61.2%
Drayage Hours per Container	2.2	3.6	1.4	61.2%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	82	103	21.17	25.9%
CO	479	607	127.94	26.7%
NOx	1,870	2,264	394.43	21.1%
PM_{10}	63	75	12.47	19.9%
$PM_{2.5}$	54	65	10.81	19.9%
CO_2	111,494	142,708	31,214	28.0%
Fuel Use and Total Cost				
Fuel - Gallons	9,965,092	12,754,918	2,789,826.7	28.0%
Total Drayage Cost	$ 234,250,746	$ 334,563,283	$ 100,312,537	42.8%
Drayage Cost per Container	$ 76	$ 108	$ 32	42.8%

As Exhibit 16 suggests, the combined 2007 port-area[5] impact of the various initiatives described above, including a reduction in average terminal transaction time from roughly 60 minutes to a 2007 average of 19 minutes, was to:

- eliminate over 700,000 drayage trip legs, covering over 9 million VMT;
- reduce total driver and tractor hours by 4.2 million;
- reduce emissions by 19.9% to 26.7%, including nearly 400 tons of NOx;
- reduce fuel consumption by almost 2.8 million gallons; and
- reduce drayage cost by over $100 million.

The absolute magnitude of these impacts is testament to the huge volume of drayage activity in major ports and the power of cumulative incremental improvements.

[5]Restricting the drayage distance to five miles effectively "moves" the off-dock rail terminals closer to the port.

Introduction

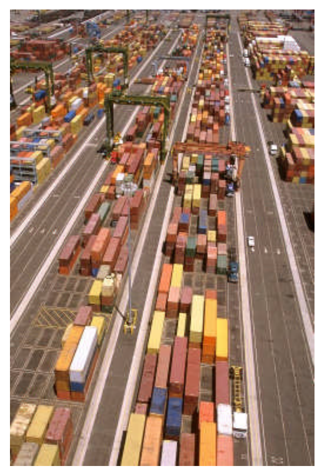
Purpose

Drayage of marine containers is now widely recognized as a critical emissions, congestion, and capacity issue for major container ports and rail intermodal terminals. Ports, technologists, and local planning agencies are struggling to reduce emissions, reduce congestion, and increase productivity so that growing cargo flows can coexist with port and terminal area communities.

There has been a critical need for analytic tools to aid in that struggle. The objective of this project was to develop an emissions and activity model – DrayFLEET – that accurately depicts drayage activity in terms of VMT, emissions, cost, and throughput, and can reliably reflect the impact of changing management practices, terminal operations, and cargo volume.

Overview of Port Drayage

Port drayage provides the critical link between marine container terminals and customers, railroads, and other facilities.



Marine Terminals. As container vessels are unloaded, the containers are moved on chassis to storage or parking areas within the terminals.

- "Stacked" terminals store containers in stacks or rows off the chassis (right). These terminals typically use in-terminal chassis (known as "bomb carts", below) between the vessel and the storage areas. At the storage areas, a variety of mechanical lift types transfer the container.
- "Wheeled" terminals store containers on street-legal chassis in large parking areas. The yard tractors position the street chassis to receive the container from the vessel, and the container remains on the chassis for storage and subsequent delivery.

- At a few terminals, "straddle carriers" (right) move the containers within the terminal.

A drayage driver arriving to pick up a loaded import container may encounter one of three basic systems.

- At wheeled terminals the driver will simply locate and retrieve the container on its chassis in the parking area.

- At stacked terminals, the driver will usually first retrieve a street-legal chassis from a chassis lot, then position the chassis in the container storage stacks to receive the container from a lift machine.

- At some stacked and straddle carrier terminals, the drayage driver will retrieve a street-legal chassis then proceed to a designated transfer zone. A lift machine then brings the container to the waiting driver.

These operations and procedures are generally reversed for export containers or empty containers being returned to the terminal.

Many marine container terminals are mixed operations. Empty containers may be stacked even when loads are parked on chassis. Most terminals maintain chassis fleets on-site, but some, such as Barbours Cut at Houston, maintain some of the chassis at off-terminal lots. Empty containers, particularly those belonging to leasing companies, may also be stored off-terminal at privately operated depots.

The drayage activity model created for this project was designed to accommodate these operational variations.

Rail Intermodal. Rail intermodal transportation is an integral part of the container movement system. The percentage of port container traffic transferred to rail ranges from a high of around 75% at Tacoma to near zero at smaller ports serving local and regional customers. The new British Columbia port at Prince Rupert is expected to be 100% rail intermodal with no drayage to local or regional customers. Transfer to rail can be either on-dock or off-dock.

- At on-dock rail transfer facilities (right), the transfer is handled by terminal equipment, either yard tractors and chassis or straddle carriers.

- At off-dock facilities, commercial over-the-road drayage drivers and tractors transfer the containers. The distances covered range from a few hundred yards to 20 miles.

The drayage activity model can accommodate either variation or, as is common, a mix of the two.

Transshipment. Some port terminals engage in transshipment – transfer of containers between oceangoing vessels or between ships and barges without exiting the terminal gates. These transfers do not involve over-the-road drayage but are accounted for in the model to ensure comprehensiveness.

Inter-terminal Drayage. Containers or empty chassis may be drayed between two marine terminals for a variety of reasons.

- For transshipment between two water carriers at different terminals.

- To relocate containers between two terminals served by the same ocean carrier or alliance.
- To relocate leased or pool equipment.
- To rectify delivery errors or mismatched containers and chassis.

The importance of inter-terminal drayage varies widely between ports. Even where insignificant, however, it is included in the model to maintain comprehensiveness.

Comprehensive Picture. A major objective of the modeling effort was to create a comprehensive picture of port drayage movements. While meeting this objective necessarily increases model size and complexity, comprehensiveness is vital for several reasons.

- If some drayage movements are excluded from the model, the model cannot capture the impact of management initiatives on those movements, whether positive or negative.
- Credibility of model results with terminal operators and drayage firms depends in large part on the completeness and accuracy with which their operations are portrayed. An incomplete accounting of significant drayage activity for any reason would undercut user confidence in the model.
- Because port drayage activity is a highly inter-connected system, failure to account for any significant function is likely to distort the portrayal of other functions.

The project team therefore endeavored to create model options for all significant drayage functions at any port complex, even though those model options may be rarely used. The model therefore includes:

- Drayage trips of all types to and from marine container terminals, for any reason.
- Drayage trips between rail intermodal terminals and marine terminals, and associated bobtail and chassis trips that may not begin or end at the port.
- "Cross-town" trips to reposition empty import containers for export loads, to shift empty marine containers from rail terminals to depots, or to obtain empty containers from depots for export loads.

The port drayage activity model therefore includes a number of trips and trip types that do not begin or end at port terminals but which are necessary to support the overall port container flow.

There are, nevertheless, some types of drayage trips indirectly associated with port operations that have not been modeled. The model does not attempt to account for drayage tractor movements that are not directly attributable to cargo flows. Such movements would include trips for servicing, fuel, and repair; side trips for meals, rest, or errands; and trips made on non-port assignments such as domestic rail intermodal drayage.

Because volumes vary from year to year and month to month while movement patterns tend to persist, the model relies primarily on pattern indicators and proportions to estimate drayage trips, times, and mileages. This approach facilitates forward-looking analyses of drayage activity and emissions with growing cargo volumes.

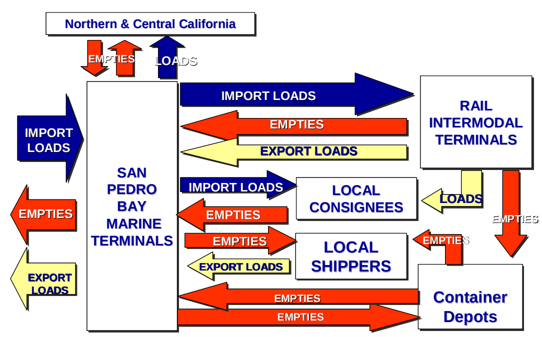
Activity-Based Approach

The DrayFLEET model incorporates an activity-based approach. Each significant drayage trip type or activity is assigned a time and distance value. That value may be a precise empirical measurement, a weighted average, or an industry rule of thumb, depending on the data available. The model takes the total container volume handled by the port or terminal in question and determines the volume and mix of drayage activities required or implied. The time and VMT for those activities are tallied to develop port or terminal total drayage minutes and VMT.

For input to the emissions model, each activity time is divided into minutes by driving cycle component: idling, creep, transition, and cruise. Drayage time and miles also become inputs to the cost and capacity portions of the model. The drayage activity cycle is made up of idling, queuing/creeping, and driving in various combinations.

- Drayage drivers idle at marine or intermodal terminals, customer facilities, and on breaks or while waiting for assignment.
- Drayage drivers creep, starting and stopping, in queues at terminal and customer/facility entrance and exit gates, and may also queue for inspections, repairs, and other ancillary activities.
- Drayage drivers drive between terminals, customer locations, storage yards, waiting locations, and their home or domicile.

In any drayage operation the need to move loaded containers drives the system. Movements of empty containers, bare chassis, and bobtail tractors ordinarily result from loaded movements. Drayage movements fall into a few basic patterns, which are mirrored in the DrayFLEET model.



- **Out-and-back "stay with" trips.** In a "stay-with" trip the driver waits at the customer facility while the container is loaded or unloaded.
- **Out-and-back "drop and pick" trips.** In "drop and pick" operations the driver stages an inbound container at the customer site and removes a different container with minimal waiting time.
- **Triangulated crosstown trips.** Instead of shuttling between terminal and customer, a driver may deliver an empty to a depot or to an exporter before returning to the port.

- **Bobtails.** Tractor-only movements between home or domicile and the first work assignment, between work assignments, and from the last work assignment home.

A driver's duty cycle can be a series of repetitive shuttles (e.g. between marine and off-dock rail terminals) or a complex pattern built up from these simpler elements. The adjacent diagram shows the major loaded and empty container flows associated with the Southern California ports. As complex as this diagram is, it does not show the bobtail and empty chassis movements required to make the system work. The challenge in modeling this activity is to abstract the myriad trip elements and combinations into a manageable number of activity categories while capturing the total trucking time and VMT.

Terminal Management Initiatives

Ports and terminal operators are engaged in numerous management and operations initiatives that can reduce drayage VMT and emissions. For example:

- Extended gate hours tend to reduce peak period congestion and idling/queuing time. Extended gate hours may also reduce the need for drayage firms to park and store containers overnight.

- Container status and appointment systems (e.g. VoyagerTrack or eModal) tend to reduce terminal congestion and waiting time, and may also reduce non-productive trips when containers are not ready to move.

- Chassis pools reduce the time required to locate a serviceable chassis, reduce the need for chassis "flips" in rail yards, and reduce delays for chassis repairs.

- Virtual container yards are expected to increase opportunities for reusing empty containers and reduce empty movements.

- Bringing rail terminals closer to the port (near-dock) reduces the time and VMT required for a given intermodal container volume. Bringing rail terminals into the port (on-dock) will eliminate over-the-road drayage for containers handled there.

- Truck scrapping or rebuild/replacement programs will not significantly change drayage activity cycles, but may increase productivity by reducing downtime as well as emissions. Some new or retrofitted tractors, however, use more fuel than older units.

The model must include appropriate variables and input factors to reflect these and other industry changes that affect drayage.

Changes in drayage equipment and technology will affect the emissions, fuel consumption, and cost associated with a given mix and level of drayage activity. The team's model design includes explicit input factors for variables such as fuel consumption rates under load and at idle, and a full range of emissions factors for each part of the activity cycle.

DrayFLEET Activity Model

Approach

The working goals of the activity modeling effort were to:

- Establish the distribution and mix of drayage trip types and elements characteristic of different marine terminal types and container volumes.
- Identify the factors that determine the level and type of drayage activity. Key factors include the mix of local and intermodal business, distances to customers, and the regional import/export balance.
- Create an Excel spreadsheet model that condenses the full range of drayage activities into manageable categories while retaining flexibility.

The resulting model is activity based, not statistical, and directly reflects activity changes in response to new patterns and requirements. The model attempts to capture all significant container drayage movements within the port system:

- Loaded and empty containers on chassis
- Bare chassis and bobtail (tractor only) moves
- Rail, barge, depot, and customer trips

The model likewise attempts to account for <u>all</u> cargo-related drayage time:

- Gate queues and transactions
- Delays and "trouble window" visits
- Chassis searches and "flips"

The internal model logic maintains functional relationships so that changes in one factor result in appropriate changes to other interconnected factors.

Activity Model Structure

The activity modeling approach includes several key features:

- Port-specific or generic default values for every variable and input
- Accommodation of user inputs that differ from defaults
- A streamlined user "front end" to facilitate primary inputs and "what if" scenarios
- An embedded flow chart of port-related container trips to account for all significant movements

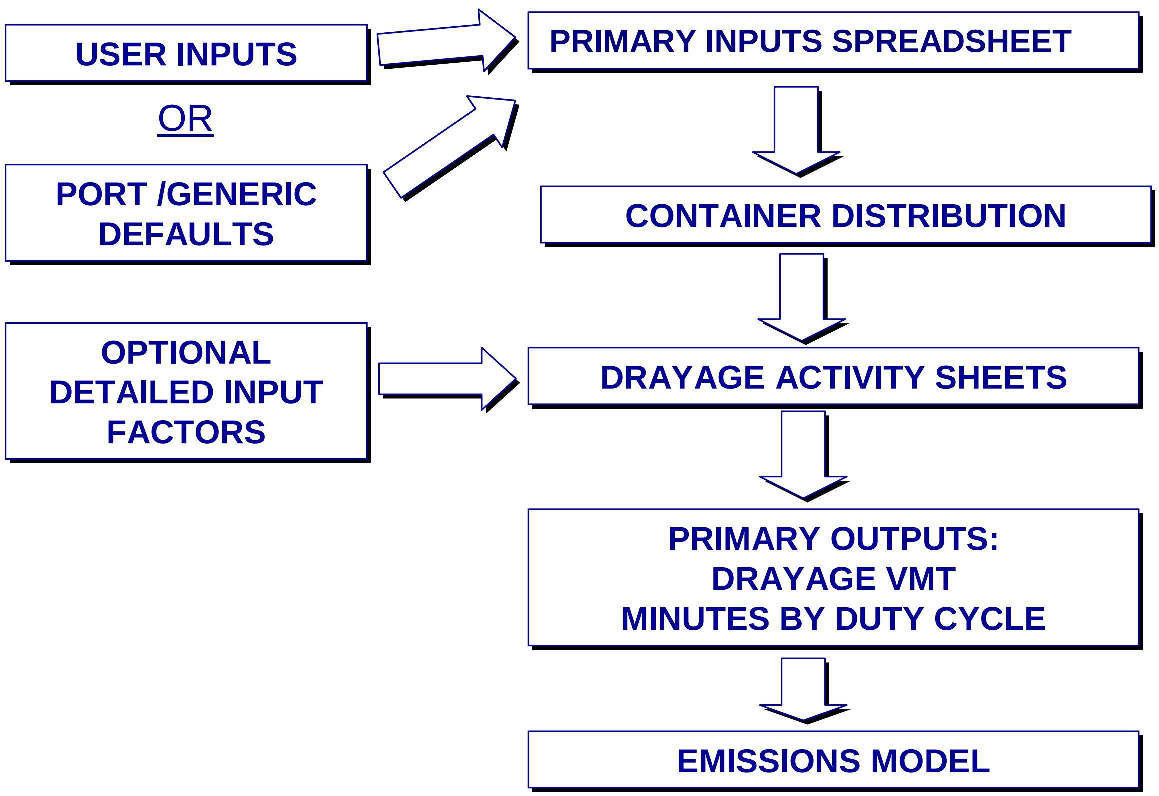
- Activity tally sheets to capture default or user-specified factors for over-the-road drayage, terminal trips, etc.

- Summary activity model outputs in minutes by duty cycle to serve as emissions model inputs.

Exhibit 17 gives an overview of the model structure and the flow of information.

Major inputs are chosen or inputted on the Primary Inputs spreadsheet. The model is fully loaded with default values for every variable. These port-specific or generic defaults can be replaced with more accurate or more specific values as desired by the user.

Exhibit 17: Drayage Activity Model Structure



The Container Distribution worksheet determines the number and nature of drayage trips implied by the Primary Inputs values. The trips are allocated among seven major activity centers, each with its own tally sheet.

- Marine Terminals

- Inter-Terminal Drayage

- Off-Dock Rail Intermodal

- Shippers and Consignees

- Container Depots

- Street Turns and Crosstowns
- Other Port Trucks

Each of these drayage activity tally sheets has its own set of secondary user-changeable default inputs.

The drayage activity sheets are linked to detailed and summary output sheets. The activity model outputs become inputs for the emissions section of the model.

Input categories include:

- Port and terminal information (e.g. TEU, import/export balance)
- Default/scenario operational factors (e.g. transaction times)
- Management strategies (e.g. on-dock rail, automated gates)
- Drayage tractor fleet and technologies (e.g. retrofits)

Outputs provided include:

- Activity outputs (e.g. trip legs and VMT)
- Duty cycle outputs (e.g. idle, creep, transition, and cruise minutes)
- Comparison charts to illustrate changes from defaults

Primary Inputs

The Primary Inputs worksheet is used to assemble the basic model inputs (Exhibit 18). This streamlined "front end" to the model allows the user to override default port and terminal information as needed, and to choose among the management strategies to be modeled.

Exhibit 18: Primary Inputs Structure

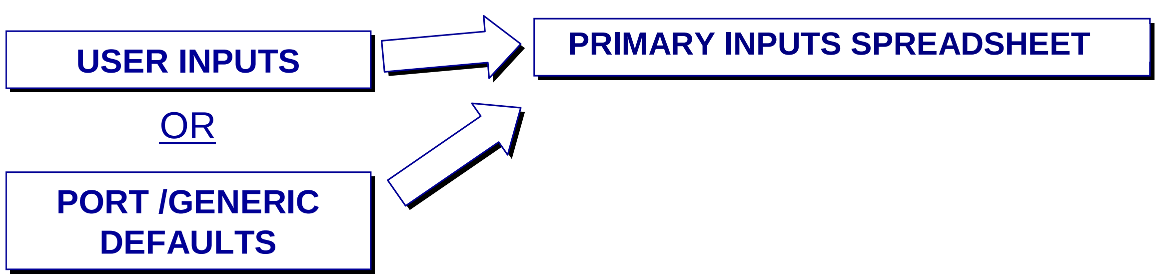


Exhibit 19 shows the Primary Inputs worksheet. This worksheet (shown in its entirety below) has five sections covering key input values, port or terminal management initiatives, activity outputs, emissions and cost outputs, and a note section to identify the model application and scenario.

Exhibit 19: Primary Inputs Worksheet

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0d of 06/10/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,000,000	2,000,000
Average TEU per Container	1.75	1.75
Inbound Share	50%	50%
Inbound Empty Share	5%	5%
Outbound Empty Share	25%	25%
Rail Intermodal Share	25%	25%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	10%	10%
Container Shippers/Receivers		
Weighted Average Miles from Port	25	25
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	0%	0%
Automated Gates (% of gate transactions)	0%	0%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	0%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Port	
Terminal(s)	
Scenario	
Date	

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,498,452	3,498,452	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	0.0	0.0%
Total Drayage VMT	65,706,753	65,706,753	0	0.0%
Drayage VMT per Container	57.5	57.5	0.0	0.0%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	1,869,294	1,869,294	0	0.0%
Creep Hours	994,223	994,223	0	0.0%
Transient Hours	572,700	572,700	0	0.0%
Cruise Hours	1,506,026	1,506,026	0	0.0%
Total Drayage Hours	4,942,243	4,942,243	0	0.0%
Drayage Hours per Container	4.3	4.3	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	53	53	0.00	0.0%
CO	298	298	0.00	0.0%
NOx	1,108	1,108	0.00	0.0%
PM_{10}	37	37	0.00	0.0%
$PM_{2.5}$	31	31	0.00	0.0%
CO_2	88,497	88,497	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	7,909,626	7,909,626	0.0	0.0%
Total Drayage Cost	$ 159,451,797	$ 159,451,797	$ -	0.0%
Drayage Cost per Container	$ 140	$ 140	$ -	0.0%

For each of the Primary Inputs there is a Default value and a Scenario value. The model uses the Default value unless it is superseded by a different user entry in the Scenario columns. The Primary Input items are as follows.

Primary Port and Marine Terminal Inputs

The key port or terminal inputs specify the overall volume and pattern of trade. The model has default values for every variable. The user can replace other defaults with specific scenario information as available.

Exhibit 20: Primary Port Inputs

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,000,000	2,000,000
Average TEU per Container	1.75	1.75
Inbound Share	50%	50%
Inbound Empty Share	5%	5%
Outbound Empty Share	25%	25%
Rail Intermodal Share	25%	25%

Calendar Year – Default 2007. The user can choose the calendar year for the analysis using the drop-down menu. The calendar year is used to calibrate the age of tractors in the fleet distribution data and the appropriate emissions factors for tractors of each age.

Annual TEU – Default 2,000,000. This value is the total annual Twenty-foot Equivalent Units (TEU) handled by the port or terminal in question. Overall volume, of course, is the single largest factor in total emissions.

Average TEU/Container – Default 1.75. This average is used to convert the TEU data to an equivalent container count. The value reflects the mix of 20', 40', and 45' containers handled, and is usually between 1.5 (equivalent to half 20' and half 40') and 1.9 (equivalent to a predominance of 40' and 45' containers). The model itself treats all sizes alike in modeling drayage activity.

The number of containers is calculated by the model as the product of the Annual TEU and the Average TEU/Container conversion factor. This container count drives the model allocation of drayage activity.

Inbound Share – Default 50%. This value is the percentage of TEU or containers moving inbound from vessel to port or terminal, whether loaded or empty, import or domestic cargo. The inbound share should be based on TEU or container count, not tonnage or revenue.

Inbound Empty Percent – Default 5%. Due to the imbalance in U.S. container trade few ports have substantial volumes of inbound empty containers. This factor is included for comprehensiveness.

Outbound Empty Percent – Default 25%. This factor typically ranges from a low of around 10% at ports with nearly balanced trade to a high of around 60%-70% at very imbalanced ports. The share should be expressed as a percentage of TEU or containers.

Rail Intermodal Share – Default 25%. This percentage should reflect the total of on-dock and off-dock rail intermodal movement of port containers (in % of TEU or containers, not tonnage), both loaded and empty. This percentage should not include cargo transloaded to domestic containers or trailers, or domestic freight moved in international containers. The split between on-dock and off-dock rail is entered under Initiative Inputs.

Exhibit 21: Primary Marine Terminal Inputs

Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	30	30

Average Inbound Gate Queue Minutes – Default 15 minutes. This factor is the average minutes that drayage drivers spend waiting in queues outside terminal gates. Typical values could range from 5 to 60 minutes. The time spent at the gate and the time spent transacting business inside the terminal are separate variables.

Average Container Yard Minutes per Transaction – Default 30 minutes. This factor is the average minutes required inside the marine terminal container yard to complete a single transaction. Such transactions include picking up or draying a loaded or empty container or chassis, locating or draying a bare chassis, switching containers between chassis (a "chassis flip"), or live lifts of containers on or off a chassis. The model default uses the same time for each of these transactions, with 30 minutes being a common rule of thumb. The time includes movement within the terminal (e.g. gate to stack and stack to gate), time to locate the right unit, time to hook up the tractor or make the transfer, time for visual inspection, and time for the driver to climb in and out of the cab. The user can specify different times for each of these activities on the Marine Terminal Spreadsheet if desired.

Primary Off-Dock Rail Terminal Inputs

The default handling of rail intermodal containers is off-dock, and the number of rail intermodal containers is calculated by the model from the Primary Port Inputs. This number will be reduced by the percentage of on-dock rail specified under Initiative Inputs. The final number should correspond to lift data from the railroads, although a precise comparison should not be expected due to the factors discussed under Data Sources.

Exhibit 22: Primary Rail Terminal Inputs

Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15

Weighted Average Miles from Port – Default 5 miles. Where there is only one marine terminal and one off-dock rail terminal this input is simply the distance between them. In a complex system such as Los Angeles/Long Beach with three off-dock rail terminals and twelve marine terminals, a reliable weighted average may require significant analysis.

Average Inbound (IB) Gate Queue Minutes – Default 5 minutes. This factor is the average time draymen spend waiting to enter the inbound gates at off-dock rail terminals. Time spent at the gate and in the terminal are separate factors. The queue time at rail terminals (right) tends to be less than at marine terminals.

Average Rail Yard Minutes per Transaction – Default 15 minutes. This factor corresponds to the time required in the rail terminal yard (after passing through the gate) for any one of several possible transactions: e.g. picking up or dropping off a loaded container, empty container, or bare chassis. The transaction time for rail terminals is typically less than for marine terminals.

The Off-dock Rail Terminal spreadsheet contains individual entries for each possible activity. These factors may be changed as needed by the user to reflect known or anticipated transaction differences.

Primary Container Depot Inputs

Container depots are off-terminal storage and maintenance facilities for containers (and sometimes chassis). The use of off-terminal storage varies widely – highest at ports with large accumulations of empty containers and limited on-terminal capacity, lowest where loaded container flows balance and terminals have more space.

Exhibit 23: Primary Container Depot Inputs

Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	10%	10%

At ports such as Houston, where the container terminals are part of the marine terminal complex but still physically distant from the marine terminals themselves, the model version is reconfigured accordingly. The critical difference is that at Houston the movement between depots and marine terminals is handled by on-terminal equipment ("hostlers") rather than by over-the-road truckers (drayman), and is not part of the drayage emissions estimate.

Weighted Average Miles from Marine Terminal – Default 2 miles. Where there is just one marine terminal and one depot, this factor is just the distance between them. Where there are multiple terminals and multiple depots the input value should be the weighted average. As detailed depot trip data by terminal is not likely to be readily available, a next-best approach may be to weight the average by relative sizes or capacities.

Share of Empties Stored at Depots – Default 10 miles. This input is the percentage of empty containers that are either returned to a leasing company depot ("off-hired") or stored at a depot for other reasons.

Drayage Cost Inputs

There are two drayage cost inputs in the Primary Inputs section; others are on the Cost & Capacity worksheet.

Exhibit 24: Drayage Cost Inputs

Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Average Labor Cost per Hour – Default $12.00. The average hourly cost of drayage labor (truck drivers). For owner-operators, this would be the average hourly earnings after expenses. For employee drivers, this would be wages plus benefits.

Average Fuel Price – Default $4.00. The average price per gallon for diesel fuel.

The drayage cost estimates are discussed in greater detail in a following section.

Primary Shipper/Receivers Inputs

At most ports local and regional shipper (exporters) and receiver (importers) facilities are the most common end points for port drayage trips.

Exhibit 25: Primary Shipper/Receiver Inputs

Container Shippers/Receivers		
Weighted Average Miles from Port	25	25
Weighted Average Crosstown Trip Miles	10	10

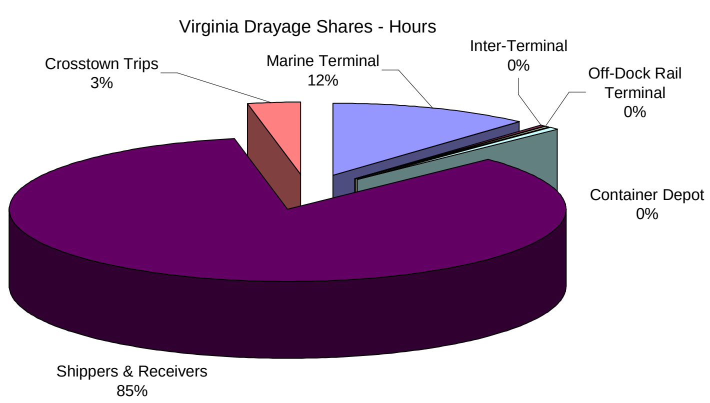
Weighted Average Miles from Marine Terminal – Default 25 miles. The key input for this part of the model is the distance traveled to local and regional shippers and consignees. Ideally, the input value should be an average of distances weighted by the volume of containers traveling each distance. As discussed under Data Sources, it may be necessary to identify clusters of customers by distance range instead of analyzing the distances customer-by-customer.

"Crosstowns" are port-related movements that do not begin or end at port terminals. An example would be a bobtail trip from the driver's home to a rail terminal for the purpose of picking up a port-bound container. Street interchanges ("street turns") are trips made to interchange containers between drayage firms, or trips made to reuse empty import containers for export loads, without going to the marine terminal in either case.

Weighted Average Crosstown Miles – Default 10 miles. This input should be the weighted average of all cross town trips. Since it is unlikely that precise empirical data would be available on this point, alternate methods of estimating the value might be necessary (as noted under Data Sources). This value is a major determinant in the benefits of Virtual Container Yards, as long crosstown trips to link importers and exporters diminish the VMT benefits of reuse.

Because they account for such a high percentage of trips and usually have longer trips lengths as well, shipper/receiver trips usually account for a very large share of total drayage activity (measured in hours and miles) and emissions (measured in annual tons). Exhibit 26 shows a dramatic example taken from the Port of Virginia case study. Under these circumstances, the benefits of port and marine terminal measures to reduce emissions may be obscured by the overall level of activity.

Exhibit 26: Port of Virginia Drayage Activity Shares - Hours



The alternative is to model only the activity within the port area. This step can be accomplished by restricting the weighted average miles to shippers/consignees to, for example, 5 or 10 miles. The case studies provide examples of this approach, which allows modelers to focus on those drayage activities where the port and marine terminals have a greater degree of control or influence.

Initiative Inputs

This section of the input worksheet allows users to specify the extent to which various port and terminal management initiatives have been implemented.

Exhibit 27: Initiative Inputs

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	0%	0%
Automated Gates (% of gate transactions)	0%	0%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	0%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Stacked Terminal. This input is the percentage of containers (loaded and empty) that are typically stacked at the marine terminal(s) rather than parked on chassis. Because a stacked terminal requires a drayman to make additional in-terminal moves to pick up and drop bare chassis, increasing the percentage of stacking will increase total drayage activity and emissions unless accompanied by a neutral chassis pool (see below) to rationalize the chassis supply.

On-Dock Rail. This input is the percentage of rail intermodal containers or TEU that are transferred at on-dock rail facilities rather than at off-dock or near-dock facilities. The default handling for rail intermodal containers is off-dock. The model assumes no truck drayage for rail intermodal containers that are transferred at on-dock facilities. (On-terminal handling equipment is not covered by DrayFLEET.) The percentage entered here can be in containers or TEU.

Automated Gates. Handling containers at automated terminal gates (e.g. via OCR, swipe card, RFID, or other technology) typically reduces time at the gates. The input value should be the percentage of container transactions that are handled at automated gates. Alternately, the user can enter the percentage of gates that are automated, assuming that each gate handles the same percentage of containers.

Extended Gate Hours. Typical standard marine terminal hours start at 7–8 am and end at 4–5 pm, depending on local practice. Access outside those times requires “extended” gate hours, with attendant labor costs to the terminal. This item should be the percentage of containers or TEU that use off-peak gate hours, up to a maximum of 50%.

Container Information/Appointment System. This entry is the percentage of containers or TEU whose movement or handling is covered by an information system accessible to draymen (e.g. eModal, VoyagerTrack). This value is usually less than 100% because some drayage firms or infrequent truckers do not use the system.

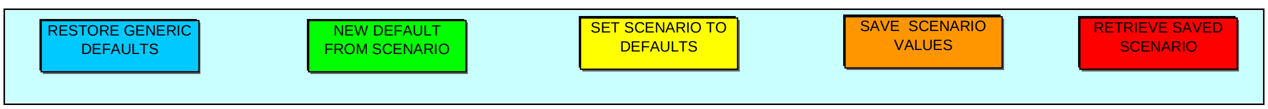
Virtual Container Yard. This entry is the percentage of containers or TEU for which a Virtual Container Yard (VCY) or other container status and interchange system is available (even if the containers in question are not listed as available). This value is usually less than 100% because some drayage firms do not use available systems. Note that a VCY can make very little difference if crosstown relocation distances between importers and exporters are long (comparable to shipper-to-port distances) or if a very few containers are being reused to begin with (Default 1%, see Secondary Inputs).

Neutral Chassis Pool. This entry is the percentage of containers or TEU handled at terminals with neutral chassis pools (or alternately, the percentage of containers or TEU mounted on a neutral pool chassis). Use of a neutral chassis pool will change the impact of a stacked terminal from negative (more activity and emissions) to positive (less activity and reduced emissions).

DrayFLEET Macros

There are five macro buttons at the bottom of the Primary Inputs and Outputs worksheet (Exhibit 28).

Exhibit 28: Primary Input & Output Macros



These buttons can be used to manage default and scenario inputs on the Primary Inputs and Outputs and Secondary Inputs worksheets as explained in the DrayFLEET User's Guide

Secondary Inputs

The Secondary Inputs worksheet (Exhibit 29) provides an opportunity to fine-tune several aspects of port and terminal container flow and drayage operations. The model contains typical or generic default values for all these inputs. Wherever data is available to set these parameters to port-specific values, the accuracy of the DrayFLEET model will be improved.

Exhibit 29: Secondary Inputs Worksheet

SmartWay DrayFLEET Version 1.0 Secondary Inputs & Outputs

This worksheet allows the user to specify drayage activity parameters in greater detail where information is available.

	Default	Scenario
Port Operations		
Barge/Transshipment Share	0%	**0%**
Inter-Terminal Dray Share	1%	**1%**
Marine Terminal Operations		
% of bobtails using bypass gate	0%	**0%**
% bare chassis at gates	10%	**10%**
% bobtail tractors at gates	30%	**30%**
Rail Terminal Operations		
Inbound/Import % empty via rail	5%	**5%**
Outbound/Export % empty via rail	25%	**25%**
% of bobtails using bypass gate	0%	**0%**
% live lift	0%	**0%**
% of rail empties returned to depots	1%	**1%**
Container Depot Operations		
% bobtail moves	20%	**20%**
% of depot empties sent to rail	1%	**1%**

	Default	Scenario
Shipper/Receiver Operations		
% bobtail moves	20%	**20%**
% of drivers waiting for load/unload	0%	**0%**
% of empties supplied from depots	1%	**1%**
% of empties returned to depots	1%	**1%**
% of empties reused for loads	1%	**1%**
% of empties supplied from rail	1%	**1%**
% of empties returned to rail	1%	**1%**
Other Port Truck Operations		
Wtd. Avg. Miles from Port	25	**25**
Export Tons Trucked	-	**-**
Avg. Export Tons per truck	20	**20**
Import Tons Trucked	-	**-**
Avg. Import Tons per truck	20	**20**
% bobtail moves	20%	**20%**

Port Operations

Barge/Transshipment Share – Default 0%. As noted in the model description, some ports have significant volumes of in-terminal transfers to barge or ocean-going vessels that do not involve drayage. If the barge or vessel transfers involve drayage to another terminal, those trips should be considered part of inter-terminal drayage.

Inter-Terminal Dray Share – Default 1%. For a port analysis, enter the percentage of containers that are drayed between port terminals. For a single terminal analysis, enter zero.

Marine Terminal Operations

% of Bobtails using Bypass Gate – Default 0%. Many marine terminals have a bypass gate for bobtail trips to reduce congestion at the main gates. This input is the percentage of bobtail trips using such bypass gates.

% Bare Chassis at Gates – Default 10%. If available, this input is the port-specific share of bare chassis passing through marine terminal gates as a percentage of total gate movements.

% of Bobtail Tractors at Gates – Default 30%. If available, this input is the port-specific percentage of bobtail trips at marine terminal gates as a percentage of total gate movements.

Rail Terminal Operations

Inbound/Import Empty % via Rail – Default 5%. The percentage of empty containers on rail movements from the Port (remembering that the railroad will consider such movements *outbound*). This number is usually small.

Outbound/Export Empty % via Rail – Default 25%. The percentage of empty containers on rail movements to the Port (remembering that the railroad will consider such movements *inbound*). This number is usually larger than the import number.

% of Bobtails using Bypass Gate – Default 0%. Many rail terminals have a bypass gate for bobtail trips to reduce congestion at the main gates. This is the percentage of bobtail trips using such bypass gates.

% Live Lifts – Default 0%. The norm for rail terminals is for draymen to park containers on chassis for subsequent loading by the terminal operator, and to pick up parked containers on chassis that have been previously unloaded from trains. "Live lifts" occur when the drayman waits to have the container transferred from chassis to rail car (or vice versa).

% of Rail Empties Returned to Depots – Default 1%. The percentage of empty containers that arrive at off-dock rail terminals and are drayed to off-dock container depots for storage rather than being drayed to the marine terminals.

Container Depot Operations

% of Bobtail Moves – Default 20%. The percentage of bobtail trips at container depot gates as a percentage of total depot gate movements.

% of Depot Empties Sent to Rail – Default 1%. The percentage of empty containers sent to rail intermodal terminals from off-dock container depots rather than being sent to marine terminals.

Shipper/Receiver Operations

% of Bobtail Moves – Default 20%. The percentage of bobtail trips at shipper/receiver gates as a percentage of total shipper/receiver gate movements.

% of Drivers Waiting for Load/Unload – Default 0%. The norm for most shippers and receivers is for the drayman to park loaded or empty containers on chassis for subsequent handling by the customer, and to pick up parked containers on chassis that are ready to go to marine terminals or elsewhere. These are generally referred to as "drop and pick" operations. "Stay with" trips occur when the drayman waits to have a loaded import container unloaded or an empty export container loaded. Where information on the prevalence of "stay with" waits is available, the appropriate percentage should be entered here.

% of Empties Supplied from Depots – Default 1%. The percentage of empty containers for export loads supplied from off-dock container depots rather than from marine terminals. This percentage can vary widely between ports.

% of Empties Returned to Depots – Default 1%. The percentage of emptied import containers that are drayed to off-dock container depots rather than to the marine terminals. This percentage can vary widely between ports.

% of Empties Supplied from Rail – Default 1%. The percentage of empty containers for export loads supplied from off-dock rail terminals rather than from marine terminals or depots. This percentage can vary widely between ports.

% of Empties Returned to Rail – Default 1%. The percentage of emptied import containers that are drayed to off-dock rail intermodal terminals rather than to the marine terminals. This percentage can vary widely between ports.

% of Empties Reused for Loads – Default 1%. The percentage of emptied import containers that are repositioned and used for an export load, either by the original drayman or by another firm. This percentage tends to be low, less than 5% at most ports. The VCY initiative input on the Primary Inputs and Outputs worksheet will double this value, but will have minimal impact if the opportunity to reuse empties is itself minimal or if there are long crosstown distances involved.

Other Port Truck Inputs (Optional)

This section is provided to enable users to account for significant movements of port-related trucks handling commodities other than containerized cargo. These movements could include bulk or break-bulk cargoes. Depending on the regularity of these movements and the level of detail in available data, this portion of the model could be less precise than the container movements.

Exhibit 30: Other Port Truck Inputs

Other Port Truck Operations		
Wtd. Avg. Miles from Port	25	**25**
Export Tons Trucked	-	**-**
Avg. Export Tons per truck	20	**20**
Import Tons Trucked	-	**-**
Avg. Import Tons per truck	20	**20**
% bobtail moves	20%	**20%**

Weighted Average Miles from Port – Default 25 miles. This input is the average distance other trucks travel to and from the Port. A weighted average would be ideal.

Export Tons Trucked – Default 0. This input is the annual short tons of export cargo moved to the port by truck. Note that ports usually track tonnage in metric tons while U.S. Army Corps of Engineers data is in short tons. This amount should not include tonnage moving by rail, which usually includes bulk materials for which the port or terminal will have records.

Average Export Tons per Truck – Default 20 tons. The average export non-containerized cargo load per truck in short tons can vary considerably, with bulk commodities higher than break-bulk cargos. The 20-ton default is a compromise.

Import Tons Trucked – Default 0. This is the annual short tons of import cargo moved from the port by truck. This should not include tonnage moving by rail.

Average Import Tons per Truck – Default 20 tons. The average import cargo load per truck in short tons.

% Bobtail Moves – Default 20%. The percentage of bobtail tractor moves in the Other Port Trucks activity. Note that only tractor-trailer operations will generate bobtail moves. Activity using straight trucks (such as conventional single-unit dump trucks or flatbed trucks delivering steel) will not generate bobtail moves.

Drayage Fleet and Technology Inputs

The drayage fleet inputs are on a separate worksheet and consist of a drayage fleet age distribution by percentage, and a technology section.

Drayage Fleet Age Distribution

There are two drop-down age distribution menus (Exhibit 31) with age distribution options.

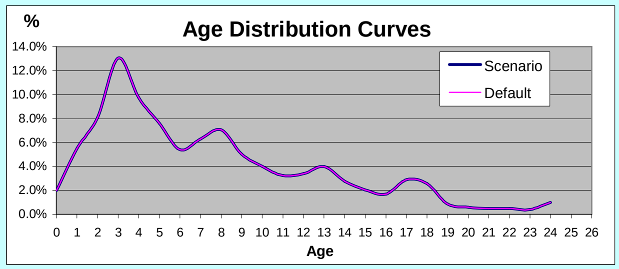
Exhibit 31: Fleet Age Distribution Worksheet

SmartWay DrayFLEET Version 1.0 - Drayage Fleet Inputs

Values on this worksheet are not affected by reset macros

Fleet Age Distribution

Scenario	Same as Default		Default	US VIUS Default	
Age	#	%	Age	#	%
0	26	2.0%	0	26	2%
1	72	5.5%	1	72	5%
2	107	8.1%	2	107	8%
3	172	13.0%	3	172	13%
4	129	9.7%	4	129	10%
5	100	7.6%	5	100	8%
6	71	5.4%	6	71	5%
7	83	6.3%	7	83	6%
8	93	7.0%	8	93	7%
9	66	5.0%	9	66	5%
10	53	4.0%	10	53	4%
11	43	3.2%	11	43	3%
12	45	3.4%	12	45	3%
13	53	4.0%	13	53	4%
14	36	2.8%	14	36	3%
15	27	2.0%	15	27	2%
16	22	1.7%	16	22	2%
17	38	2.9%	17	38	3%
18	34	2.6%	18	34	3%
19	11	0.9%	19	11	1%
20	8	0.6%	20	8	1%
21	6	0.5%	21	6	0%
22	6	0.5%	22	6	0%
23	5	0.4%	23	5	0%
24	13	1.0%	24	13	1%
Total	1,320	100%	Total	1,320	100%



Drayage Fleet Technology and Strategy Inputs*

Technology Retrofits		
Particulate Filter/Trap	% of eligible fleet retrofit	50%
Oxidation Catalyst	% of eligible fleet retrofit	50%
Flow-Through Filter	% of eligible fleet retrofit	50%
Idle Reduction		
Idling Control Strategies	% reduction in idle	50%
Fuel Conservation		
Single-Wide Tires	% of fleet	50%
Automatic Tire Inflation	% of fleet	50%
Tare Weight Reduction	% of fleet	50%
	lbs of weight saved	2,000
Low Friction Engine Lubricant	% of fleet	50%
Low Friction Drive Train Lubricant	% of fleet	50%
Direct Drivetrain	% of fleet	50%
Single Axle Drive (vs. Dual Axle)	% of fleet	50%
Speed Management Policy (55 mph)	% of fleet	50%

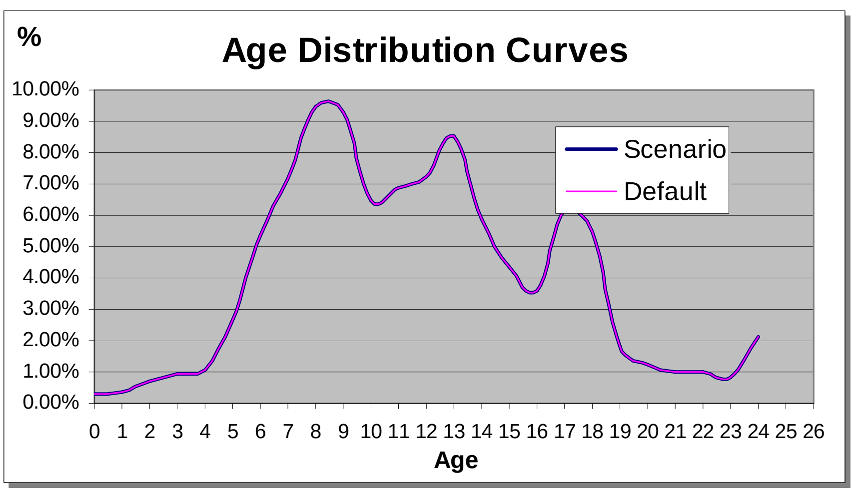
Default. The Default Age Distribution Menu offers a choice between four pre-set age distributions shown in Exhibit 32.

Exhibit 32: Fleet Age Distributions

Age Years	LALB Default	Houston Default	US VIUS Default	MOBILE6.2 8b
0	0.3%	0.0%	2.0%	0.0%
1	0.4%	0.0%	5.5%	4.2%
2	0.7%	2.0%	8.1%	7.9%
3	0.9%	1.0%	13.0%	7.4%
4	1.1%	2.0%	9.7%	6.9%
5	2.6%	1.0%	7.6%	6.5%
6	5.3%	5.9%	5.4%	6.0%
7	7.2%	14.9%	6.3%	5.6%
8	9.5%	13.9%	7.0%	5.3%
9	9.3%	5.0%	5.0%	4.9%
10	6.5%	5.9%	4.0%	4.6%
11	6.9%	15.8%	3.2%	4.3%
12	7.2%	8.9%	3.4%	4.0%
13	8.5%	9.9%	4.0%	3.8%
14	5.9%	5.0%	2.8%	3.5%
15	4.4%	0.0%	2.0%	3.3%
16	3.6%	2.0%	1.7%	3.1%
17	6.2%	0.0%	2.9%	2.9%
18	5.5%	2.0%	2.6%	2.7%
19	1.8%	4.0%	0.9%	2.5%
20	1.3%	0.0%	0.6%	2.4%
21	1.0%	1.0%	0.5%	2.2%
22	1.0%	0.0%	0.5%	2.1%
23	0.8%	0.0%	0.4%	1.9%
24	2.1%	0.0%	1.0%	1.8%

Scenario. The Scenario menu offers two choices: a distribution equal to the default or a user-specified custom distribution (which must total 100%). Enter the number of trucks in each age group, and the model will calculate the percentages.

The chart to the right of the drop-down menus (below) compares the chosen Default and Scenario cases. This chart can be very useful in verifying the reasonableness of user-specified distributions.



DrayFLEET Technology and Strategy Inputs

Drayage trucks can be retrofit with technologies to save fuel and reduce emissions. The DrayFLEET model accounts for the emission reductions from retrofitting drayage trucks with exhaust aftertreatment devices; the impact that retrofits have on fuel economy (both positive and negative); and the emission reductions from strategies to improve fuel economy. Controls for modeling the effect of equipping or retrofitting portions of the drayage fleet with advanced emission control and fuel economy technologies are also on the Drayage Fleet Inputs worksheet as shown below.

Exhibit 33: DrayFLEET Technology and Strategy Options

Drayage Fleet Technology and Strategy Inputs*

Technology Retrofits		
☐ Particulate Filter/Trap	% of eligible fleet retrofit	50%
☐ Oxidation Catalyst	% of eligible fleet retrofit	50%
☐ Flow-Through Filter	% of eligible fleet retrofit	50%
Idle Reduction		
☐ Idling Control Strategies	% reduction in idle	50%
Fuel Conservation		
☐ Single-Wide Tires	% of fleet	50%
☐ Automatic Tire Inflation	% of fleet	50%
☐ Tare Weight Reduction	% of fleet	50%
	lbs of weight saved	2,000
☐ Low Friction Engine Lubricant	% of fleet	50%
☐ Low Friction Drive Train Lubricant	% of fleet	50%
☐ Direct Drivetrain	% of fleet	50%
☐ Single Axle Drive (vs. Dual Axle)	% of fleet	50%
☐ Speed Management Policy (55 mph)	% of fleet	50%

Each strategy can be selected for analysis by activating the adjacent checkbox. Additionally, the user needs to specify the technology penetration rate (%) indicating the extent to which the chosen strategy or technology has been adopted. In each case, the percentage applies to the portion of the fleet or duty cycle to which the strategy is applicable. Reflashing, for example, is only applicable to a narrow range of tractors in the 1993-1998 model years while operating in Cruise mode. A 50% penetration rate would mean that half of these eligible tractors were reflashed, not that half of the fleet had been reflashed.

Additional insights can be gained from the DrayFLEET model technical report and the SmartWay Partnership website.

Particulate Filter/Trap (also know as Diesel Particulate Filter or DPF)

Effects: Reduces emissions of PM, HC and CO; slight increase in fuel use and CO_2

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of eligible vehicles that implement the retrofit.

Notes: Engines certified to meet 2004 or later standards require exhaust aftertreatment and the presence of diesel particulate filters is already assumed in the emission rates from MOBILE6.

Therefore only pre-2004 model year trucks are eligible for this retrofit technology. DrayFLEET does not apply any benefit for 2004 or newer trucks.

Oxidation Catalyst

Effects: Reduces emissions of PM, HC and CO; no impact on NOx or fuel use.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of eligible vehicles that implement the retrofit.

Notes: A Diesel Oxidation Catalyst is an exhaust system device that reduces emissions of particulates and other pollutants. Engines certified to meet 2004 or later standards already require exhaust after treatment. Therefore only pre-2004 model year trucks are eligible for this retrofit technology.

Flow-Through Filter

Effects: Reduces emissions of PM, HC, and CO; no impact on NOx or fuel use.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of eligible vehicles that implement the retrofit.

Notes: A Flow-Through Filter is an exhaust system device that reduces emissions of particulates and other pollutants. Engines certified to meet 2004 or later standards already require exhaust aftertreatment. Therefore only pre-2004 model year trucks are eligible for this retrofit technology.

Idle Reduction

Effects: Reduces emissions of PM, HC, CO, saves fuel which is reflected in reduced CO_2

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of applicable idling that is eliminated.

Notes: The benefits from reduced idle are only applied to idle mode activity (e.g., extended waiting). Idle occurring as part of other operating modes (e.g. queuing in Creep mode) would not be effected. For example, idling from delay at arterial intersections as part of transient mode would not be eliminated.

Single-Wide Tires

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the technology.

Notes: The modeled emission benefit already accounts for the weight reduction associated with switching single rim/tire configurations. That weight reduction should not be considered included with analysis of Tare Weight Reduction.

Automatic Tire Inflation

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the technology.

Notes: Automatic tire inflation systems monitor and continually adjust the level of pressurized air to tires, maintaining proper tire pressure even when the truck is moving.

Tare Weight Reduction

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the technology. For reduction in tare weight, a second input box is provided for the user to specify the weight reduction achieved (in pounds).

Notes: Since drayage tractors are usually second hand they often have features such as aerodynamic fairings and sleeper cabs that add weight but provide no benefit in drayage service. By removing unneeded features or buying a tractor without them, tare weight can be reduced and fuel conserved.

Low Friction Engine Lubricant

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the technology.

Notes: Low-friction engine lubricants are usually synthetic, low-viscosity compounds.

Low Friction Drivetrain Lubricant

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the technology.

Notes: Low-friction drivetrain lubricants are usually synthetic, low-viscosity compounds.

Direct Drivetrain

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the technology.

Notes: Direct drivetrain technologies reduce weight and transmission losses, thereby conserving fuel.

Single-Axle Drive (vs. Dual Axle)

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the technology.

Notes: Most tractors built for highway service have two rear axles, both powered. Where a tractor in urban service can dispense with the second powered axle, there is an opportunity to reduce weight and transmission losses.

Speed Management Policy (55 mph)

Effects: Reduces fuel consumption and CO_2 emissions.

User Input: The measure is activated by checking the control box. The user provides an estimate of the fraction of the drayage fleet that implements the strategy.

Notes: Whether implemented as a policy via driver training or through speed governors, a maximum speed management strategy conserves fuel. Emission benefits from speed management are only applied to Cruise Mode vehicle operation. The effect on drayage operations is limited, however, as very little of the time is spent at highway speeds.

Container Distribution

The core of the activity model is the Container Distribution Worksheet (Exhibit 34). The flow chart draws on the volume and distribution information from the input sheet to allocate flows of loaded containers, empty containers, empty chassis, and bobtails among the various activity centers.

Exhibit 34: Container Distribution Worksheet

DrayFLEET Port Container Distribution Worksheet

Note: For clarity and consistency, all directions are Port orientation. Inbound=Import, Outbound=Export

Marine Container Terminals		
To/From Vessels	**Number**	**%**
Annual Port TEU	2,000,000	na
Equiv. Containers	1,142,857	100%
IB/Import Loads	542,857	48%
IB/Import Empties	28,571	3%
OB/Export Loads	428,571	38%
OB/Export Empties	142,857	13%
Non-gate Container Moves		
	On-Dock Barge Transhipment	**On-Dock Rail**
	Port Share 0%	**Port Share 0%**
	-	-
	-	-
	Number	**Number**
IB/Import Loads	-	-
IB/Import Empties	-	-
OB/Export Loads	-	-
OB/Export Empties	-	-

Terminal Gate Moves	
Outgate Loads	548,286
Outgate Empties	331,786
Outgate Chassis	25,672
Outgate Bobtails	388,176
Other Outgate Trucks	-
Outgate Subtotal	**1,293,919**
Ingate Loads	**432,857**
Ingate Empties	**448,324**
Ingate Chassis	27,541
Ingate Bobtails	385,197
Other Ingate Trucks	-
Ingate Subtotal	**1,293,919**
Net Port Container Gain/Loss	1,109
Terminal Gate Total	**2,587,839**

Marine Terminal Trips	**Containers & Chassis Handled**		**Crosstown Trips**	
	Shipper/Receiver Trips			
Outgate 717,214	**Port Share 75%**	**Number**	Bobtails to S/Rs	182,143
	IB/Import Loads	407,143	Bobtails from S/Rs	182,143
	IB/Import Empties	321,429	Empties to Rail	3,214
Ingate 718,929	OB/Export Loads	321,429	Empties from Rail	4,071
	OB/Export Empties	407,143	Empties to Depot	3,214
			Empties from Depot	4,071
			Import Ctrs Reused	3,214
	Inter-Terminal Drayage Trips			
Outgate 5,714	**Port Share 1%**	**Number**		
	IB/Import Loads	5,429		
	IB/Import Empties	286		
	IB/Import Chassis	-		
Ingate 5,714	OB/Export Loads	4,286		
	OB/Export Empties	1,429		
	OB/Export Chassis	-		
	Off-Dock Rail Intermodal Trips			
Outgate 154,849	**Port Share 25%**	**Number**	Bobtails to Rail	13,989
	IB/Import Loads	135,714	Bobtails from Rail	17,346
	IB/Import Empties	7,143	Chassis from Depots	-
Ingate 156,113	IB/Import Chassis	11,991	Chassis to Depots	-
	OB/Export Loads	107,143	Empties to Depots	357
	OB/Export Empties	35,714	Empties from Depots	143
	OB/Export Chassis	13,256	Empties to S/R	4,071
			Empties from S/R	3,214
	Off-Dock Container Depot Trips			
Outgate 27,966	IB/Import Loads	0	Bobtails to Depots	6,992
	IB/Import Empties	14,286	Bobtails from Depots	6,992
	IB/Import Chassis	13,681	Chassis from Rail	
Ingate 27,966	OB/Export Loads	0	Chassis to rail	
	OB/Export Empties	13,681	Empties from Rail & S/R	3,571
	OB/Export Chassis	14,286	Empties to Rail & S/R	4,176
	Other Port Truck Trips			
Outgate 0	IB/Import Loads	0	Inbound Bobtails	-
	IB/Import Empties	-	Outbound Bobtails	-
Ingate 0	OB/Export Loads	0		
	OB/Export Empties	-		
Total Terminal + Crosstown Trips		**3,008,904**	**Crosstown Total**	**421,066**

The crucial function of this worksheet is to implement the fundamental movement logic, account for all the necessary drayage movements, and balance the flows where they should be balanced.

The worksheet functions as a check on the logic and completeness of the scenario inputs. The complexity of port container flows can easily lead to under-counting or double-counting, with resulting errors in activity and emissions estimates. The activity model therefore includes the container flow chart to help insure that flows are appropriately balanced, allocated to correct activity categories, and neither undercounted nor double counted. The container flow chart is driven by entries elsewhere, total TEU and proportional splits between activity and customer groups. There are no user entries on this worksheet.

The worksheet begins with the movement of loaded and empty containers on and off the ocean-going vessel (Exhibit 35, shaded in turquoise). The worksheet uses units of containers, translating from TEU to containers via the factor from the input page.

Exhibit 35: Marine Container Terminal Flows

Marine Container Terminals		
To/From Vessels	**Number**	**%**
Annual Port TEU	2,000,000	na
Equiv. Containers	1,142,857	100%
IB/Import Loads	542,857	48%
IB/Import Empties	28,571	3%
OB/Export Loads	428,571	38%
OB/Export Empties	142,857	13%

The first analytic step is to allocate part of the volume to barge/transshipment and on-dock rail transfer, where present.

Exhibit 36: Allocation to Barge/Transshipment and On-Dock Rail

Non-gate Container Moves		
	On-Dock Barge Transhipment	**On-Dock Rail**
	Port Share 0%	**Port Share 0%**
	-	-
	-	-
	Number	**Number**
IB/Import Loads	-	-
IB/Import Empties	-	-
OB/Export Loads	-	-
OB/Export Empties	-	-

In both cases the volumes are determined by the Primary Input values. In the absence of information to the contrary the model assumes that the inbound/outbound and load/empty balances for barge and rail service are the same as for the port as a whole. Neither barge nor on-dock rail transfers are expected to generate empty chassis or bobtail drayage moves, since by definition on-dock rail transfers are served by on-dock equipment (e.g. yard hostlers or straddle carriers) rather than street-legal drayage tractors. (If containers must be moved by over-the-road draymen to and from another marine terminal or other facility for barge or on-dock rail transfer, those flows would be regarded as inter-terminal movements.)

The worksheet divides the remaining inbound and outbound loaded and empty container flows between the off-terminal activity centers. The model allocates loaded and empty flows to inter-terminal moves, off-dock rail, and container depots according to values from the input sheet. All other loaded and empty flows are then allocated to shippers and consignees.

Marine Terminal Gate Flows

The inbound and outbound flows at the marine terminal gates (Exhibit 37, in aqua shading) include all the loaded and empty container movements to and from the off-dock activity centers and flows of empty chassis and bobtails estimated as percentages of the total gate volume. These percentages are empirically derived, ideally from marine terminal gate records, and are entered on the marine terminal activity sheet.

Exhibit 37: Marine Terminal Gate Moves from Flow Chart

Terminal Gate Moves	
Outgate Loads	548,286
Outgate Empties	331,786
Outgate Chassis	25,672
Outgate Bobtails	388,176
Other Outgate Trucks	-
Outgate Subtotal	**1,293,919**
Ingate Loads	**432,857**
Ingate Empties	**448,324**
Ingate Chassis	27,541
Ingate Bobtails	385,197
Other Ingate Trucks	-
Ingate Subtotal	**1,293,919**
Net Port Container Gain/Loss	1,109
Terminal Gate Total	**2,587,839**

Bobtail movements occur as the working day begins and ends, and during the day whenever a drayman makes a one-way trip (e.g. dropping off an export empty without picking up an import load). Drayage firms and drivers try to minimize bobtail moves as they earn no revenue. Where drivers have pulled an empty container from an import customer in the afternoon, they may wait until the next morning to return the empty to the port rather than making a one-way trip in the afternoon and a return bobtail trip in the morning. The Rail Intermodal Terminals also have bobtail and empty chassis trips for the same reasons. The flow chart "imports" these estimates from the Off-Dock Rail Terminal sheet.

The frequency of bobtail trips increases where draymen are unsuccessful in pulling the container they came for and go away empty-handed. Port and terminal information systems such as eModal or VoyagerTrack attempt to minimize bobtail trips by making container status information available on-line.

All parties try to minimize empty chassis movements. Such movements typically result from equipment imbalances.

- Not enough chassis, too many chassis, or the wrong types of chassis at the marine or rail terminals.
- A need to shift empty containers from port to depot without bringing any back.
- A container-chassis mismatch (carrier Y's container on carrier X's chassis).

The worksheet also "imports" the ingate and outgate empty chassis volumes from the marine terminal spreadsheet, where they are determined by an empirical percentage.

The total marine terminal ingate and outgate moves (including bobtails and bare chassis) will balance, but the number of containers moved should not be expected to balance. Most ports have either a small net gain or loss in the number of containers handled. At Houston, import containers moved to the Gulf by rail or truck from other ports (e.g. LA/LB) are emptied and then trucked to Barbours Cut for outbound movement by water. This leaves the Port of Houston with more outbound containers than inbound. In Southern California, for example, there is a net loss for two reasons:

- the containers that move eastbound via rail do not all return westbound to San Pedro Bay – some exit the U.S. via other ports such as Houston; and
- some import containers are repositioned once empty to Central California for export loads via Oakland.

The worksheet does not show any bare chassis or bobtail moves for the inter-terminal drayage since those moves are already counted as part of the marine terminal activity.

There are bobtail moves to and from shippers and consignees, but no empty chassis moves since the containers remain on chassis for loading or unloading.

The empty chassis moves to and from the container depot are also accounted for in the marine terminal portion of the flow chart.

The cells of the worksheet are locked and do not allow or anticipate user inputs or modifications. This approach preserves the internal logic of the model.

- If the flows shown on the worksheet do not appear correct it is an indication of problems with input factors either on the primary input sheet or on one of the activity center sheets.
- If the overall container count is wrong either the TEU total, the inbound/outbound balance, the load/balance, and the containers per TEU conversion factors should be checked.
- If the barge or on-dock rail volumes appear wrong, the barge percentage, the rail percentage, and the on-dock rail shares should be checked.

The most useful empirical data are often marine terminal gate counts. If the totals and proportions in the marine gate section of the worksheet do not agree with empirical data, the following issues should be considered (other than inaccuracy of the data).

- Proportions and volumes of containers moved via barge or on-dock rail. In particular, the load/empty balances of barge or rail flows may differ significantly from the overall port balance, and can be adjusted using variables on the Primary Inputs sheet.
- Proportions of bobtail or bare chassis moves (on the Marine Terminal activity center sheet). There may be local reasons for higher or lower percentages of bobtail or bare chassis moves, such as off-terminal storage, or a higher number of inter-terminal moves.
- The existence of bypass gates, inter-terminal or depot moves by yard tractors, or other reasons why some moves are not reflected in terminal gate counts.

- A mismatch between the pattern reflected in gate counts and the overall annual port drayage pattern. This mismatch might occur if a monthly or weekly sample includes non-typical activity such as service disruptions or large-scale equipment repositioning.

The marine terminal gate flow numbers on the worksheet are matched on the marine terminal activity center sheet. The relationships on that sheet should be reviewed in detail if the flow chart numbers appear incorrect.

Marine Terminal Trips

The Marine Terminal Trips column (Exhibit 38) lists the outgate (red arrows) and ingate (blue arrows) container movements implied by the Primary Inputs.

Exhibit 38: Port Container Trips Column

Marine Terminal Trips	Containers & Chassis Handled	
	Shipper/Receiver Trips	
Outgate 717,214	**Port Share 75%**	**Number**
	IB/Import Loads	407,143
	IB/Import Empties	321,429
Ingate 718,929	OB/Export Loads	321,429
	OB/Export Empties	407,143
	Inter-Terminal Drayage Trips	
Outgate 5,714	**Port Share 1%**	**Number**
	IB/Import Loads	5,429
	IB/Import Empties	286
	IB/Import Chassis	-
Ingate 5,714	OB/Export Loads	4,286
	OB/Export Empties	1,429
	OB/Export Chassis	-
	Off-Dock Rail Intermodal Trips	
Outgate 154,849	**Port Share 25%**	**Number**
	IB/Import Loads	135,714
	IB/Import Empties	7,143
Ingate 156,113	IB/Import Chassis	11,991
	OB/Export Loads	107,143
	OB/Export Empties	35,714
	OB/Export Chassis	13,256
	Off-Dock Container Depot Trips	
Outgate 27,966	IB/Import Loads	0
	IB/Import Empties	14,286
	IB/Import Chassis	13,681
Ingate 27,966	OB/Export Loads	0
	OB/Export Empties	13,681
	OB/Export Chassis	14,286
	Other Port Truck Trips	
Outgate 0	IB/Import Loads	0
	IB/Import Empties	-
Ingate 0	OB/Export Loads	0
	OB/Export Empties	-

- The Inter-Terminal Dray flows are just the sum of the loads and empties in each direction.
- The Shipper-Receiver flows are adjusted for the number of street turns, for empties supplied from depots, and for empties returned to depots.
- The Off-Dock Rail Intermodal flows are adjusted for the number of empties returned to depots.
- The Container Depot flows are adjusted for the number of empties received from non-port sources or supplied to non-port users.

Container & Chassis Handled Columns

The numbers of loads and empties in the Container & Chassis Handled columns start with basic assumptions.

- The Inter-Terminal dray moves are assumed to have the same mix of loads and empties as the port as a whole. The moves are by definition, balanced since they are all in the port system (e.g. an outgate at one terminal is an ingate at another terminal).

- The Shipper/Receiver flows reflect the port's general inbound/outbound cargo mix. These flows are balanced from the Shipper/Consignee perspective but empties may move to and from depots as well as port terminals.

- The Off-Dock Rail Intermodal flows reflect the overall port import/export mix but are not inherently balanced since containers that leave by rail may not return to the same port.

- The Container Depot flows are dictated by the Primary Inputs for the percentage of empty containers stored at depots, the number of containers supplied from depots, and the percentage of empty containers returned directly to depots.

Inter-terminal Drayage

Inter-terminal drayage occurs when loaded containers, empty containers, or bare chassis must be shifted between marine container terminals. (Moves to off-terminal container depots are considered separately.) The need to move loaded containers is usually generated by connecting services between ocean carriers. Connections are most required between major routes and feeder services, or between international and domestic carriers. Where transfers are made to barge or other carriers within the same terminal, those transfers should be accounted for in the barge/transshipment section.

Exhibit 39: Inter-Terminal Drayage on Container Distribution Worksheet

Outgate 5,714 →

← Ingate 5,714

Inter-Terminal Drayage Trips			
Port Share 1%	**Number**		
IB/Import Loads	5,429		
IB/Import Empties	286		
IB/Import Chassis	-		
OB/Export Loads	4,286		
OB/Export Empties	1,429		
OB/Export Chassis	-		

Shippers/Receivers

Movements to/from shippers and receivers are allocated as shown in Exhibit 40. Note that total container movements through the facility are balanced – whatever comes in loaded must leave either loaded or empty and vice versa. The many cross-town flows on the right, however, illustrate that there can be multiples sources and destinations of these movement, especially for the empty containers. The movement totals from this section of the Container Distribution spreadsheet are transmitted to the Shipper/Receiver Tally Sheet

Exhibit 40: Shippers/Receiver Trips on Container Distribution Worksheet

Outgate 717,214

Ingate 718,929

Shipper/Receiver Trips			
Port Share 75%	**Number**	Bobtails to S/Rs	182,143
IB/Import Loads	407,143	Bobtails from S/Rs	182,143
IB/Import Empties	321,429	Empties to Rail	3,214
OB/Export Loads	321,429	Empties from Rail	4,071
OB/Export Empties	407,143	Empties to Depot	3,214
		Empties from Depot	4,071
		Import Ctrs Reused	3,214

Off-Dock Rail Intermodal

Movements to/from off-dock rail terminals are allocated as shown in Exhibit 41. Overall container movements through the facility are not necessarily balanced – import containers destined to inland points may not come back to the same port once emptied. The many cross-town flows on the right may not be balanced either, since there is usually a fleet of chassis at the rail terminal and the size of the fleet can change over time. The movement totals from this section of the Container Distribution spreadsheet are transmitted to the Off-Dock Rail Intermodal Tally Sheet.

Exhibit 41: Off-Dock Rail Intermodal on Container Distribution Worksheet

Outgate 154,849

Ingate 156,113

Off-Dock Rail Intermodal Trips			
Port Share 25%	**Number**	Bobtails to Rail	13,989
IB/Import Loads	135,714	Bobtails from Rail	17,346
IB/Import Empties	7,143	Chassis from Depots	-
IB/Import Chassis	11,991	Chassis to Depots	-
OB/Export Loads	107,143	Empties to Depots	357
OB/Export Empties	35,714	Empties from Depots	143
OB/Export Chassis	13,256	Empties to S/R	4,071
		Empties from S/R	3,214

Container Depots

Movements to/from off-dock container depots are allocated as shown in Exhibit 42. Overall container movements through the depots are balanced – over time, every container that is brought in to a depot eventually leaves (although there may be a long storage time). The many cross-town flows on the right may not be balanced due to multiple sources of empty containers. The movement totals from this section of the Container Distribution spreadsheet are transmitted to the Container Depot Tally Sheet.

Exhibit 42: Container Depots on Container Distribution Worksheet

	Off-Dock Container Depot Trips			
Outgate 27,966	IB/Import Loads	0	Bobtails to Depots	6,992
	IB/Import Empties	14,286	Bobtails from Depots	6,992
	IB/Import Chassis	13,681	Chassis from Rail	
Ingate 27,966	OB/Export Loads	0	Chassis to rail	
	OB/Export Empties	13,681	Empties from Rail & S/R	3,571
	OB/Export Chassis	14,286	Empties to Rail & S/R	4,176

Other Port Trucks

If used in the model, the Other Port Truck option results would be displayed as in Exhibit 43.

Exhibit 43: Other Port Trucks on Container Distribution Worksheet

	Other Port Truck Trips			
Outgate 0	IB/Import Loads	0	Inbound Bobtails	-
	IB/Import Empties	-	Outbound Bobtails	-
Ingate 0	OB/Export Loads	0		
	OB/Export Empties	-		

Crosstown Trips

The Crosstown Trips column (Exhibit 44) displays moves generated by port container trade but which do not involve port terminals.

Exhibit 44: Crosstown Trips Column

Containers & Chassis Handled		Crosstown Trips	
Shipper/Receiver Trips			
Port Share 75%	**Number**	Bobtails to S/Rs	182,143
IB/Import Loads	407,143	Bobtails from S/Rs	182,143
IB/Import Empties	321,429	Empties to Rail	3,214
OB/Export Loads	321,429	Empties from Rail	4,071
OB/Export Empties	407,143	Empties to Depot	3,214
		Empties from Depot	4,071
		Import Ctrs Reused	3,214
Inter-Terminal Drayage Trips			
Port Share 1%	**Number**		
IB/Import Loads	5,429		
IB/Import Empties	286		
IB/Import Chassis	-		
OB/Export Loads	4,286		
OB/Export Empties	1,429		
OB/Export Chassis	-		
Off-Dock Rail Intermodal Trips			
Port Share 25%	**Number**	Bobtails to Rail	13,989
IB/Import Loads	135,714	Bobtails from Rail	17,346
IB/Import Empties	7,143	Chassis from Depots	-
IB/Import Chassis	11,991	Chassis to Depots	-
OB/Export Loads	107,143	Empties to Depots	357
OB/Export Empties	35,714	Empties from Depots	143
OB/Export Chassis	13,256	Empties to S/R	4,071
		Empties from S/R	3,214
Off-Dock Container Depot Trips			
IB/Import Loads	0	Bobtails to Depots	6,992
IB/Import Empties	14,286	Bobtails from Depots	6,992
IB/Import Chassis	13,681	Chassis from Rail	
OB/Export Loads	0	Chassis to rail	
OB/Export Empties	13,681	Empties from Rail & S/R	3,571
OB/Export Chassis	14,286	Empties to Rail & S/R	4,176
Other Port Truck Trips			
IB/Import Loads	0	Inbound Bobtails	-
IB/Import Empties	-	Outbound Bobtails	-
OB/Export Loads	0		
OB/Export Empties	-		
osstown Trips	**3,008,904**	**Crosstown Total**	**421,066**

These flows include:

- Import Containers Reused (also known as "street turns") – empty import containers being used for export loads rather than being returned to the ports. This practice is much more common at some ports than at others, and is facilitated by Virtual Container Yards and information systems. Each street turn eliminates two empty trips to port terminals, but incurs time and mileage according to the Crosstown activity sheet.

- Rail terminal bobtails and empty chassis moves, which occur at off-dock rail terminals for the same reasons they occur at marine terminals. If the rail terminal also handles domestic intermodal business, those trips will generate additional bobtail and chassis moves that should not be reflected in the activity model.

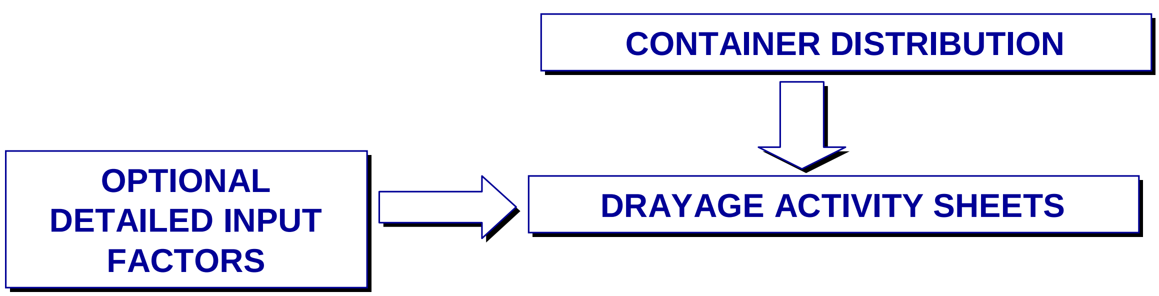
- Direct off-hires are returns of empty containers to an off-dock container depot rather than to a marine terminal. This is normal practice abroad and at U.S. ports such as Houston where tight terminal space leads operators to store empties off-dock. There are two classes of such movements. Direct "off hires" are containers owned by leasing companies and returned ("off-hired") when they are no longer needed by the ocean carrier lessee. These containers accumulate in the depots until they are needed again by the ocean carriers or they are repositioned by vessel to Asia or other areas of demand. The flow chart assumes that in the course of a year the depot inventory remains constant, and that the empties drayed into the depots are eventually drayed to marine terminals. Where carrier-owned containers are stored off-dock (either routinely or in times of surplus), these direct-to-depot flows should reflect that practice as well.

- Empties from depots supply the capacity needs of exporters without a trip to the marine terminal. In ports such as Houston where empties are routinely stored off-dock supplying empties from the depots may be the norm. At other ports with more on-terminal space for empties or smaller export capacity demand, supplying empties from depots may be uncommon.

Drayage Activity Sheets: Common Features

Drayage Activity sheets for each drayage activity track the drayage miles and minutes for each activity and allocate them between idle, creep, transition, and cruise duty cycles. Each tally sheet uses trip data from the default values or user-chosen scenario (Exhibit 45), and outputs activity and duty cycle data to a summary sheet. Detailed default values on the tally sheets (e.g. the time needed to transfer a container between two chassis) can be changed by the user if needed.

Exhibit 45: Inputs to Drayage Activity Tally Sheets



All of the activity tally spreadsheets employ a common format and approach, with changes in the nomenclature and content to suit the application. The Marine Terminal tally sheet, which is the most complex, is shown below as an example.

Exhibit 46: Activity Worksheet Example

Marine Terminal Drayage Activity

RESTORE GENERIC DEFAULTS

This worksheet reflects movements of loaded containers, empty containers, bare chassis, and bobtail tractors to and from marine container terminals

Note: OB/Export Containers come IN to the Marine Terminal Gate, and vice versa

Activity	Trips	%	Duration (Minutes)	Waiting Time (Minutes)	Travel Time (minutes)	Distance (Miles)
Outbound/Export Containers			= user changeable inputs			
Total Containers Entering Terminal Gate	**881,181**					
Loaded Containers	**432,857**	33%	(over-the-road movement shown on other worksheets)			
Empty Containers	**448,324**	35%				
Bare Chassis	**27,541**	2%	12	-	12	**5**
Bobtail Tractors	**385,197**	30%	35	-	35	**15**
Total Trips	**1,293,919**	**100%**				
Entry Gate Transactions						
Entry Gate Transaction	**1,293,919**	100%	**3**	3	-	-
Outside Queuing	**1,293,919**	100%	**15**		15	0.5
Trouble Window	**64,696**	**5%**	**45**	41	4	0.1
Bypass Entrance	**-**	0%	**1**	-	1	0.3
Container Yard Activity						
Pick Up Loaded Container on Chassis	**548,286**	30%	**27**	25	2	0.5
Pick Up Empty Container on Chassis	**331,786**	18%	**27**	25	2	0.5
Locate & Pick Up Bare Chassis	**25,672**	1%	**27**	15	2	0.5
Drop Loaded Container on Chassis	**432,857**	24%	**27**	25	2	0.5
Drop Empty Container on Chassis	**448,324**	25%	**27**	25	2	0.5
Drop Bare Chassis	**27,541**	2%	**5**	5	2	0.5
Chassis Flip/Transfer	**8,801**	0%	**42**	40	2	0.5
Live Lift Container onto Chassis	**-**	0%	**27**	27	0	0.1
Live Lift Container off of Chassis	**-**	0%	**27**	27	0	0.1
Total Transactions	**1,823,266**	**100%**				
Container Yard Delays						
Trouble Window	**91,163**	5%	**30**	27	3	0.1
Equipment Issue	**45,287**	5%	**60**	52	8	0.3
Inbound/Import Containers						
Total Containers Exiting Terminal Gate	**880,071**					
Loaded Containers	**548,286**	42%	(over-the-road movement shown on other worksheets)			
Empty Containers	**331,786**	26%				
Bare Chassis	**25,672**	2%	12	-	12	**5**
Bobtail Tractors	**388,176**	30%	35	-	35	**15**
Total Trips	**1,293,919**	**100%**				
Exit Gate Transactions						
Exit Gate Transaction	**1,293,919**	100%	**3**	5	-	-
Inside Queuing	**1,293,919**	100%	**5**		17	0.5
Trouble Window	**64,696**	**5%**	**30**	-	-	-
Bypass Exit	**-**	0%	**1**		-	
Loaded Subtotal	**981,143**	**38%**	**49,446,025**	**31,524,895**	**17,921,130**	**970,866**
Bobtail/Chassis/Empty Subtotal	**1,606,696**	**62%**	**86,133,537**	**35,788,879**	**50,344,659**	**13,065,180**
Marine Terminal Total	**2,587,839**	**100%**	**135,579,562**	**67,313,774**	**68,265,789**	**14,036,046**

On the left the tally sheets list possible activities. The list is similar across the various facility types, although not all activities take place in every location. The cells hold either values linked to other sheets, calculated values, output values, or optional input variables, as shown above. Cells containing calculated values and output values are locked. Cells shaded in tan allow user inputs.

The outputs are totaled separately for loaded containers and for unloaded equipment (bobtails, bare chassis, and empty containers). The tally sheets contain hidden cells in which the minutes by duty cycle phase are multiplied by the number of trips in each category and totaled. The output cells are ultimately linked to the Primary Inputs and Outputs and Activity Summary sheets.

The number of trips for each activity is derived either from the Container Distribution worksheet (such as the number of inbound loaded containers arriving at the marine terminal gates), or from logical relationships within the activity spreadsheet (such as the number of bare chassis moves at the outbound gate being equal to the number of times a drayman locates and picks up a bare chassis). The entries in the Number of Trips columns are not user changeable.

Most entries in the frequency (% of trips) column are calculated by the model. Some, shown by tan shading, are empirical or rule-of-thumb values that can be changed by the user if required. Others, such as the default split between queuing (100%) and queuing bypass (0%), can be altered on the Secondary Inputs sheet to reflect the implementation of "bobtail gates" or other measures to speed the handling of simple transactions. One of the more important functions of these optional input variables is to reflect management initiatives such as container status information systems, which are intended to reduce trouble window visits due to container holds or documentation problems.

The four Duration columns – three for time, the other for distance – are critical to the estimation of total drayage time, VMT, emissions, and cost. The most common and significant activity times are limited to the Primary Inputs, such as the yard activities at the marine terminal. Other times are based on industry rules of thumb and are user-changeable on the Secondary Inputs sheet to reflect local conditions. As discussed in the data sources section, detailed data on activity times may be hard to obtain, hence the use of industry rules of thumb as defaults.

The distances column may have various uses, depending on the facility involved.

- On the Marine Terminal spreadsheet, most distances correspond to in-terminal travel. Larger wheeled terminals will entail larger distances, while stacked terminals will exhibit shorter in-terminal trips.

On other activity tally spreadsheets the Inbound and Outbound sections show over-the-road travel distances. These distances must be empirically derived, and should ideally be weighted by trip counts. Again, as the Data Sources section explains, some creativity may be required to develop reliable input values where definitive data are lacking.

Operating Modes. This section of each activity tally spreadsheet (Exhibit 47), which is ordinarily hidden, is a critical factor in the emissions estimates. Duty cycle data are scarce, so the model supplies a series of appropriate default values. The default duty cycle for over-the-road trips on this and other spreadsheets is the California Air Resources Board (CARB) Highway Heavy Duty Diesel Truck (HHDDT) test cycle of 16.6% Idle, 7.0% creep, 15.4% transient, and 57.8% Cruise.

The complete duty cycle is applied only to the over-the-road activities within the drayage activity model, not to terminal activities or queuing. For most activities the tally sheet tracks waiting time (modeled at Idle) separately from movement time. The movement time is modeled at Creep (average of 1.8 mph, for gate transactions and queuing) or at Transient (average of 15.4 mph, for movement within the yard and through bypass gates).

The tally sheet tracks the minutes accumulated in each operating mode and the total distance traveled. These results are reported separately for loaded moves and for empty, bare chassis, and bobtail moves combined.

The Duty Cycle section of the spreadsheet is a critical factor in the emissions estimates. Duty cycle data are scarce, so the model supplies a series of appropriate default values. The default duty cycle for over-the-road movements is the CARB HHDTT cycle, as discussed in the section on estimating emissions. In most instances, the key issue is the percentage of time spent idling. Idling generates emissions and incurs cost while yielding no transportation output, and is therefore the target of many management initiatives.

Each activity tally sheet has a comparable operating cycle section which is normally hidden as there are no user inputs or displays of results.

Exhibit 47: Operating Mode and Activity Tallies

OPERATING MODE SPEEDS

CUMULATIVE OPERATING MODE TIMES

CUMULATIVE OPERATING MILEAGE

OPERATING MODE ASSIGNMENT

Activity	Idle %	Cre... %	Transient %	Cruise %	Avg. Travel MPH	Idle (min...	Creep (minutes)	Transient (minutes)	Cruise (minutes)	Total (Mi...	Total Miles
Outbound/Export Containers	0	1.8	15.4	39.9							
Total Containers Entering Terminal Gate											
Loaded Containers											
Empty Containers											
Bare Chassis	16.6%	7.0%	18.5%	57.8%	26.0	52,821	22,273	58,807	183,376	317,277	137,707
Bobtail Tractors	16.6%	7.0%	18.5%	57.8%	26.0	2,216,270	934,527	2,467,448	7,694,152	13,312,398	5,777,959
Total Trips											
Entry Gate Transactions											
Entry Gate Transaction	0%	100%	0%	0%	1.8	3,881,758	-	-	-	3,881,758	-
Outside Queuing	0%	100%	0%	0%	1.8	-	19,408,791	-	-	19,408,791	582,264
Trouble Window	0%	100%	0%	0%	1.8	2,641,752	269,567	-	-	2,911,319	8,087
Bypass Entrance	0%	0%	100%	0%	15.4	-	-	-	-	-	-
Container Yard Activity											
Pick Up Loaded Containe...			100%	0%	15.4	5,511,340	-	1,068,089	-	6,579,429	274,143
Pick Up Empty Containe...			100%	0%	15.4	3,335,093	-	646,336	-	3,981,429	165,893
Locate & Pick Up ...			100%	0%	15.4	385,082	-	50,011	-	435,093	12,836
Drop Loaded Container on Chassis	0%	0%	100%	0%	15.4	4,351,058	-	843,228	-	5,194,286	216,429
Drop Empty Container on Chassis	0%	0%	100%	0%	15.4	4,506,525	-	873,358	-	5,379,883	224,162
Drop Bare Chassis	0%	0%	100%	0%	15.4	137,707	-	53,652	-	191,359	13,771
Chassis Flip/Transfer	0%	0%	100%	0%	15.4	220,475	-	17,144	-	237,619	4,400
Live Lift Container onto Chassis	0%	0%	100%	0%	15.4	-	-	-	-	-	-
Live Lift Container off of Chassis	0%	0%	100%	0%	15.4	-	-	-	-	-	-
Total Transactions											
Container Yard Delays											
Trouble Window	0%	100%	0%	0%	1.8	2,431,022	303,878	-	-	2,734,900	9,116
Equipment Issue	0%	100%	0%	0%	1.8	2,339,838	377,393	-	-	2,717,231	11,322
Inbound/Import Containers											
Total Containers Exiting Terminal Gate											
Loaded Containers											
Empty Containers											
Bare Chassis	16.6%	7.0%	18.5%	57.8%	26.0	49,236	20,761	54,816	170,930	295,743	128,361
Bobtail Tractors	16.6%	7.0%	18.5%	57.8%	26.0	2,233,408	941,754	2,486,528	7,753,648	13,415,337	5,822,637
Total Trips											-
Exit Gate Transactions											
Exit Gate Transaction	0%	100%	0%	0%	1.8	6,469,597	-	-	-	6,469,597	-
Inside Queuing	0%	100%	0%	0%	1.8	-	21,565,323	-	-	21,565,323	646,960
Trouble Window	0%	100%	0%	0%	1.8	-	-	-	-	-	-
Bypass Exit	0%	0%	100%	0%	15.4	-	-	-	-	-	-
Loaded Subtotal	16,807,752	16,009,813	1,911,317	-		16,807,752	16,009,813	1,911,317	-	34,728,882	970,866
Bobtail/Chassis/Empty Subtotal	23,955,229	27,834,453	6,708,099	15,802,106		23,955,229	27,834,453	6,708,099	15,802,106	74,299,887	13,065,180
Marine Terminal Total	40,762,981	43,844,266	8,619,416	15,802,106		40,762,981	43,844,266	8,619,416	15,802,106	109,028,770	14,036,046

Marine Terminal Spreadsheet

The marine container terminal and the drayage activities that take place there are the focus of most port drayage initiatives. The marine terminal spreadsheet therefore provides an extensive list of possible activities and attaches container counts, times, miles, and duty cycle phases to each.

Exhibit 48: Marine Terminal Spreadsheet

Marine Terminal Drayage Activity

This worksheet reflects movements of loaded containers, empty containers, bare chassis, and bobtail tractors to and from marine container terminals

RESTORE GENERIC DEFAULTS

Note: OB/Export Containers come IN to the Marine Terminal Gate, and vice versa

Activity	Trips	%	Duration (Minutes)	Waiting Time (Minutes)	Travel Time (minutes)	Distance (Miles)
Outbound/Export Containers			= user changeable inputs			
Total Containers Entering Terminal Gate	881,181					
Loaded Containers	432,857	33%	(over-the-road movement shown on other worksheets)			
Empty Containers	448,324	35%				
Bare Chassis	27,541	2%	12	-	12	5
Bobtail Tractors	385,197	30%	35	-	35	15
Total Trips	1,293,919	100%				
Entry Gate Transactions						
Entry Gate Transaction	1,293,919	100%	3	3	-	-
Outside Queuing	1,293,919	100%	15		15	0.5
Trouble Window	64,696	5%	45	41	4	0.1
Bypass Entrance	-	0%	1	-	1	0.3
Container Yard Activity						
Pick Up Loaded Container on Chassis	548,286	30%	27	25	2	0.5
Pick Up Empty Container on Chassis	331,786	18%	27	25	2	0.5
Locate & Pick Up Bare Chassis	25,672	1%	27	15	2	0.5
Drop Loaded Container on Chassis	432,857	24%	27	25	2	0.5
Drop Empty Container on Chassis	448,324	25%	27	25	2	0.5
Drop Bare Chassis	27,541	2%	5	5	2	0.5
Chassis Flip/Transfer	8,801	0%	42	40	2	0.5
Live Lift Container onto Chassis	-	0%	27	27	0	0.1
Live Lift Container off of Chassis	-	0%	27	27	0	0.1
Total Transactions	1,823,266	100%				
Container Yard Delays						
Trouble Window	91,163	5%	30	27	3	0.1
Equipment Issue	45,287	5%	60	52	8	0.3
Inbound/Import Containers						
Total Containers Exiting Terminal Gate	880,071					
Loaded Containers	548,286	42%	(over-the-road movement shown on other worksheets)			
Empty Containers	331,786	26%				
Bare Chassis	25,672	2%	12	-	12	5
Bobtail Tractors	388,176	30%	35	-	35	15
Total Trips	1,293,919	100%				
Exit Gate Transactions						
Exit Gate Transaction	1,293,919	100%	3	5	-	-
Inside Queuing	1,293,919	100%	5		17	0.5
Trouble Window	64,696	5%	30	-	-	-
Bypass Exit	-	0%	1		-	
Loaded Subtotal	981,143	38%	49,446,025	31,524,895	17,921,130	970,866
Bobtail/Chassis/Empty Subtotal	1,606,696	62%	86,133,537	35,788,879	50,344,659	13,065,180
Marine Terminal Total	2,587,839	100%	135,579,562	67,313,774	68,265,789	14,036,046

Inbound Gate

The Inbound Gate section splits the total container trips into loaded containers (export cargo), empty containers, bare chassis, and bobtails. The values shown under Number of Trips shaded in yellow are linked to the Flow Chart, and should not be altered by the user. If these values appear incorrect it is an indication of problems with the Primary Inputs.

The Bare Chassis and Bobtail counts are estimated as percentages of total gate moves. The values of 2% for bare chassis and 30% for bobtails are from the Secondary Inputs sheet. The other frequencies or shares are calculated by the model.

The model assigns default durations to each gate transaction, with the loaded export container taking three minutes. Note that empty container and bare chassis transactions require an equipment interchange and at least a cursory inspection. A bobtail arrival usually just requires an identity check and instructions on where to find the equipment being sought, both of which may be accomplished at an unattended remote stanchion.

The gate transactions themselves incur no mileage and consist solely of idling.

Queuing

The queuing section of the spreadsheet assumes by default that all inbound movements wait the same time in the queue outside the gate. The model allows for a queue bypass, however, such as is frequently provided for bobtail moves that do not require an equipment interchange.

A small portion of the inbound movements will be diverted to a "trouble window" or equivalent. Typical reasons include missing or incomplete documentation, disputes over equipment condition, or unpaid fees. The default for trouble window diversions is 5%.

The model assigns the Primary Input value for average time in the queue (15 minutes in the example). Defaults of 1 minute for the bypass and 45 minutes for the trouble window can be altered by the user as required.

The model assigns 0.5 miles for each queuing alternative, and an additional 0.1 miles for the trouble window. Actual averages may be obtained through observation. Note that the length of the inbound queue is a function of how many trucks are in line, not road length.

The duty cycle mode default is creep for the normal queue, since "creep" reflects stop-and-go operation at an average speed of 1.8 mph. The bypass is modeled in the transient mode. The trouble window has a default 100% idle cycle.

Container Yard

Container yard activities usually account for most of the time spent by drayage drivers and tractors at the marine terminal. The model spreadsheet shows nine different transactions. Most are linked to flow chart and gate volumes as shown below.

Exhibit 49: Marine Terminal Container Flow Linkages

Yard Activity	Linked to…
For Wheeled Terminals	
Pick up loaded Container on Chassis	Outbound Loaded Containers
Pick up Empty Container on Chassis	Outbound Empty Containers
Locate & Pick up Bare Chassis	Outbound Bare Chassis
Drop Loaded Container on Chassis	Inbound Loaded Containers
Drop Empty Container on Chassis	Inbound Empty Containers
Drop Bare Chassis	Inbound Bare Chassis
Chassis Flip	(Calculated as percentage)
For Stacked Terminals	
Live Lift Container on Chassis	Outbound Containers
Live Lift Container off Chassis	Inbound Containers

The entries for number of trips are thus generated within the model. If they do not match empirical data, the disparity suggests a problem with Primary Inputs or Secondary Inputs (% of trips).

The duty cycle for yard activities is transient while moving, and idle while waiting.

Yard Delay and Repair

The model provides separate accounting for significant delays in the container yard and the need for equipment repair (usually chassis). The model allows for 5% of the trips to involve some significant delay averaging 30 minutes and an additional 0.1 miles at creep. By default, 5% involve an extended delay in the yard (60 minutes) to repair a defect, with an extra 0.3 miles of travel at creep.

Note that there is a potential for double-counting if weighted average transaction times for container yard transactions include cases of extended delay or repair. There is also a potential for double counting with the roadability delay category under Outbound Delay, below.

The major cause of outbound yard delay would be difficulty locating the desired container, which should be minimized by good terminal operating systems and communications. Outbound yard repair most often involves the chassis, as the chassis has far more moving parts than the container. A drayage driver can be cited and fined for pulling a chassis with non-working lights or missing mud flaps, and a bald or under-inflated tire or faulty brakes can cause an accident. Draymen would ordinarily only wait for repairs to loaded equipment – they will reject an empty container or bare chassis rather than wait for repair.

Outbound Gate

The outbound gate trip volumes are linked as described above in Exhibit 49. The bare chassis and bobtail trip volumes are estimated by the model based on the Secondary Inputs.

Times for the outbound gate are similar to the inbound gate. Marine terminals are very careful about valuable import cargo leaving the premises. Both loaded and empty containers are being interchanged from the marine terminal to the drayman. The outbound gate time also allows for in-terminal queuing.

Outbound Delay

Outbound Delay can result from chassis roadability issues raised at the gate (or at a "roadability canopy"), or from documentation issues sent to the trouble window. Both are accounted for in the model by 5% rule-of-thumb estimates. The roadability delay entails a longer wait – 60 minutes versus 30 minutes at the trouble window. Both are allocated as 100% creep.

Activity Tallies

The Marine Terminal Spreadsheet tallies from left to right and top to bottom.

The green-shaded cells at the bottom of the spreadsheet contain vertical totals for loaded container movements, for non-loaded equipment (empty containers, bare chassis, bobtails), and total movements. These green-shaded cells are linked to the detailed and summary output sheets.

Inter-Terminal Spreadsheet

The format of the Inter-Terminal drayage spreadsheet is similar to the Marine Terminal spreadsheet, but is used differently. Instead of reflecting activity at gates and container yards, this model section represents over-the-road movements between terminals.

Exhibit 50: Inter-Terminal Spreadsheet

Inter-Terminal Drayage Mileage & Time

This worksheet reflects time and distance travelled in movements of loaded containers, empty containers, bare chassis, and bobtail tractors between marine container terminals

Activity	Trips	%	Duration (Minutes)	Waiting Time	Travel Time	Distance (Miles)
Inter-Terminal Drayage Trips			= user changeable inputs			
Total Inter-Terminal Container Movements	**5,714**					
Loaded Containers	**5,429**	95%	9	-	9	**4**
Empty Containers	**286**	5%	9	-	9	**4**
Bare Chassis	**-**	0%	9	-	9	**4**
Bobtail Tractors		0%	9	-	9	**4**
Total Trips	**5,714**	**100%**				
Loaded Subtotal	**5,429**	**95%**	**50,030**	**8,329**	**41,701**	**21,714**
Bobtail/Chassis/Empty Subtotal	**286**	**5%**	**2,633**	**438**	**2,195**	**1,143**
Inter-Terminal Total	**5,714**	**100%**	**52,663**	**8,767**	**43,895**	**22,857**

The number of trips in both directions is linked to the Container Distribution, and determined by the Inter-Terminal Dray Share on the Primary Inputs sheet.

The key input is the distance between terminals, which has a default value of 4 miles. As in other cases, where there are only two facilities the input value should be the distance between them. In a multi-terminal complex, the ideal input would be the various distances weighted by the number of trips between each pair. This level of detailed data is unlikely to be available, however. Where inter-terminal drayage volumes are thought to be evenly dispersed, a weighted average of the distances between terminal pairs would be a next-best input value. Where some pairs of terminals have more inter-terminal drayage than others (due, for example, to split vessel calls from an ocean carrier alliance), some judgmental weighting may be appropriate.

The model calculates the trip duration in minutes based on the distance and duty cycle proportions.

The default duty cycle for over-the-road trips on this and other spreadsheets is the California Air Resources Board (CARB) Highway Heavy Duty Diesel Truck (HHDDT) test cycle of 16.6% idle, 7.0% creep, 18.5% transition, and 57.8% cruise. It must be noted that this duty cycle (or an alternate duty cycle inputted by the user) is applied only to the over-the-road activities within the drayage activity model, not to terminal activities or queuing.

The inter-terminal drayage spreadsheet does not, by default, include chassis and bobtail trips. These are accounted for on the marine terminal spreadsheet.

All gate and container yard activities for inter-terminal drayage are likewise represented on the Marine Terminal spreadsheet.

As with the other activity spreadsheets the Inter-Terminal spreadsheet tallies from left to right and top to bottom. The model calculates minutes in each duty cycle element and total miles. Separate totals are maintained for loaded containers; bobtails, bare chassis, and empty containers; and for the total. These totals are linked to the Detailed Outputs and Summary Outputs.

Off-Dock Rail Terminal Spreadsheet

The Off-Dock Rail Terminal portion of the model reflects drayage trips to and from port terminals, and port-related activity at and within the rail facility.

Exhibit 51: Off-Dock Rail Terminal Spreadsheet

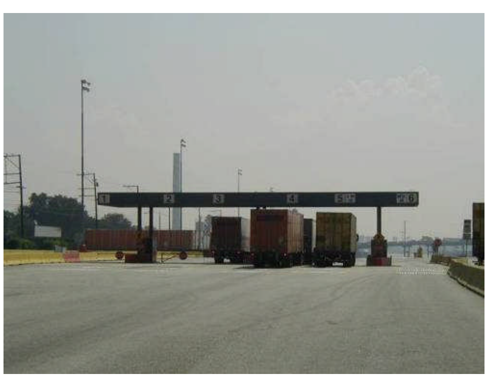
Off-Dock Rail Terminal Drayage Activity

This worksheet reflects movements of loaded containers, empty containers, bare chassis, and bobtail tractors to and from off-dock rail intermodal terminals

Note: Inbound/Import containers come IN to the Rail Terminal Entry Gate, and vice versa

Activity	Trips	%	Duration (Minutes)	Waiting Time	Travel Time	Distance (Miles)
Inbound/Import Containers			= user changeable inputs			
Total Containers Entering Terminal Gate	**146,214**					
Loaded Containers	**135,714**	78%	12	-	12	5.0
Empty Containers	**10,500**	6%	12	-	12	5.0
Bare Chassis	**13,256**	8%	12	-	12	5.0
Bobtail Tractors	**13,989**	8%	12	-	12	5.0
Total Trips	**173,459**	**100%**				
Entry Gate Transactions						
Entry Gate Transaction	**173,459**		**2**			
Outside Queuing	**173,459**	100%	**5**	-	5	0.2
Trouble Window	**1,735**	**1%**	**30**	30	-	-
Bypass Entrance	**-**	0%	**3**	-	3	0.8
Rail Intermodal Yard Activity						
Pick Up Loaded Container on Chassis	**107,143**	34%	**15**	11	4	1.0
Pick Up Empty Container on Chassis	**35,714**	11%	**15**	11	4	1.0
Locate & Pick Up Bare Chassis	**13,256**	4%	**15**	11	4	1.0
Drop Loaded Container on Chassis	**135,714**	43%	**15**	11	4	1.0
Drop Empty Container on Chassis	**10,500**	3%	**15**	11	4	1.0
Drop Bare Chassis	**13,256**	4%	**15**	11	4	1.0
Chassis Flip/Transfer	**1,429**	1%	**30**	26	4	1.0
Live Lift Container onto Chassis	**-**	0%	**15**	13	2	0.5
Live Lift Container off of Chassis	**-**	0%	**15**	13	2	0.5
Total Transactions	**317,011**	**101%**				
Yard Delay & Repair						
Trouble Window	**4,816**	4%	**30**	-	4	0.1
Equipment Issue	**3,612**	3%	**60**	-	33	1.0
Outbound/Export Containers						
Total Containers Exiting Terminal Gate	**142,857**					
Loaded Containers	**107,143**	62%	12	-	12	5.0
Empty Containers	**35,714**	21%	12	-	12	5.0
Bare Chassis	**13,256**	8%	12	-	12	5.0
Bobtail Tractors	**17,346**	10%	12	-	12	5.0
Total Trips	**173,459**	**100%**				
Exit Gate Transactions						
Exit Gate Transaction	**173,459**	100%	**0**	-	-	-
Inside Queuing	**173,459**	100%	**5**	-	5	0.2
Trouble Window	**1,735**	**1%**	**30**	30	-	0.1
Bypass Exit	**-**	0%	**3**	-	3	0.8
Loaded Subtotal	**242,857**	**70%**	**7,278,759**	**3,235,285**	**4,043,474**	**944,523**
Bobtail/Chassis/Empty Subtotal	**104,060**	**30%**	**2,606,158**	**1,075,622**	**1,530,536**	**423,240**
Off-Dock Rail Terminal Total	**346,917**	**100%**	**9,884,917**	**4,310,907**	**5,574,010**	**1,367,763**

Inbound Rail Terminal Gate



The key input for the over-the-road trips is the distance. As with analogous inputs in other model segments the ideal input value would be a weighted set of distances and volumes. Lacking terminal-by-terminal trip data, the next-best input value would be the distances to rail facilities (if there is more than one) weighted by their relative volumes of port-related activity.

This spreadsheet follows the common model approach to over-the-road trips by calculating times based on distance and the default CARB HHDDT duty cycle. An alternate user-specified duty cycle would yield different times (and, ultimately, different emissions estimates).

The rail terminal spreadsheet uses the same format as other activity tally sheets. The number of trips is linked to the Container Distribution chart and is driven by the Primary Inputs. The On-dock Rail factor in the Initiative Inputs section governs the split between on-dock and off-dock rail.

The number of trips shown on this spreadsheet is likely to differ from data kept or provided by the railroads.

- Many port-area rail terminals also handle domestic containers and trailers and may also handle domestic "backhaul" freight in international containers. These activities are not covered by the model.
- Almost all rail intermodal terminals are actually operated by independent firms under contract to the railroad. These firms use terminal operations software (OASIS is the most common system) to track and manage terminal activity. The accuracy of any information generated depends on the diligence of the contractor and their ability or willingness to extract the data.
- Railroads compensate contractors primarily on the basis of lifts – transfer to and from the rail cars using mechanized lift equipment. For a variety of reasons the number of lifts is likely to differ from the count of gate transactions.

Queuing

Queuing at rail terminals is treated similarly to queuing at Marine Terminals. Queuing time is generally shorter at rail terminals (default is 5 minutes) because the transactions are simpler and there are often more gates. A smaller percentage are sent to the trouble window by default, again because the rail terminal transactions are typically simpler.

Yard

The yard transactions at rail terminals fall in the same categories as transactions at marine terminals. The transactions tend to be quicker (the default is 15 minutes rather than 30 minutes for marine terminals). The distances tend to be longer (default is 1.0 miles versus 0.5 miles at marine terminals) because rail terminal yards are typically elongated rather than more square and compact. Few if any rail yards stack containers on the ground, so live lifts are not usually used. The percentage of chassis flips is an industry rule-of-thumb (default is 1%).

Yard Delay and Repair

Treatment of yard delays and repairs is analogous to the marine terminal approach.

Outbound Gate

The outbound gate numbers are linked to the Container Distribution chart, except for the bare chassis and bobtail volumes (which again are user-changeable input percentages on the

Secondary Inputs sheet). The times include the over-the-road trip, using the same approach as the inbound gate.

Outbound Delay

The rail terminal spreadsheet uses the same basic approach to outbound delays as the marine terminal spreadsheet. The percentage of roadability delays is 3%, and the percentage of trouble window visits is lower (1%) to reflect the simpler transactions.

Shipper/Receiver Spreadsheet

Shippers and receivers (consignees) are the underlying customers for container transportation and in most ports will account for the majority of drayage trips and mileage.

Exhibit 52: Shipper/Receiver Spreadsheet

Shipper & Receiver Drayage Activity

This worksheet reflects movements of loaded containers, empty containers, and bobtail tractors to and from shippers (exporters) and receivers (importers)

Activity	Trips	%	Duration (Minutes)	Waiting Time	Travel Time	Distance (Miles)
Inbound/Import Containers			= user changeable inputs			
Containers Entering Shipper/Receiver Gate	**728,571**					
Loaded Containers	**407,143**	45%	58	-	58	25.0
Empty Containers	**321,429**	35%	58	-	58	25.0
Bobtail Tractors	**182,143**	20%	58	-	58	25.0
Total Trips	**910,714**	**100%**				
Entry Gate Transactions						
Entry Gate Transaction	**910,714**	100%	**2**	2		
Outside Queuing	**910,714**	100%	**3**		3	0.1
Trouble Window	**4,554**	**1%**	**30**	30	-	-
Loading/Unloading						
Pick Up Loaded Container on Chassis	**321,429**	22%	**10**	10	0	0.1
Pick Up Empty Container on Chassis	**407,143**	28%	**10**	10	0	0.1
Drop Loaded Container on Chassis	**407,143**	28%	**10**	10	0	0.1
Drop Empty Container on Chassis	**321,429**	22%	**10**	10	0	0.1
Wait for Container Loading	**-**	0%	**60**	60	0	0.1
Wait for Container Unloading	**-**	0%	**30**	30	0	0.1
Total Transactions	**1,457,143**	**100%**				
Yard Delay						
Yard Delay	**4,554**	**1%**	**15**	15	-	-
Outbound/Export Containers						
Containers Exiting Shipper/Receiver Gate	**728,571**	80%				
Loaded Containers	**321,429**	35%	58	-	58	25.0
Empty Containers	**407,143**	45%	58	-	58	25.0
Bobtail Tractors	**182,143**	10%	58	-	58	25.0
Total Trips	**910,714**	**100%**				
Exit Gate Transactions						
Exit Gate Transaction	**910,714**	100%	**2**	2		-
Outside Queuing	**910,714**	100%	**3**		3	0.1
Trouble Window	**4,554**	**1%**	**30**	30	-	-
Loaded Subtotal	**728,571**	**40%**	**53,034,048**	**15,585,333**	**37,448,715**	**18,352,714**
Bobtail/Chassis/Empty Subtotal	**1,092,857**	**60%**	**75,900,178**	**19,869,035**	**56,031,143**	**27,492,643**
Shipper/Receiver Total	**1,821,429**	**100%**	**128,934,226**	**35,454,368**	**93,479,858**	**45,845,357**

Inbound Gate

In this part of the model, the Inbound Gate section refers to the trip from marine terminal to shipper/consignee location. The number of trips is linked to the Flow Chart and is not user-changeable.

There are ordinarily no bare chassis trips to or from shippers or receivers. In North America, containers are rarely removed from their chassis at customer facilities.

Queuing

Some customer facilities have entrance gates with manned guardhouses, others do not. The model default values assign 100% of the trips to a 2-minute gate queue. A small percentage (1% default) are allocated to a 30-minute wait at a trouble window. At shipper/receiver facilities, "trouble window" type delays would typically result from lack of an open loading dock or parking space, an export load that was not ready for pickup, an issue involving cargo or equipment condition, or a documentation problem.

Yard

The "yard" at a shipper/receiver facility is the parking lot and loading docks. There are two ways in which draymen can serve a shipper or consignee.

- "Drop and Pick". For large customers, such as a retail chain import distribution center, it is more efficient for the drayman to drop a loaded import container in the parking lot for subsequent unloading and pull an empty container for return to the port. The loaded containers are moved to and from the loading docks by company yard hostlers (or sometimes by the drayage tractors), but that customer activity is not tracked in the model. For large exporters, the drayman would drop an empty container in the parking lot and pull a full export load for the trip to the port. By default the model assigns 100% of the trips to the "drop and pick" pattern.

- "Stay With". At distant customer locations or where the customer does not have a steady stream of business, the drayage driver will normally stay with the container as it is loaded (export) or unloaded (import). The default model assigns 0% of the trips to the "stay with" pattern.

The proportion of "stay with" and "drop and pick" transactions can be adjusted on the Secondary Inputs sheet.

There are no bare chassis transactions or chassis flips at shipper/receiver facilities.

Yard Delay and Repair

Significant yard delays and repair needs are rare at shipper/receiver facilities. The sites are smaller and usually less congested, so drayage drivers are not delayed trying to locate the right container. With no lift operations, equipment damage and delay for repair is also rare. The model default is 1% for both categories.

Outbound Gate

At shipper/receiver facilities the outbound gate is a mirror of the inbound gate, with the same default values.

Outbound Delay

Roadability delays are rare at shipper/receiver facilities and not reflected in the model. Trouble window times are covered in the queuing section.

Container Depot Spreadsheet

The Container Depot spreadsheet uses the same overall format as the other activity sheets but is simpler because only a few of the functions are used.

Exhibit 53: Container Depot Spreadsheet

Container Depot Drayage Activity

This worksheet reflects movements of empty containers, bare chassis, and bobtail tractors to and from off-dock container storage depots

Activity	Trips	%	Duration (Minutes)	Waiting Time	Travel Time	Distance (Miles)
Containers to Depot			= user changeable inputs			
Empty Containers	**14,286**	41%	5	-	5	2.0
Bare Chassis	**13,681**	39%	5	-	5	2.0
Bobtail Tractors	**6,992**	20%	5	-	5	2.0
Total Trips	**34,958**	**100%**				
Entry Gate Transactions						
Entry Gate Transaction	**34,958**	100%	**3**	3	-	-
Outside Queuing	**34,958**		**5**	-	5	0.2
Trouble Window	**1,748**	**5%**	**15**	15	-	-
Depot Yard Activity						
Pick up Empty Container on Chassis	**6,840**	16%	**10**	10	0	0.1
Locate & Pick up Bare Chassis		0%	**10**	10	0	0.1
Drop Empty Container on Chassis	**7,143**	17%	**10**	10	0	0.1
Drop Bare Chassis	**13,681**	0%	**10**	10	0	0.1
Chassis Flip		0%	**10**	10	0	0.1
Live Lift Container on Chassis	**6,840**	50%	**15**	15	0	0.1
Live Lift Container off Chassis	**7,143**	50%	**15**	15	0	0.1
Total Transactions	**41,647**	**100%**				
Depot Yard Delays						
Trouble Window	**2,082**	**0**	**30**	-	-	-
Equipment Issue	**2,082**	**0**	**60**	-	-	-
Containers form Depot						
Empty Containers	**13,681**	39%	5	-	5	2.0
Bare Chassis	**14,286**	41%	5	-	5	2.0
Bobtail Tractors	**6,992**	20%	5	-	5	2.0
Total Trips	**34,958**	**100%**				
Exit Gate Transactions						
Exit Gate Transaction	**34,958**	100%	**3**	-	-	-
Inside Queuing	**34,958**	100%	**3**	-	3	0.1
Trouble Window	**350**	**1%**	**15**	11	4	0.1
Loaded Subtotal	**-**	**0%**	**-**	**-**	**-**	**-**
Bobtail/Chassis/Empty Subtotal	**69,916**	**100%**	**1,644,057**	**1,074,117**	**569,940**	**154,695**
Container Depot Total	**69,916**	**100%**	**1,644,057**	**1,074,117**	**569,940**	**154,695**

Inbound Gates

The Inbound Gate trip volumes are derived from the Container Distribution chart and are not user-changeable. Container depots only handle empty containers and chassis, so there are no loaded containers in the picture. Chassis movements and bobtails are modeled as percentages of the total as in other activities.

The default distance is 4 miles, and the time is calculated by the model using the default CARB HHDDT duty cycle.

Queuing

Queuing time is minimal at depots due to the relatively simple nature of transactions and the lack of vessel-induced peaking. The model default values are 5 minutes for gate queuing and a 5% allocation to the trouble window, with a 15 minute duration there.

Yard

Container depots are a mix of wheeled and stacked storage. The default model allows 50% in each configuration and splits the inbound and outbound yard functions equally. The time required to pickup or drop a container on chassis is just 10 minutes since the facilities are small and the transactions are simple. Live lifts on or off are timed at 15 minutes since the drayman must wait for lift equipment. All distances have a default value of 0.1 miles. There are no loaded container, bare chassis, or chassis flip transactions.

Yard Delay and Repair

The default Container Depot spreadsheet does not include any drayage time for yard delays or repairs. Since only interchangeable empty containers are being handled, draymen would not wait to find a specific container (as they would with an import load) or to have a specific container or chassis repaired.

Outbound Gate

The Outbound Deport Gate mirrors the Inbound Gate.

Outbound Delay

The default Container Depot spreadsheet allows 1% for a 15-minute visit to the trouble window. This would most commonly be due to an equipment condition or documentation issue. No allowance is made for roadability delays.

Crosstown Trips Spreadsheet

The Crosstown Trips spreadsheet is provided to account for categories of drayage trips that do not involve port facilities. Such trips include "street turns" in which emptied import containers are reused for export loads. Since few import consignees are also export shippers, the containers must be repositioned – either by the same drayman or by another drayage firm to which the container is interchanged.

Exhibit 54: Crosstown Trips Spreadsheet

Crosstown Drayage Activity						
This worksheet reflects ancillary movements of empty containers, bare chassis, and bobtail tractors between non-port facilities						
Activity	**Trips**	**%**	**Duration (Minutes)**	**Waiting Time**	**Travel Time**	**Distance (Miles)**
Inbound/Import Containers			= user changeable inputs			
Empty Containers	**10,000**	5%	23	-	23	10.0
Bare Chassis	**-**	0%	23	-	23	10.0
Bobtail Tractors	**203,123**	95%	23	-	23	10.0
Total Trips	**213,123**	**100%**				
Drayage Yard Activity						
Pick up Empty Container on Chassis	**8,286**	45%	**15**	15	-	-
Drop Empty Container on Chassis	**10,000**	55%	**15**	15	-	-
Total Transactions	**18,286**	**100%**				
Yard Delay & Repair						
Yard Delay	**1,829**	10%	**30**	30	0	0.1
Equipment Repair	**914**	5%	**30**	30	4	1.0
Outbound/Export Containers						
Empty Containers	**8,286**	4%	23	-	23	10.0
Bare Chassis	**-**	0%	23	-	23	10.0
Bobtail Tractors	**206,480**	96%	23	-	23	10.0
Total Trips	**214,766**	**100%**				
Loaded Subtotal		**0%**	**-**	**-**	**-**	**-**
Bobtail/Chassis/Empty Subtotal	**427,889**	**100%**	**10,219,578**	**1,997,840**	**8,221,738**	**4,280,035**
Crosstown DrayageTotal	**427,889**	**100%**	**10,219,578**	**1,997,840**	**8,221,738**	**4,280,035**

Since an increase in container reuse is a major objective of virtual container yards (VCYs), this portion of the model is vital to estimating the impact of such strategies.

Inbound

The number of trips, as on other activity spreadsheets, is governed by the Container Distribution chart and not user-changeable.

Setting the distance (on the Primary Inputs sheet) will likely require some creativity, as the scarcity of street turns at present provides little guidance. The default model simulates a 10-mile trip.

- If the same drayage firm picks up the empty import container and drops it for export load the movement can be direct.
- If a second drayage firm serves the exporter, that firm would rarely have access to the empty container at the importer's facility (due to legal, institutional, and competitive barriers). In those cases the first drayage firm would pull the empty container to an outside location – usually the company yard – for the interchange.

No "gate" time is added.

Queuing

There is no queuing involved in crosstown trips.

Yard

The yard times for street turns are minimal (15 minutes), as the facilities are small and there are few containers to choose from. There are no bare chassis or chassis flips, nor are there any live lifts. The distances within the yard are set at zero.

Yard Delay and Repair

The Crosstown Trips spreadsheet allows 30 minutes for yard delays or waits for repairs. Containers or chassis needing repairs would rarely be accepted for street interchange or revised for export loads.

Outbound

The outbound section mirrors the inbound trips.

Outbound Delay

The street turn process does not entail outbound delay.

Other Port Trucks Worksheet

This worksheet is provided to account for movements of non-container port trucks, such as those moving bulk or break-bulk cargoes. The format of this worksheet is simpler than the others. The default model does not include such trips, so all such data must be added by the user.

Exhibit 55: Other Port Trucks Worksheet

Other Port Truck Activity						
This worksheet reflects movements of non-container trucks or other truck movements not covered in other worksheets						
Activity	**Trips**	**%**	**Duration (Minutes)**	**Waiting Time**	**Travel Time**	**Distance (Miles)**
Inbound/Import Trips			= user changeable inputs			
Loaded Trucks	-	0%	58	-	58	25.0
Empty Trucks	-	0%	58	-	58	25.0
Bobtail	-	0%	23	-	23	**10**
Total Trips	**-**	**0%**				
Entry Gate Transactions						
Entry Gate Transaction	-	99%	**1**	1	-	-
Outside Queuing	-		**2**	-	2	0.1
Trouble Window	-	**1%**	**30**	30	-	-
Yard Activity						
Loading	-	0%	**60**	59	1	**0.2**
Unloading	-	0%	**30**	29	1	**0.2**
Total Transactions	**-**	**0%**				
Yard Delay & Repair						
Yard Delay	-	**1%**	**15**	15	-	-
Outbound/Export Trips						
Loaded Trucks	-	0%	58	-	58	25.0
Empty Trucks	-	0%	58	-	58	25.0
Bobtail	-	0%	23	-	23	**10**
Total Trips	**-**	**0%**				
Exit Gate Transactions						
Exit Gate Transaction	-	99%	**1**	1	-	-
Inside Queuing	-		**2**	-	2	0.1
Trouble Window	-	**1%**	**30**	30	-	-
Loaded Subtotal	**-**	**0%**	**-**	**-**	**-**	**-**
Bobtail/Empty Subtotal	**-**	**0%**	**-**	**-**	**-**	**-**
Other Port Trucks Total	**-**	**0%**	**-**	**-**	**-**	**-**

Activity Percentages. This column contains the percentage of non-container truck movements by activity type, derived from the Secondary Inputs sheet..

Activity Durations. This column assigns the appropriate number of minutes to each drayage activity. Travel times are calculated by the model; waiting times require user inputs.

Distances. The distances on this sheet refer to distances traveled by non-container trucks to and from port facilities. The values may be replaced by the user.

Drayage Cost and Capacity

The Cost and Capacity worksheet (Exhibit 56) covers drayage cost, productivity, and the cost of technology upgrades.

Exhibit 56: Drayage Cost & Capacity Worksheet

SmartWay DrayFLEET Version 1.0 - Drayage Cost and Capacity

Annual Average Drayage Cost and Fleet Requirement Estimates

Time-Based Costs	
Driver Labor Costs	
Labor Cost per Hour	$ 12.00
Tractor Costs	
Average Cost of Tractor	$ 50,000
Avg. Technology Upgrades	$ -
Interest Rate	12%
Avg. Economic Life (yrs.)	6
Avg. Residual Value (%)	20%
Implied Annual Payment	$ 9,384
Avg. Insurance per Tractor	$ 6,000
Licenses & Fees per Tractor	$ 1,500
Fed User's Tax per Tractor	$ 550
Avg. Maintenance/Tractor/Year	$ 5,000
Upgrade Maintenance	$ -
Avg. Tractor days per week	5
Avg. Tractor hours per day	12
Avg. Tractor availability	95%
Total Avg. Tractor Cost Per Hour	$ 7.57
Average Hourly Cost	$ 19.57

Distance-Based and Overhead Costs	
Mileage Based Costs	
Fuel Cost/Gallon	$ 4.00
Total Annual Fuel Gallons	7,909,626
Total Annual Fuel Cost	$ 31,638,502
Average MPG, Incl. Idling	8.3
Implied Fuel Cost/Mile	$ 0.48
Avg. Tires/MIle	$ 0.10
Average cost per mile	$ 0.58
Avg. Admin. Cost per Load	$ 25
Total Costs	
Time-Based Costs	$ 96,714,048
Mileage-Based Costs	$ 38,209,177
Load-Based (Admin) Costs	$ 24,528,571
Annual Drayage Cost	$ 159,451,797
Average Cost per Load	$ 163
Average Cost per TEU	$ 80
Productivity	
Avg. Tractor Hours per day	12
Avg. Tractor days per week	5
Avg. Tractor Availability	1
Avg. Annual Hours per Tractor	2,964
Fleet Size Req. (FTE Tractors)	1,667

Technology Upgrades

Drayage Fleet Inuts	Capital Cost Default	Capital Cost Scenario	Annual Maintenance Default	Annual Maintenance Scenario	Implementation % Default	Implementation % Scenario
Technology Retrofits						
Particulate Filter/Trap	$ 7,000	$ 7,000	$ 100	$ 100	0%	0%
Oxidation Catalyst	$ 1,200	$ 1,200	$ -	$ -	0%	0%
Flow-Thorugh Filter	$ 5,500	$ 5,500	$ -	$ -	0%	0%
Idle Reduction						
Idle Control Strategy	$ -	$ -	$ -	$ -	0%	0%
Fuel Conservation						
Single Wide Wheels & Tires	$ 5,600	$ 5,600	$ -	$ -	0%	0%
Automatic Tire Inflation	$ 900	$ 900		$ -	0%	0%
Low Friction Engine Lubricant	$ -	$ -	$ 198	$ 198	0%	0%
Low Friction Drive Train Lubricant	$ -	$ -	$ 33	$ 33	0%	0%
Direct Drivetrain	$ -	$ -	$ -	$ -	0%	0%
Single Axle Drive (vs. Dual Axle)	$ -	$ -	$ -	$ -	0%	0%
Speed Management Policy (55mph)	$ -	$ -	$ -	$ -	0%	0%
Weight Reduction - Lbs	2,000	2,000	$ -	$ -	0%	0%
Average Upgrade Cost	$ -	$ -	$ -	$ -		

Drayage Cost

Conventional drayage costs are more complex than commonly thought and require more than back-of-envelope estimates. Drayage has few if any significant economies of scale. Moreover, the primary objective of the project is to model the impacts of changes in drayage activity. Activity-based costing is therefore the preferred approach.

The drayage cost model is in three sections: Time-Based Costs, Distance-Based and Overhead Costs, and a Total Cost Estimate.

The Time-Based Costs, below, include labor, tractor ownership, and time-based tractor maintenance.

Exhibit 57: Time-Based Drayage Costs

Time-Based Costs	
Driver Labor Costs	
Labor Cost per Hour	$ 12.00
Tractor Costs	
Average Cost of Tractor	$ 50,000
Avg. Technology Upgrades	$ -
Interest Rate	12%
Avg. Economic Life (yrs.)	6
Avg. Residual Value (%)	20%
Implied Annual Payment	$ 9,384
Avg. Insurance per Tractor	$ 6,000
Licenses & Fees per Tractor	$ 1,500
Fed User's Tax per Tractor	$ 550
Avg. Maintenance/Tractor/Year	$ 5,000
Upgrade Maintenance	$ -
Avg. Tractor days per week	5
Avg. Tractor hours per day	12
Avg. Tractor availability	95%
Total Avg. Tractor Cost Per Hour	$ 7.57
Average Hourly Cost	$ 19.57

Labor Cost per Hour. This value is specified on the Primary Inputs worksheet.

Financial Variables. The financials variables shown in the tan shaded cells above are typical industry defaults. New default values should be entered if more specific information is available on prevalent local practices.

Drayage tractors are typically older than over-the-road equipment, because the fuel economy, road comfort, and reliability of new tractors are not as important in drayage, because drayage rates will not support new equipment purchases, and because owner-operators are usually not well capitalized.

Owner-operators typically buy a used tractor about four years old, which is the age at which many are retired from major long-haul fleets and become available in the used market. Such a tractor costs about $50,000, has about 6 years of life remaining in drayage service, and will cost about $9,384 annually to own. Time-based maintenance is typically about $5000 annually.

Insurance is a significant cost factor, and a major headache for drayage firms and owner-operators. Drayage firms typically have two tiers of insurance coverage, with the first tier covering the firm and paid for as part of overhead. Owner-operators, as subcontractors, must carry their own insurance, which forms the second tier. Their total bill, including Non-Trucking or "bobtail" insurance, runs between $1,800 and $7,200 per tractor each year, with a typical cost of about $6,000. Differences in insurance costs could overwhelm differences in tractor ownership cost.

Licenses and fees vary by state. Illinois has the highest fees at $2,200 per year, and some states are under $500. Tractors that operate in more than one state pay a proportioned fee. The typical proportioned state fee is about $1,500.

The normal Federal Highway Use Tax is $550, but some firms reported lower figures.

Tractors normally operate 50-60 hours per week to give the driver 50 hours of productive work after time lost in maintenance.

- Some drivers and firms work a full 10-hour shift on Saturday, some do not, and very little drayage work is done on Sunday.
- Some owner-operators and firms use a tractor for two daily shifts, with two different drivers.

Default overall time-based tractor costs are $7.57 per hour. Some operators can reduce hourly tractor costs with intensive usage at twenty hours per day (two shifts, two drivers). By buying an older, cheaper tractor, an owner-operator can save on payments, but his savings will be offset by higher maintenance costs.

The distance-based and overhead costs below include fuel and tires.

Exhibit 58: Distance-Based and Overhead Costs

Distance-Based and Overhead Costs		
Mileage Based Costs		
Fuel Cost/Gallon	$	4.00
Total Annual Fuel Gallons		7,909,626
Total Annual Fuel Cost	$	31,638,502
Average MPG, Incl. Idling		8.3
Implied Fuel Cost/Mile	$	0.48
Avg. Tires/MIle	$	0.10
Average cost per mile	$	0.58
Avg. Admin. Cost per Load	$	25

The fuel consumption estimate is derived from the emissions portion of the model and incorporates separate fuel consumption rates for each model year of truck, each mode, and loaded versus empty operation. The average miles per gallon shown in the exhibit is calculated from the total fuel consumption and the total VMT, not the other way around,

Fuel Cost/Gallon. Linked to the Primary Inputs worksheet. Fuel costs vary by state, and vary with current diesel supply conditions.

Tires/Mile. The default is an industry norm, and the user should enter more precise data if available. Note that this value is for the tractor tires only, not the chassis tires. Drayage tractors incur higher tire costs than over-the-road tractors, about $.10 per mile. The drayage environment (rail ramps and city driving) is rough on tires, and leads to premature damage as well as rapid wear. Some contacts suggest that drayage tire wear resembles local pick up and delivery fleet experience.

Overhead Cost per Load. The default is an industry rule-of-thumb; the user should enter more precise local data if available. Drayage firms typically pay owner-operators 70 to 75 percent of the fixed rate on each move, with 70 percent being the norm. The remaining 25-30 percent covers overhead and operating margin, with the operating margin ranging from 5 to 7 percent. Note that overhead is only assessed against loaded moves.

The Total Cost Estimate below is calculated by the model. There are no user entries.

Exhibit 59: Total Drayage Cost Estimate

Total Costs		
Time-Based Costs	$	96,714,048
Mileage-Based Costs	$	38,209,177
Load-Based (Admin) Costs	$	24,528,571
Annual Drayage Cost	$	159,451,797
Average Cost per Load	$	163
Average Cost per TEU	$	80

Productivity and Capacity Analysis

The fleet requirement analysis below is straightforward and entails no user entries. The tractor hours per week, tractor days per week, and tractor availability are linked to the cost model discussed above. These three factors together yield the annual operating hours available from each tractor.

Exhibit 60: Productivity Analysis

Productivity	
Avg. Tractor Hours per day	12
Avg. Tractor days per week	5
Avg. Tractor Availability	1
Avg. Annual Hours per Tractor	2,964
Fleet Size Req. (FTE Tractors)	1,667

Dividing the total drayage hours by the hours available from a tractor engaged full-time in drayage yields the number of full-time-equivalent (FTE) tractors required. This result is displayed on the Primary Outputs worksheet.

The estimated number of FTE tractors required will be much less than the number of tractors actually engaged in port drayage. Many, perhaps most of the tractors providing port drayage are also engaged in rail intermodal drayage, contract carriage, and local trucking of various kinds. A recent analysis of the Southern California drayage fleet, for example, found that port container traffic at Los Angeles/Long Beach is drayed by a fleet of about 16,800 "high frequency" trucks and a pool of 24,200 "low frequency" units occasionally used in port drayage[6]. Even the "high frequency" tractors, however, are not all engaged full-time in port drayage. The same report estimates that about 7,000 tractors are engaged nearly full time in port drayage.

Note that the number of tractor hours per day and days per week determines the estimated number of full-time-equivalent (FTE) tractors required to complete all the modeled drayage tasks and trips. If desired, these numbers could be adjusted to reflect average hours per days and days per week spent in port drayage by a mixed-use fleet, thereby estimating the size of the mixed-use fleet required rather than the FTE tractors required.

Technology Upgrade Costs

This worksheet also includes cost estimates for the various emissions control and fuel conservation technologies discussed in an earlier section. For each technology option there is a capital cost, an annual maintenance cost, and an implementation percentage as applicable (Exhibit 61).

[6] *Economic Analysis* of the Proposed Clean Truck Program (CTP), Economics & Politics, Inc. and CGR Management Consultants, LLC., September 2007.

Exhibit 61: Technology Cost Inputs

Drayage Fleet Inuts	Capital Cost Default	Capital Cost Scenario	Annual Maintenance Default	Annual Maintenance Scenario	Implementation % Default	Implementation % Scenario
Technology Retrofits						
Particulate Filter/Trap	$ 7,000	$ 7,000	$ 100	$ 100	0%	0%
Oxidation Catalyst	$ 1,200	$ 1,200	$ -	$ -	0%	0%
Flow-Thorugh Filter	$ 5,500	$ 5,500	$ -	$ -	0%	0%
Idle Reduction						
Idle Control Strategy	$ -	$ -	$ -	$ -	0%	0%
Fuel Conservation						
Single Wide Wheels & Tires	$ 5,600	$ 5,600	$ -	$ -	0%	0%
Automatic Tire Inflation	$ 900	$ 900		$ -	0%	0%
Low Friction Engine Lubricant	$ -	$ -	$ 198	$ 198	0%	0%
Low Friction Drive Train Lubricant	$ -	$ -	$ 33	$ 33	0%	0%
Direct Drivetrain	$ -	$ -	$ -	$ -	0%	0%
Single Axle Drive (vs. Dual Axle)	$ -	$ -	$ -	$ -	0%	0%
Speed Management Policy (55mph)	$ -	$ -	$ -	$ -	0%	0%
Weight Reduction - Lbs	2,000	2,000	$ -	$ -	0%	0%
Average Upgrade Cost	$ -	$ -	$ -	$ -		

The tan-shaded cells provide options for user input. The implementation percentages are linked to the Drayage Fleet Inputs.

Activity Model Outputs

Primary Model Outputs

For convenience, the primary model outputs are on the same spreadsheet as the Primary Inputs. Once the model has been calibrated to the specifics of a port default case, the user can work with the Primary Inputs and Outputs spreadsheet to run scenarios.

The Primary Activity Outputs (Exhibit 62) summarize the high-level drayage activity indicators:

- Total number of trip legs
- Drayage trips legs per container
- Total drayage VMT
- Drayage VMT per container
- FTE tractor fleet required
- Hours by duty cycle or mode
- Total drayage hours
- Drayage hours per container

Exhibit 62: Primary Activity Outputs

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,498,452	3,498,452	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	0.0	0.0%
Total Drayage VMT	65,706,753	65,706,753	0	0.0%
Drayage VMT per Container	57.5	57.5	0.0	0.0%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	1,869,294	1,869,294	0	0.0%
Creep Hours	994,223	994,223	0	0.0%
Transient Hours	572,700	572,700	0	0.0%
Cruise Hours	1,506,026	1,506,026	0	0.0%
Total Drayage Hours	4,942,243	4,942,243	0	0.0%
Drayage Hours per Container	4.3	4.3	0.0	0.0%

The Primary Emissions Outputs (Exhibit 63) summarize the high-level emissions estimate: indicators:

- Hydrocarbons (HC)
- Carbon Monoxide (CO)
- Nitrogen Oxide (NOx)
- Diesel Particulate Matter (PM_{10} and $PM_{2.5}$)
- Carbon Dioxide (CO_2), estimated from fuel consumption

This output section also includes total fuel consumption and total cost.

Exhibit 63: Primary Emissions Outputs

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	53	53	0.00	0.0%
CO	298	298	0.00	0.0%
NOx	1,108	1,108	0.00	0.0%
PM_{10}	37	37	0.00	0.0%
$PM_{2.5}$	31	31	0.00	0.0%
CO_2	88,497	88,497	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	7,909,626	7,909,626	0.0	0.0%
Total Drayage Cost	$ 159,451,797	$ 159,451,797	$ -	0.0%
Drayage Cost per Container	$ 140	$ 140	$ -	0.0%

Activity Summary

The Activity Summary page assembles the results from the six activity tally sheets.

Exhibit 64: Activity Summary Page

SmartWay DrayFLEET Version 1.0 - Summary of Detailed Drayage Activity											
Activity Group	Number of Trips	Distance (Miles)	Idle (%)	Creep (%)	Transient (%)	Cruise (%)	Idle (hours)	Creep (hours)	Transient (hours)	Cruise (hours)	Total (hours)
Loaded Drayage											
Marine Terminal	981,143	970,866	64%	32%	4%	0%	525,415	266,830	31,855	-	824,100
Inter-Terminal	5,429	21,714	17%	7%	19%	58%	139	59	155	482	834
Off-Dock Rail Terminal	242,857	944,523	44%	13%	20%	22%	53,921	16,029	24,413	26,950	121,313
Container Depot	-	-	0%	0%	0%	0%	-	-	-	-	-
Shippers & Receivers	728,571	18,352,714	29%	10%	15%	46%	259,756	85,528	134,370	404,247	883,901
Crosstown Trips	-	-	20%	7%	18%	56%	33,297	11,534	30,529	94,966	170,326
Other Port Trucks	-	-	0%	0%	0%	0%	-	-	-	-	-
Net Subtotal*	**976,857**	**19,318,951**	**44%**	**19%**	**11%**	**26%**	**872,528**	**379,980**	**221,321**	**526,645**	**2,000,474**
Empty/Chassis/Bobtail Drayage											
Marine Terminal	1,606,696	13,065,180	42%	32%	8%	18%	596,481	463,908	111,802	263,368	1,435,559
Inter-Terminal	286	1,143	17%	7%	19%	58%	7	3	8	25	44
Off-Dock Rail Terminal	104,060	423,240	41%	13%	20%	27%	17,927	5,443	8,518	11,548	43,436
Container Depot	69,916	154,695	65%	18%	5%	11%	17,902	5,062	1,333	3,103	27,401
Shippers & Receivers	1,092,857	27,492,643	26%	10%	16%	48%	331,151	128,292	199,189	606,371	1,265,003
Crosstown Trips	427,889	4,280,035	20%	7%	18%	56%	33,297	11,534	30,529	94,966	170,326
Other Port Trucks	-	-	0%	0%	0%	0%	-	-	-	-	-
Net Subtotal*	**2,521,595**	**45,416,936**	**34%**	**21%**	**12%**	**33%**	**996,766**	**614,243**	**351,379**	**979,382**	**2,941,769**
Total Drayage											
Marine Terminal	2,587,839	14,036,046	50%	32%	6%	12%	1,121,896	730,738	143,657	263,368	2,259,659
Inter-Terminal	5,714	22,857	17%	7%	19%	58%	146	62	163	507	878
Off-Dock Rail Terminal	346,917	1,367,763	44%	13%	20%	23%	71,848	21,472	32,931	38,497	164,749
Container Depot	69,916	154,695	65%	18%	5%	11%	17,902	5,062	1,333	3,103	27,401
Shippers & Receivers	1,821,429	45,845,357	27%	10%	16%	47%	590,906	213,821	333,559	1,010,619	2,148,904
Crosstown Trips	427,889	4,280,035	20%	7%	18%	56%	66,595	23,069	61,058	189,931	340,653
Other Port Trucks	-	-	0%	0%	0%	0%	-	-	-	-	-
Net Total*	**3,498,452**	**65,706,753**	**38%**	**20%**	**12%**	**30%**	**1,869,294**	**994,223**	**572,700**	**1,506,026**	**4,942,243**

* Subtotals and Total are corrected to remove double-counting of marine terminal trips

The number of trips is summed, and inter-connected to remove double-counting. (Otherwise, for example, a marine terminal-to-rail trip would be counted on both ends.)

The duty cycle proportions – idle, creep, transition, and cruise – are recalculated for this spreadsheet.

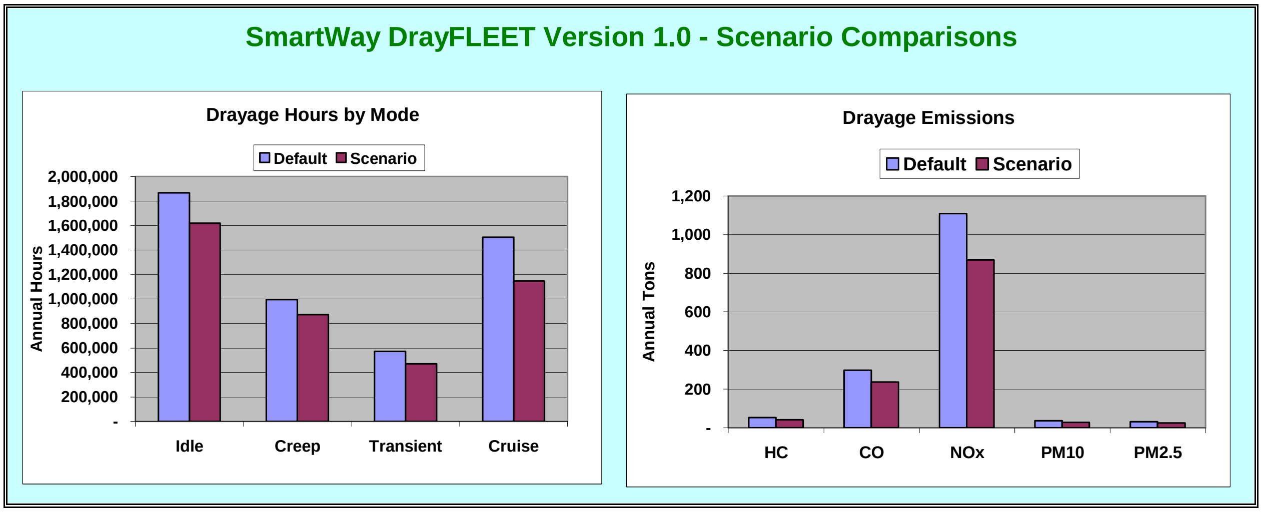
Printing out a copy of this spreadsheet for the default case and again for an analytic scenario can provide a useful basis for comparison.

Outputs are displayed separately for scenarios and defaults, and for loads versus empty/chassis/bobtail trips. The output matrix displays averages and other indicators of change (e.g. trips and VMT per TEU)

Scenario Comparisons Sheet

The Scenario Comparisons Sheet offers a different perspective on scenario/default comparisons (Exhibit 65). This worksheet displays two graphs comparing the most important model outputs: drayage hours by operating mode, and emissions (CO_2 is not shown since its scale is radically different). The example shows an instance which increased on-dock rail intermodal handling has reduced drayage hours and emissions.

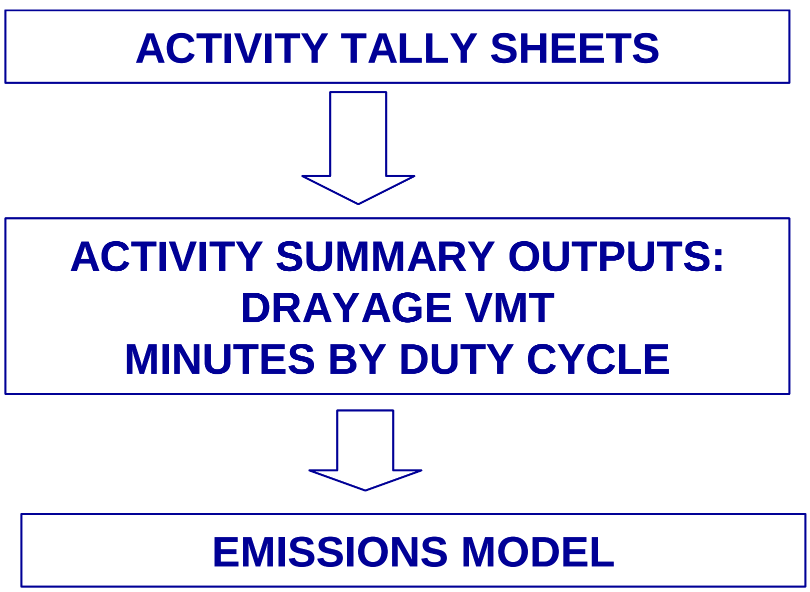
Exhibit 65: Scenario Comparisons



Scenario Activity Outputs

Scenario outputs become inputs to the emissions model (Exhibit 66) discussed in the next section.

Exhibit 66: Flow of Information to Emissions Model



DrayFLEET Emissions Estimates

Approach

This section discusses the emissions portion of the DrayFLEET model. After reviewing the basic approach employed by the model, this section delves into additional component details and specific emissions data.

In general, DrayFLEET calculates emissions by combining the amount of time that trucks spend within various modes of operation (idle, creep, transient, and cruise) with EPA emissions rate data specific to those operating modes for a given fleet age distribution. Loaded and empty emissions are calculated separately. The user needs only to select an analysis year and truck fleet age-distribution from drop down menus. The emission rate data is already part of the DrayFLEET model and the amount of time spent within each mode comes directly from the activity module.

EPA and the California Air Resources Board both maintain models to estimate emission rates for on-road vehicles. EPA developed MOBILE for application nationally; California's model, EMFAC, accounts for the unique engine and vehicle certification requirements that California has adopted. For heavy-duty trucks used in drayage (Class 8b trucks) both models are similar. This work centers on MOBILE6.2 because the DrayFLEET tool is not California-specific. The advantage of using the MOBILE6.2 emission rates is that it builds consistency with the existing SmartWay FLEET model. Varieties of other models are in the literature, or are under development, none of which would have been appropriate for use in this tool.

EPA, The California Air Resources Board, and the Coordinating Research Council (CRC) funded an extensive study of in-use emissions from heavy trucks using the West Virginia University portable laboratory system[7]. The CRC "E55/E59" data are by far the most robust data presently available, however, only the fuel economy data was used so as to maintain consistency with the MOBILE6.2 model and existing EPA guidance for calculating emissions..

Four operating modes are included in the DrayFLEET model: idle, creep, transient, and cruise. The activity portions of the model yield estimates of minutes spent by drayage tractors in each of these modes. A key issue in the project is how marine terminal management initiatives or other innovations can reduce total drayage emissions, including reductions in idling and creep as well as reductions in miles traveled. The emissions model should therefore be sensitive to changes in activity modes as well as total miles and minutes.

The emission factors and methodologies used must be consistent with MOBILE6.2. MOBILE6.2 calculates average in-use emission factors for hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), and particulate matter ($PM_{2.5}$ and PM_{10}) for heavy-duty vehicles. The MOBILE6.2 on-road emission factors are a function of fuel consumed at 20 or 40 miles per hour and are used in conjunction with estimates of vehicle miles traveled. This

[7] CRC, *"California Heavy-Heavy Duty Truck Emissions Characterization for Project E55/E59-1.5" Draft Final Report*. 2003, CRC: Alpharetta, GA.

approach works for the cruise mode, but does not capture the emission variations in creep or transition modes, or the emissions at idle when no miles are traveled.

The emissions portion of the model therefore requires a mode conversion factor to bridge the gap between the drayage activity model output and the emissions factors in MOBILE6.2. The idle, creep, and transient emissions rates will be the product of MOBILE6.2 emission rates at 20 mph (the default speed) and this mode conversion factor. Once the gram per hour emissions have been adjusted to reflect specific travel modes, the model will reflect the average speed from E55/E59 data from each mode (transition, creep, or idle). The cruise mode emission rates will be identical to the emission rates in the FLEET mode at 40 MPH, and will be taken directly from MOBILE6.2 output files.

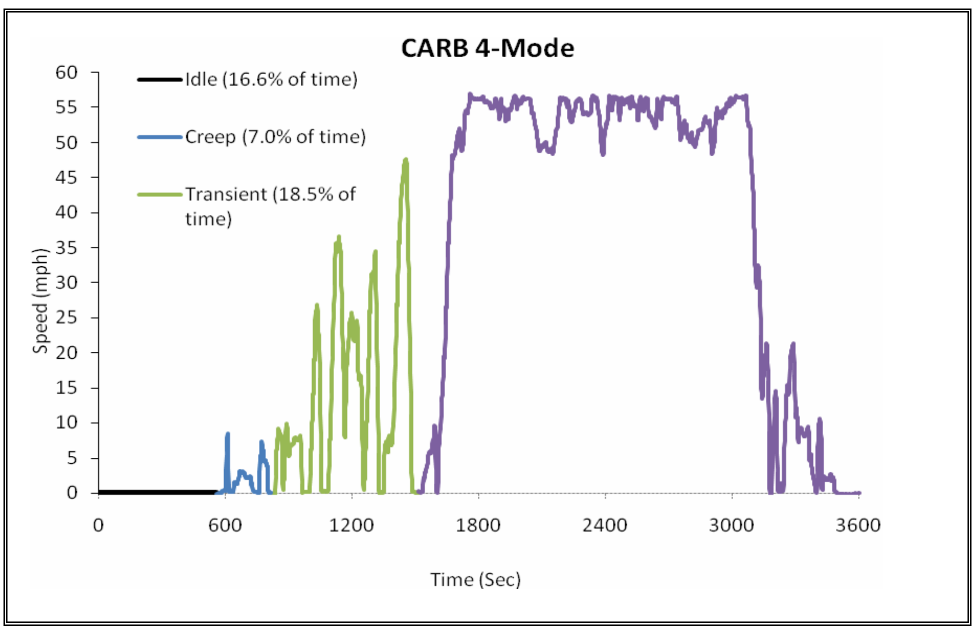
This overall process is explained step-by-step in the balance of this section.

Operating Modes

Operating mode is a categorical label used to associate dray truck activity to one of four profiles used in the DrayFLEET model emissions calculations. Operating modes are distinguished to reflect differing emissions rates under different circumstances, and to reflect the impact of marine terminal and port initiatives on the mix of idle, creep, transient, and cruise operations.

The operating modes in the DrayFLEET Model are based on the California Air Resources Board "4-mode" driving schedule[8] (Exhibit 67). Actual time spent in each mode is calculated by DrayFLEET for each terminal or port activity.

Exhibit 67: CARB 4-Mode Chassis Dynamometer Driving Schedule



[8] Gautam, et al., *Development and initial use of a heavy-duty diesel truck test schedule for emissions characterization.* SAE, 2002. **paper 2002-01-1753**.

The 4-mode schedule was designed to represent hundreds of hours of truck activity data observed during field studies[9,10]. Looking at the four modes strung together into one continuous driving cycle helps define the range and mix of overall trucking activity. Exhibit 68 shows the average speeds assigned to the four operating modes in the DrayFLEET model.

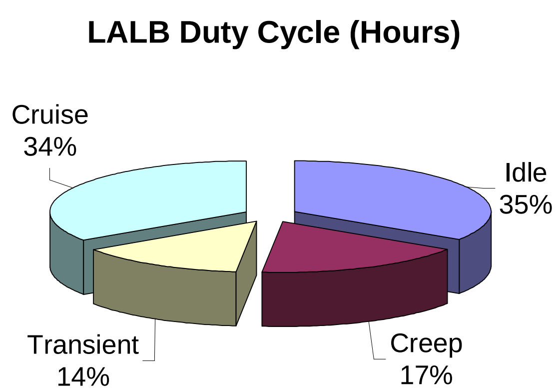
Exhibit 68: Average Speeds by Mode in DrayFLEET

Idle %	Creep %	Transient %	Cruise %
Average Speed (MPH)			
0	1.8	15.4	39.9

Idle. Idle (shown as the black line in the first 600 seconds of Exhibit 67) represents a parked truck with the engine running. The GPS instrumented truck data used to develop the four-mode schedule contained "idle trips" where the truck does not move after the engine starts. Idling for brief intervals (e.g., at traffic signals) is incorporated into the other modes, not the idle mode.

Idling emissions rates are very important in the model. As shown in Exhibit 69, idling accounts for about 35% of total drayage truck time in major ports such as Los Angeles/Long Beach. Many of the terminal management initiatives being considered have substantial impacts on the amount of idling. It is therefore critical that the model reflect idling emissions as accurately as possible.

Exhibit 69: Operating Mode Shares



Mobile 6.2 emissions factors are in grams per mile, and must be converted to grams per minute, as discussed in a following section, to be applied to idling.

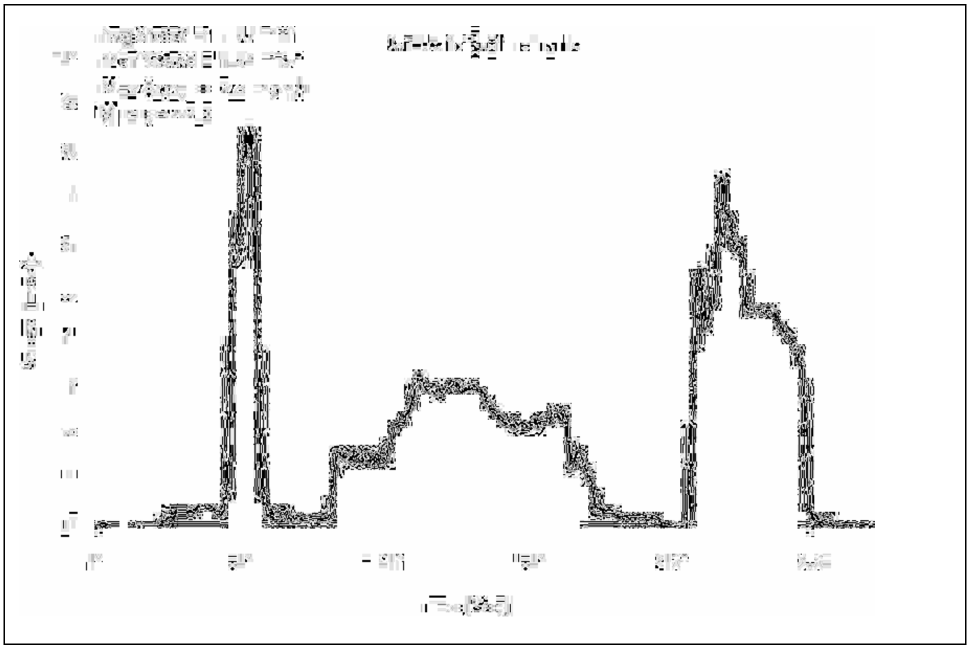
Creep. Creep (shown as the blue line from approximately second 600 to second 850 of Exhibit 67) is characteristic of how a truck might wait in queue at gates. As Exhibit 70 shows, the overall average speed of the creep mode is 1.77 mph, corresponding for example to 8.5 minutes spent moving in a quarter-mile queue. Note in Exhibit 70 that more than forty percent of creep

[9] JFA, *Heavy-Duty Truck Population, Activity and Usage Patterns*. 1998, Jack Faucett Associates http://www.arb.ca.gov/research/abstracts/93-306.htm.

[10] Battelle, *Heavy-Duty Truck Activity Data*. 1999: Battelle, 505 King Avenue, Columbus, Ohio 43201.

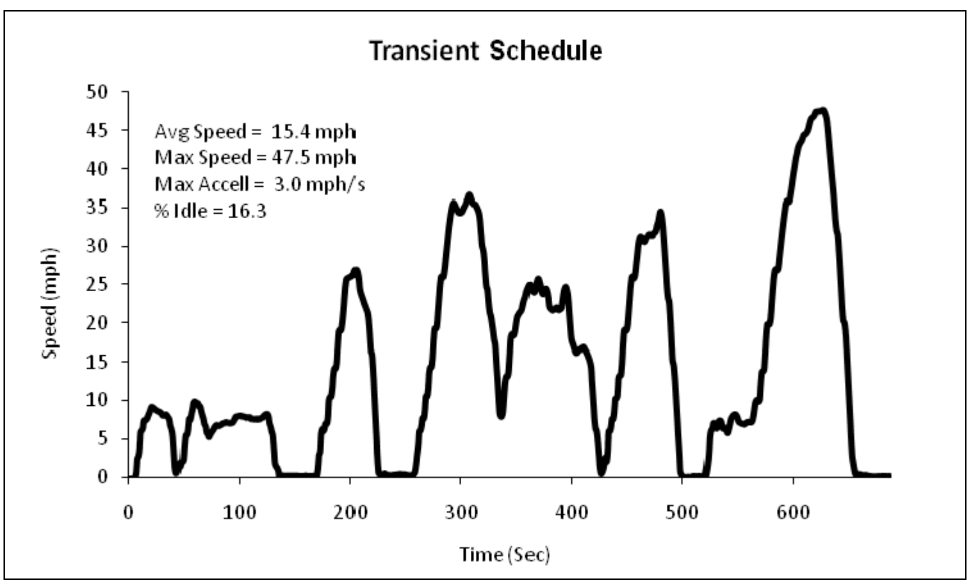
time is spent at idle, but in this case it is brief periods of idle between movements rather than a period of sustained, parked idling.

Exhibit 70: Creep Mode Detail



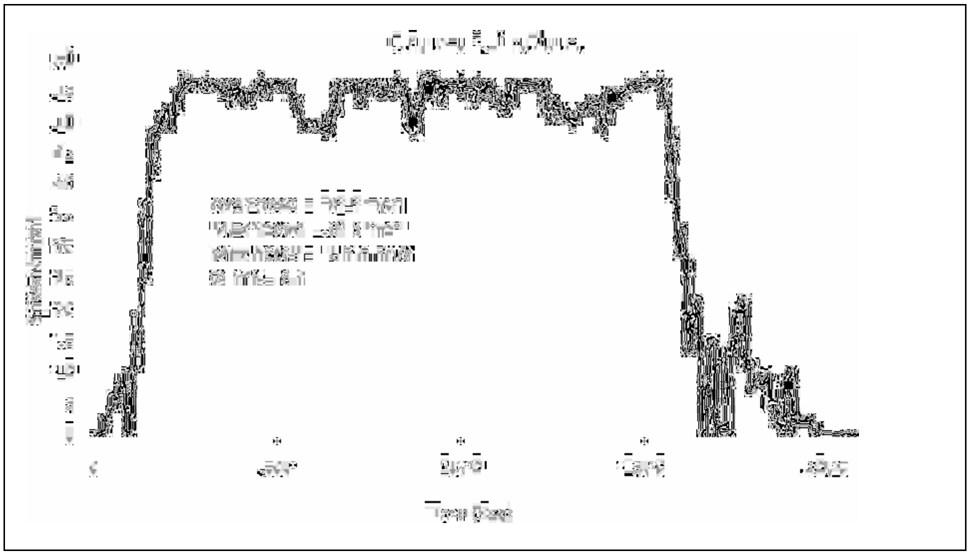
Transient. Transient (shown as the green line from approximately second 850 to second 1550 of Exhibit 67) represents truck activity on local streets, arterial roads, and highway access routes with peak speeds near 40 mph between stops at controlled intersections (Exhibit 71). Transient is also used to model movement around large terminals, as the average speed is 15.4 mph. Such speeds are consistent, for example, with observed movement times between marine and rail terminals (e.g. 15.6 minutes to travel about 4 miles over congested local streets). Over 16 percent of the transient cycle is spent idling, again in brief intervals

Exhibit 71: Transient Mode Detail



Cruise. Cruise (shown as the purple line from approximately second 850 to second 1550 of Exhibit 67) represents a highway trip with a small amount of stop and go activity at the beginning and end of the trip. The average cruise speed is 39.9 mph, and the DrayFLEET model emission calculations rely on the 40 mph emission rates from MOBILE6.2 to represent this activity.

Exhibit 72: Cruise Mode Detail



The four modes each represent typical trips, or portions thereof, not individual streets or a single queue. It is therefore necessary to look at blocks of activity and associate them with some combination of the operating modes. All of the modes contain some idle time.

Model Use of Operating Modes

The DrayFLEET activity model, described in detail in the previous chapter, allocated all drayage activities to one or more of the four operating modes. The table below gives some general examples.

Exhibit 73: Examples of Mode Use in DrayFLEET

Activity	Mode
Over-the-road Operations	Four-mode cycle
Queuing	Creep mode
Loading/unloading	Idle mode
Terminal movements	Transient
Port-area arterial movements	Transient Mode
Gate Transactions	Idle mode
Trouble Window Transactions	Idle mode

As the table suggests, many of the most important and most variable drayage activities consist of idling, making accurate emissions rates for idling of central importance in the emissions estimates. Actual time spent in these different modes is calculated by DrayFLEET.

Mode Correction Factors (MCF)

To estimate emissions across these operating modes, the DrayFLEET model requires Mode Specific Emissions factors (MSEs) in grams per hour corresponding to each combination of drayage tractor model year, age (based on calendar year), and operating mode (idle, creep, transient, cruise). Those MSEs are obtained by adjusting the emissions rates in MOBILE6.2.

MOBILE6.2 emission rates for class 8b diesel trucks underpin the DrayFLEET emission factor calculations and are embedded in the worksheets. The cruise mode uses the MOBILE6.2 emission factors at 40 mph. Adjustments account for how emissions change between the other three operating modes – idle, creep, and transient – and are explained below.

Definition of Mode Correction Factor. The DrayFLEET Model calculates mode correction factors to adjust MOBILE6.2 base speed output in grams per mile to reflect each of the four modes in grams per hour. MOBILE6.2 is intended to estimate emissions from a broad range of over-the-road trucking operations. MOBILE6.2 calculates emissions as a function of fuel consumption, expressed in grams per mile, at 20 mph or 40 mph speeds.

The Mode Correction Factor (MCF) uses the ratio of the mode specific fuel economy data from CRC (the E55/E59 data set) to the default fuel economy in MOBILE6.2. The MCF is defined in Exhibit 74. The MOBILE6.2 emissions factors are in grams/mile, so the MCF has to be in units of miles/hour to convert the MOBILE6.2 factors to grams/hour.

Exhibit 74: Mode Correction Factor for MOBILE6.2 Fuel Economy

$$MCF = 20^* (FE_{CRC} / FE_{6.2})$$

Where,

MCF = mode correction factor (with units of miles/hour),

FE_{CRC} = mode specific fuel economy from CRC chassis dynamometer testing (gallons/hour),

$FE_{6.2}$= model year specific fuel economy from MOBILE6.2 (gallons/hour at 20 mph),

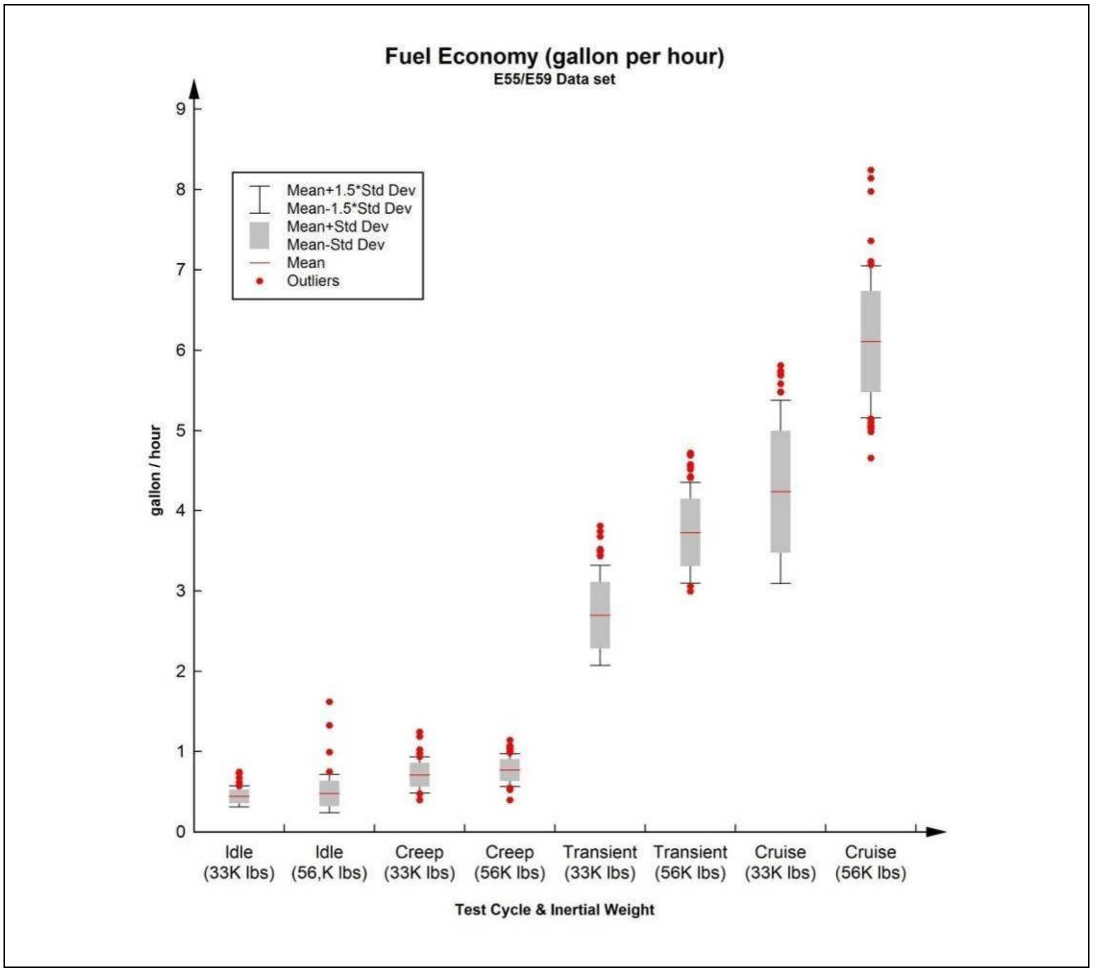
20 = MOBILE6.2 default speed in units of miles/hour

By using the ratio of the two different fuel economy factors, the MCF preserves MOBILE6.2's linkage between fuel use and emissions but allows different fuel consumption rates and emissions rates for each operating mode. The ratio is multiplied by the 20 mph base speed to reflect the magnitude change from grams per mile to grams per hour (during which the tractor would have traveled 20 miles). For example, a MOBILE6.2 HC emissions factor of 3.105 grams per mile would become 62.10 grams per hour at 20 mph.

Fuel Economy Data. Fuel economy data for use in the mode correction factor are based on the values assigned by EPA in MOBILE6.2 calculations, and the observed fuel economy from the four-mode test data collected during the Coordinating Research Council E55/E59 study.

Mode specific fuel economy was estimated using results from the CRC E55/E59 data set provided by EPA. Model year was not a statistically significant parameter[11] so the analysis only considered mode and the inertial weight (the simulated vehicle weight during the chassis dynamometer tests). The distribution of the observed fuel economy data is shown in (Exhibit 75). The variability by mode is evident, and the impact of inertial weight on the results of the transient test is significant.

Exhibit 75: Fuel Economy from the E55/E59 Data Set



The mean values shown in Exhibit 76, as a function of mode and weight, are used to calculate the mode correction factors.

[11] Review of the data suggests that variability between trucks of the same model year obscured any statistically significant model year trend.

Exhibit 76: Mode Specific Fuel Consumption

	Fuel Economy (gallons/hour)			
	Idle	Creep	Transient	Cruise
Empty Container, Bobtail, Bare Chassis (33,000 lbs. inertial weight)	0.44	0.72	2.69	4.38
Loaded Container (56,000 lbs. inertial weight)	0.44	0.77	3.73	6.15

The drayage activity model will yield estimates of miles traveled and minutes by mode (idle, creep, transition, cruise) for tractors pulling loaded containers, for bobtails (tractors without chassis), for tractors pulling empty chassis, and for tractors pulling empty containers on chassis. The mode specific fuel economy uses data from two inertial weight settings on the chassis dynamometer.

The "empty" units correspond roughly to the 30,000 lb and 33,000 lb data shown in the charts.

- A drayage tractor by itself (bobtail) weighs anywhere from 15,000 lb to 22,000 lb, with 18,000 lb a typical value. A full tank of fuel (up to 250 gallons) adds 2,000 lb, for a 20,000 lb typical total with fuel.
- An empty container chassis weighs anywhere from 6,200 lb to 8,400 lb, with around 6,800 lb being typical. A typical tractor with fuel pulling a typical empty chassis would weigh about 26,800 lb.
- An empty marine container chassis weighs anywhere from 5,400 lb to 7,500 lb, with about 7,000 lb being typical for the most common 40' steel units. A typical tractor/chassis/empty container combination would therefore weigh about 33,800 lb with fuel.

A tractor pulling a loaded container on chassis corresponds roughly to the observations at 56,000 lb and 66,000 lb weights in the charts that follow. The load in the container can raise the total weight as high as the legal limit of 80,000 lb (higher in some states or where the legal limit is exceeded) but most loads are much lighter.

Use of Mode Correction Factors. Use of the Mode Correction Factor is shown in Exhibit 77.

Exhibit 77: Use of Mode Correction Factor

MSE=MBL6.2 *MCF

Where:

MSE = mode specific emissions (grams/hour), for use in DrayFLEET

MBL6.2 = MOBILE6.2 emission factor (grams/mile at 20 mph),

MCF = mode correction factor (with units of miles/hour)

Individual MCFs and MSEs are calculated for each combination of:

- mode (idle, creep, transient – cruise uses 40 mph MOBILE6.2 factors)
- tractor model year
- tractor age (calendar year – model year)
- loaded versus empty

The need to have a separate MSE for each combination results in a very large number of emissions factors embedded in the DrayFLEET model. As an example of this complexity, Exhibit 78 displays one of 40 emissions factor tables in the DrayFLEET model.

Exhibit 78: Creep mode, loaded $PM_{2.5}$ emissions by calendar and model year (gram/ hour)

Model Year	Calandar Year																	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2010																		0.164
2009																	0.162	0.162
2008																0.160	0.160	0.160
2007															0.158	0.158	0.158	0.158
2006														1.310	1.118	1.118	1.118	1.118
2005													1.293	1.293	1.104	1.104	1.104	1.104
2004												1.276	1.276	1.276	1.090	1.090	1.090	1.090
2003											1.260	1.260	1.260	1.260	1.075	1.075	1.075	1.075
2002										1.243	1.243	1.243	1.243	1.243	1.061	1.061	1.061	1.061
2001									1.226	1.226	1.226	1.226	1.226	1.226	1.047	1.047	1.047	1.047
2000								1.210	1.210	1.210	1.210	1.210	1.210	1.210	1.032	1.032	1.032	1.032
1999							1.193	1.193	1.193	1.193	1.193	1.193	1.193	1.193	1.018	1.018	1.018	1.018
1998						1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.004	1.004	1.004	1.004
1997					1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160	0.990	0.990	0.990	0.990
1996				1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	0.976	0.976	0.976	0.976
1995			1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	0.969	0.969	0.969	0.969
1994		1.129	1.129	1.129	1.129	1.129	1.129	1.129	1.129	1.129	1.129	1.129	1.129	1.129	0.961	0.961	0.961	0.961
1993	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.647	2.647	2.647	2.647
1992	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.797	2.630	2.630	2.630	2.630
1991	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.613	2.613	2.613	2.613
1990	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.937	4.770	4.770	4.770	4.770
1989	6.768	6.875	6.972	7.060	7.139	7.211	7.277	7.335	7.390	7.438	7.482	7.522	7.558	7.591	7.453	7.481	7.505	7.527
1988	6.834	6.929	7.017	7.096	7.168	7.232	7.291	7.345	7.393	7.437	7.476	7.513	7.545	7.575	7.434	7.458	7.480	7.500
1987	8.165	8.165	8.165	8.165	8.165	8.165	8.165	8.165	8.165	8.165	8.165	8.165	8.165	8.165	7.998	7.998	7.998	7.998
1986	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.732	7.564	7.564	7.564	7.564
1985	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.638	7.471	7.471	7.471	
1984	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.535	7.368	7.368		
1983	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.442	7.274			
1982	7.339	7.339	7.339	7.339	7.339	7.339	7.339	7.339	7.339	7.339	7.339	7.339	7.339	7.339				
1981	7.515	7.515	7.515	7.515	7.515	7.515	7.515	7.515	7.515	7.515	7.515	7.515	7.515					
1980	7.388	7.388	7.388	7.388	7.388	7.388	7.388	7.388	7.388	7.388	7.388	7.388						
1979	7.232	7.232	7.232	7.232	7.232	7.232	7.232	7.232	7.232	7.232	7.232							
1978	7.216	7.216	7.216	7.216	7.216	7.216	7.216	7.216	7.216	7.216								
1977	7.183	7.183	7.183	7.183	7.183	7.183	7.183	7.183	7.183									
1976	6.897	6.897	6.897	6.897	6.897	6.897	6.897	6.897										
1975	6.772	6.772	6.772	6.772	6.772	6.772	6.772											
1974	6.649	6.649	6.649	6.649	6.649	6.649												
1973	6.414	6.414	6.414	6.414	6.414													
1972	6.294	6.294	6.294	6.294														
1971	6.174	6.174	6.174															
1970	5.926	5.926																
1969	5.810																	

Truck Fleet Age Distribution

As noted above, DrayFLEET emissions factors vary by tractor model year and age. As Exhibit 79 illustrates, the model incorporates a fleet age distribution and a designated calendar year for this purpose.

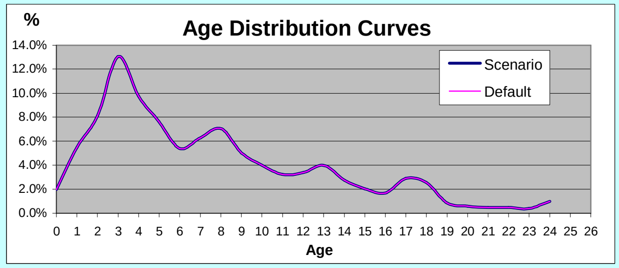
Exhibit 79: Drayage Fleet Inputs

SmartWay DrayFLEET Version 1.0 - Drayage Fleet Inputs

Values on this worksheet are not affected by reset macros

Fleet Age Distribution

Scenario	Same as Default		Default	US VIUS Default	
Age	#	%	Age	#	%
0	26	2.0%	0	26	2%
1	72	5.5%	1	72	5%
2	107	8.1%	2	107	8%
3	172	13.0%	3	172	13%
4	129	9.7%	4	129	10%
5	100	7.6%	5	100	8%
6	71	5.4%	6	71	5%
7	83	6.3%	7	83	6%
8	93	7.0%	8	93	7%
9	66	5.0%	9	66	5%
10	53	4.0%	10	53	4%
11	43	3.2%	11	43	3%
12	45	3.4%	12	45	3%
13	53	4.0%	13	53	4%
14	36	2.8%	14	36	3%
15	27	2.0%	15	27	2%
16	22	1.7%	16	22	2%
17	38	2.9%	17	38	3%
18	34	2.6%	18	34	3%
19	11	0.9%	19	11	1%
20	8	0.6%	20	8	1%
21	6	0.5%	21	6	0%
22	6	0.5%	22	6	0%
23	5	0.4%	23	5	0%
24	13	1.0%	24	13	1%
Total	1,320	100%	Total	1,320	100%



Drayage Fleet Technology Inputs

Technology Retrofits		
☐ Particulate Filter/Trap	% of eligible fleet retrofit	50%
☐ Oxidation Catalyst	% of eligible fleet retrofit	50%
☐ Flow-Through Filter	% of eligible fleet retrofit	50%
Idle Reduction		
☐ Idling Control Strategies	% reduction in idle	50%
Fuel Conservation		
☐ Single-Wide Tires	% of fleet	50%
☐ Automatic Tire Inflation	% of fleet	50%
☐ Tare Weight Reduction	% of fleet	50%
	lbs of weight saved	2,000
☐ Low Friction Engine Lubricant	% of fleet	50%
☐ Low Friction Drive Train Lubricant	% of fleet	50%
☐ Direct Drivetrain	% of fleet	50%
☐ Single Axle Drive (vs. Dual Axle)	% of fleet	50%
☐ Speed Management Policy (55 mph)	% of fleet	50%

The model incorporates a default age distribution based on Vehicle Inventory and Use (VIUS) data (taken from the MOBILE6.2 default HDV8b age distribution), a U.S. VIUS distribution for tractors and single trailers, and survey-based fleet distributions for the Port of Houston and one for the combined Ports of Los Angeles and Long Beach. The model also allows the user to develop a custom age distribution or to cerate a new scenario based on one of the default choices.

As shown in Exhibit 80 through Exhibit 83, the VIUS age distributions result in a significantly newer fleet than the two survey databases. The VIUS data are not specific to port drayage, and as a result would be expected to reflect the composition of the longer-haul, over-the-road fleet rather than the local drayage fleet shown in the port surveys.

Exhibit 80: MOBILE6.2 8b Age Distribution

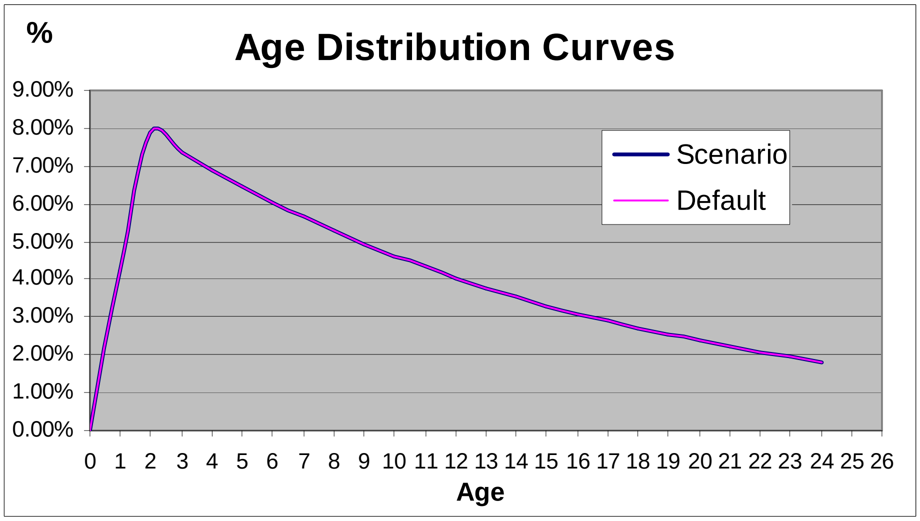


Exhibit 81: U.S. VIUS Tractor-Trailer Age Distribution

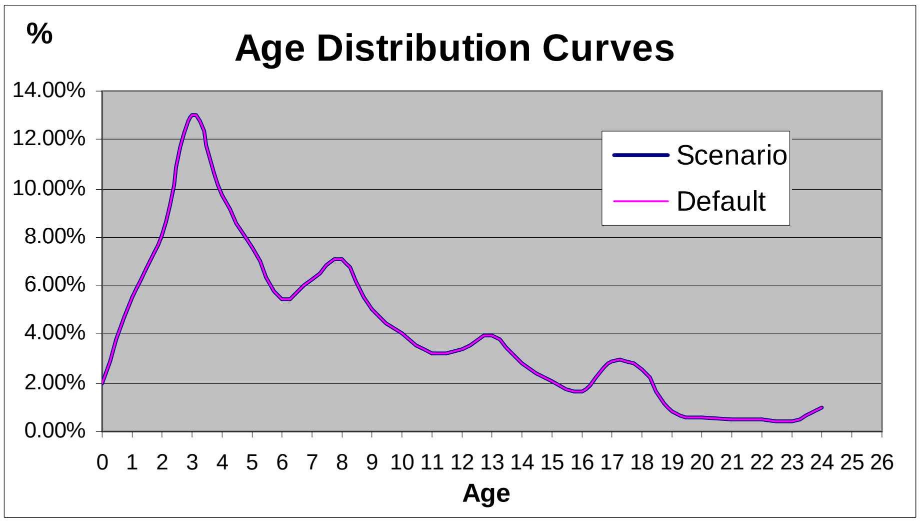


Exhibit 82: LALB Survey Age Distribution

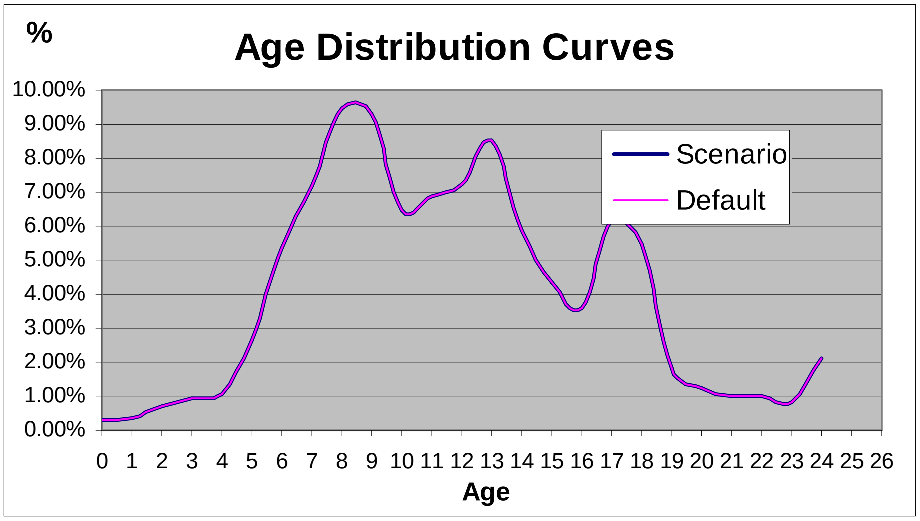


Exhibit 83: Houston Survey Age Distribution

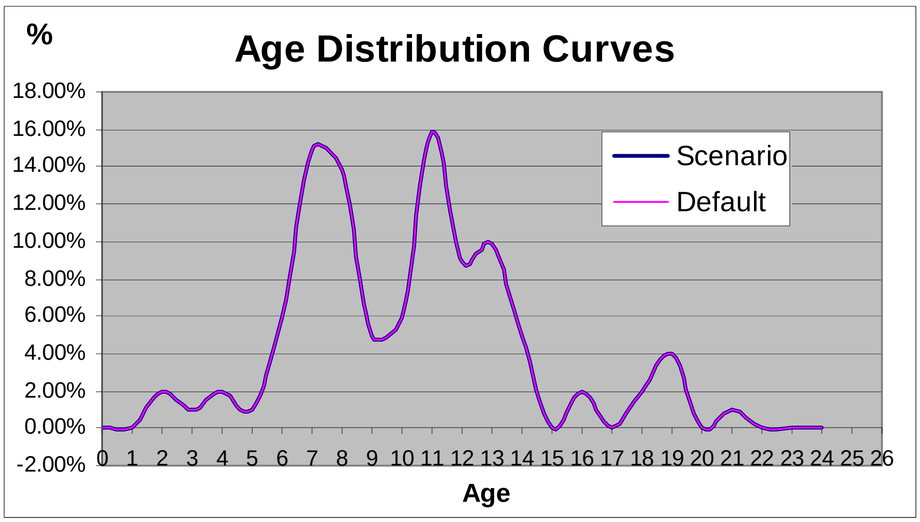


Exhibit 84 illustrates the importance of the age distribution. Changing the generic DrayFLEET model from U.S. VIUS age distribution (Exhibit 81) to the LALB survey age distribution (Exhibit 82) results in noticeable emissions and fuel use increases.

Exhibit 84: Sample Impact of Fleet Age Distribution

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	53	67	14.37	27.2%
CO	298	392	94.50	31.8%
NOx	1,108	1,561	453.24	40.9%
PM_{10}	37	53	15.99	43.8%
$PM_{2.5}$	31	46	14.75	47.8%
CO_2	88,497	91,648	3,151	3.6%
Fuel Use and Total Cost				
Fuel - Gallons	7,909,626	8,191,285	281,660.0	3.6%
Total Drayage Cost	$ 159,451,797	$ 160,578,436	$ 1,126,640	0.7%
Drayage Cost per Container	$ 140	$ 141	$ 1	0.7%

Initiative and Technology Impacts

Approach

Modeling the emissions impacts of port and terminal management initiatives such as neutral chassis pools and automated gates was a major reason for developing DrayFLEET. DrayFLEET is likewise intended to estimate the impacts of truck and engine technology such as diesel particulate filters or idling controls.

As noted earlier, DrayFLEET is a planning-level model, not an emissions inventory tool. With this goal in mind, the development team devoted considerable effort to including a wide range of port initiatives and technology options, and to insuring that the model results represented the magnitude and direction of activity and emissions impacts. Because port and terminal circumstances vary widely, modeling precision may require users to carefully compare model variable values with their own port data, and particularize the model whenever possible.

A previous section described the various initiative and technology inputs and how they are implemented in the model. This section uses the generic DrayFLEET model to illustrate the relative impact of the various options separately and in combination, and the importance of placing the impacts in context. In general:

- The examples in this section indicate that changing all (or most) of the initiative inputs together makes a substantially greater difference than treating them individually – as expected. On-dock rail makes much more difference than the others.

- The scope of the analysis makes a major difference. When the scope is restricted to the vicinity of the Port (as it would be in an emissions inventory), the same management initiatives have a much greater percentage impact.

- Port drayage activity and emissions can be dominated by long trips to and from regional customers. In those cases, the marine terminal impact is overshadowed by the much larger, unchanged activity of serving customers. In a port with shorter trips, the marine terminal and its efficiency account for a much larger share of the total activity and emissions.

- Ports and marine terminals have undertaken most of the initiatives being modeled as a means of reducing cost and congestion, or increasing throughput. The emissions benefits are not the primary motivation, although they help justify the effort.

- Truck and engine technology impacts vary with the application and context. Idle reduction, for example, is more important in the vicinity of the port while particulate filters provide benefits across all movement types and modes.

Port and Terminal Initiative Impacts

Combined Impacts and Model Scope

Exhibit 85 shows the impact of maximizing all the initiative options in the generic DrayFLEET model (e.g. setting all initiative options to 100%, except for extended gate hours, whose use is maximized at 50%).

Exhibit 85: Generic Port – Maximum Initiatives

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0E of 06/26/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,000,000	2,000,000
Average TEU per Container	1.75	1.75
Inbound Share	50%	50%
Inbound Empty Share	5%	5%
Outbound Empty Share	25%	25%
Rail Intermodal Share	25%	25%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	10%	10%
Container Shippers/Receivers		
Weighted Average Miles from Port	25	25
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	100%
On-Dock Rail (% of rail on-dock)	0%	100%
Automated Gates (% of gate transactions)	0%	100%
Extended Gate Hours (% off-peak, 50% max)	0%	50%
Container Info System (% used)	0%	100%
Virtual Container Yard (% available)	0%	100%
Neutral Chassis Pool (% used)	0%	100%

Port	Generic
Terminal(s)	All
Scenario	Maximum Initiative Implementation
Date	6/26/2008

Activity Outputs	Scenario	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,235,095	-591,140	-15.4%
Drayage Trip Legs per Container	3.3	2.8	-0.5	-15.4%
Total Drayage VMT	68,413,994	62,751,559	-5,662,435	-8.3%
Drayage VMT per Container	59.9	54.9	-5.0	-8.3%
Fleet Required (FTE Tractors)	1,756	1,410	-345	-19.7%
Annual Duty Cycle Totals				
Idle Hours	1,957,060	1,609,021	-348,040	-17.8%
Creep Hours	1,089,182	611,289	-477,894	-43.9%
Transient Hours	597,318	514,343	-82,975	-13.9%
Cruise Hours	1,559,766	1,445,224	-114,542	-7.3%
Total Drayage Hours	5,203,327	4,179,877	-1,023,450	-19.7%
Drayage Hours per Container	4.6	3.7	-0.9	-19.7%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	55	48	-7.30	-13.2%
CO	311	269	-42.08	-13.5%
NOx	1,154	1,020	-134.31	-11.6%
PM_{10}	38	34	-4.29	-11.3%
$PM_{2.5}$	32	29	-3.62	-11.3%
CO_2	145,037	128,437	-16,600	-11.4%
Fuel Use and Total Cost				
Fuel - Gallons	12,963,067	11,479,410	-1,483,656.4	-11.4%
Total Drayage Cost	$ 185,045,398	$ 152,445,354	$ (32,600,044)	-17.6%
Drayage Cost per Container	$ 162	$ 133	$ (29)	-17.6%

As the outputs show:

- The number of drayage trip legs are reduced by 15.4% while drayage VMT is reduced by 8.3%. The difference is because the port-area initiatives affect shorter trips while the longer shipper/receiver trips are affected less. On-dock rail, in particular, eliminates the five-mile trips to the off-dock rail terminal.

- Total drayage hours decline by 19.7%, an average reduction of about 0.9 hours per container. The largest reduction is in the creep mode, due to reduced queuing time at the marine terminals. Cruise hours, which are largely accounted for by shipper/receiver trips, decline only 7.3%.

- Emissions decline by a minimum of 11.3% for $PM_{2.5}$ and PM_{10}, to a maximum of 13.5% (for CO).

- Total fuel use declines by 11.4%, and drayage cost declines by 17.6%. The larger reduction in overall cost is because drayage cost is predominately a function of time, rather than distance.

While reductions of 8.3% in VMT, 11.3–13.5% in emissions, and 17.6% in cost are sizable, especially for a large port with millions of annual drayage trips, these percentage improvements are not dramatic.

The percentage impact of these or any emissions or activity changes depends on the context. Emissions inventories typically define a target area in the near vicinity of the port, consistent with the limited ability of the port or the terminal operators to affect drayage activities outside the port area. DrayFLEET, on the other hand, captures the full range and impact of port-related drayage activity at any distance. To do so DrayFLEET uses weighted average distances to off-dock rail terminals, container depots, and – most critically – shippers and receivers. Rail terminals and container depots are typically within a few miles of the port, but shippers and receivers can be spread out over a broad region.

A major limitation on the percentage impact of marine terminal efficiency or emissions measures is the share of all drayage activity associated with the marine terminals to begin with. Exhibit 86, extracted from the generic model activity summary, highlights the trips, miles, and hours in the various major activity categories. The marine terminal accounts for about 76% of the trips, but only 25% of the miles and 49% of the hours. Shipper/receiver movements account for 41% of the trips, but 67% of the miles and 41% of the hours.

Exhibit 86: Marine Terminal vs. Shipper/Receiver Activity

Activity Group	Number of Trips	Distance (Miles)	Total (hours)
Marine Terminal	2,917,414	17,012,538	2,533,308
Inter-Terminal	5,714	22,857	878
Off-Dock Rail Terminal	346,909	1,367,673	164,735
Container Depot	69,917	154,697	27,401
Shippers & Receivers	1,811,250	45,589,163	2,136,895
Crosstown Trips	426,588	4,267,065	340,110
Other Port Trucks	-	-	-
Net Total*	**3,826,235**	**68,413,994**	**5,203,327**

** Subtotals and Total are corrected to remove double-counting of marine terminal trips*

The miles and hours generated by drayage trips to and from distant customers can thus outweigh and obscure the impacts of port-area changes.

Exhibit 87 provides an example of this relationship. In Exhibit 87, the 25-mile default value for the weighted average trip to shippers and receivers was changed to five miles. That change reduced drayage VMT by 52.9%, drayage hours by 26.7%, emissions and fuel use by about 45%, and cost by 29.3%.

Exhibit 87: Five-Mile Scenario versus 25-Mile Default

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0E of 06/26/2008

Port	Generic
Terminal(s)	All
Scenario	Five-mile versus 25-mile Limits
Date	6/26/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,000,000	2,000,000
Average TEU per Container	1.75	1.75
Inbound Share	50%	50%
Inbound Empty Share	5%	5%
Outbound Empty Share	25%	25%
Rail Intermodal Share	25%	25%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	10%	10%
Container Shippers/Receivers		
Weighted Average Miles from Port	25	5
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	0%	0%
Automated Gates (% of gate transactions)	0%	0%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	0%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	68,413,994	32,188,994	-36,225,000	-52.9%
Drayage VMT per Container	59.9	28.2	-31.7	-52.9%
Fleet Required (FTE Tractors)	1,756	1,286	-469	-26.7%
Annual Duty Cycle Totals				
Idle Hours	1,957,060	1,725,478	-231,582	-11.8%
Creep Hours	1,089,182	991,532	-97,651	-9.0%
Transient Hours	597,318	339,489	-257,828	-43.2%
Cruise Hours	1,559,766	755,790	-803,977	-51.5%
Total Drayage Hours	5,203,327	3,812,289	-1,391,038	-26.7%
Drayage Hours per Container	4.6	3.3	-1.2	-26.7%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	55	32	-23.34	-42.3%
CO	311	181	-130.12	-41.9%
NOx	1,154	637	-517.58	-44.8%
PM_{10}	38	21	-17.27	-45.4%
$PM_{2.5}$	32	18	-14.60	-45.4%
CO_2	145,037	79,582	-65,455	-45.1%
Fuel Use and Total Cost				
Fuel - Gallons	12,963,067	7,112,838	-5,850,228.3	-45.1%
Total Drayage Cost	$ 185,045,398	$ 130,800,961	$ (54,244,438)	-29.3%
Drayage Cost per Container	$ 162	$ 114	$ (47)	-29.3%

In other words, the additional 20 miles (one way) to shippers and receivers accounted for over half the drayage miles, 26.7% of the hours, 45% of the emissions and fuel, and 29.3% of the cost.

Exhibit 88 compares the drayage hours by category for a 25-mile scope and a 5-mile scope. Besides the overall reduction in total and average hours, the proportions of idle, creep, transient, and cruise hours shift noticeably. With a 25-mile scope, 30% of the hours are spent in the cruise mode. Activity within 5 miles of the port, however, is dominated by idling at 45% of the total hours.

Exhibit 88: Scope Comparison

Category	Default - 25 Mile Trips		Port Vicinity - 5 Mile Trips	
Idle Hours	1,957,060	38%	1,725,478	45%
Creep Hours	1,089,182	21%	991,532	26%
Transient Hours	597,318	11%	339,489	9%
Cruise Hours	1,559,766	30%	755,790	20%
Total Drayage Hours	**5,203,327**	**100%**	**3,812,289**	**100%**
Drayage Hours per Container	**4.6**		**3.3**	

To illustrate the more dramatic impact of port and terminal initiatives within the port area, Exhibit 89 repeats the example of maximizing the initiative inputs, but with a five-mile analysis scope.

Exhibit 89: Initiative Impacts - Five-Mile Scope

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0E of 06/26/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,000,000	2,000,000
Average TEU per Container	1.75	1.75
Inbound Share	50%	50%
Inbound Empty Share	5%	5%
Outbound Empty Share	25%	25%
Rail Intermodal Share	25%	25%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	10%	10%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	100%
On-Dock Rail (% of rail on-dock)	0%	100%
Automated Gates (% of gate transactions)	0%	100%
Extended Gate Hours (% off-peak, 50% max)	0%	50%
Container Info System (% used)	0%	100%
Virtual Container Yard (% available)	0%	100%
Neutral Chassis Pool (% used)	0%	100%

Port	Generic
Terminal(s)	All
Scenario	Initiative Impacts
	Five-Mile Scope
Date	6/26/2008

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,235,095	-591,140	-15.4%
Drayage Trip Legs per Container	3.3	2.8	-0.5	-15.4%
Total Drayage VMT	32,188,994	26,730,130	-5,458,864	-17.0%
Drayage VMT per Container	28.2	23.4	-4.8	-17.0%
Fleet Required (FTE Tractors)	1,286	944	-343	-26.6%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,378,740	-346,738	-20.1%
Creep Hours	991,532	514,187	-477,345	-48.1%
Transient Hours	339,489	257,964	-81,526	-24.0%
Cruise Hours	755,790	645,766	-110,024	-14.6%
Total Drayage Hours	3,812,289	2,796,656	-1,015,633	-26.6%
Drayage Hours per Container	3.3	2.4	-0.9	-26.6%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	25	-7.17	-22.5%
CO	181	139	-41.37	-22.9%
NOx	637	505	-131.46	-20.6%
PM_{10}	21	17	-4.19	-20.2%
$PM_{2.5}$	18	14	-3.53	-20.2%
CO_2	79,582	63,343	-16,239	-20.4%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	5,661,443	-1,451,395.6	-20.4%
Total Drayage Cost	$ 130,800,961	$ 98,503,289	$ (32,297,672)	-24.7%
Drayage Cost per Container	$ 114	$ 86	$ (28)	-24.7%

A close comparison of Exhibit 89 with Exhibit 85 indicates that the absolute magnitude of the activity, emissions, and cost changes are nearly identical[12]. The percentage impacts, however, are markedly larger. Exhibit 90 compares the initiative impact percentages between the two scopes. The drayage trip count has been reduced by the same percentage in both cases, but the percentage impacts on VMT, hours, emissions, fuel use, and cost are much more apparent in the 5-mile scope.

Exhibit 90: Scope and Impact Comparison

Reductions in...	25-mile Scope	5-mile Scope
Drayage Trips	15.4%	15.4%
Drayage VMT	8.3%	17.0%
Drayage Hours	19.7%	26.6%
Emissions		
HC	13.2%	22.5%
CO	13.5%	22.9%
NOx	11.6%	20.6%
PM_{10}	11.3%	20.2%
$PM_{2.5}$	11.3%	20.2%
CO_2	11.4%	20.4%
Fuel Use	11.4%	20.4%
Cost	17.6%	24.7%

[12] The virtual container yard options accounts for much of the small difference, as that option reduces the m number of empty container trips to and from shippers and receivers. Shortening that distance therefore reduces the impact of the virtual container yard.

Given the far greater port and terminal influence over port-area activities and the growing community concerns over drayage activity and emissions in the immediate vicinity of the ports, the remainder of this section uses the five-mile analysis scope to illustrate the impacts of individual and combined initiatives.

On-Dock Rail

Exhibit 91 illustrates the importance of on-dock rail. Since on-dock rail eliminates drayage trips rather than shortening them, it has the greatest impact on activity and emissions. The on-dock rail change accounted for 15.9% out of the 26.6% total time savings for all initiatives in the five-mile scope. The importance of on-dock rail increases with the percentage of overall port volume that is moved by rail, and with the distance to off-dock rail yards.

Exhibit 91: Five-Mile Scope, On-Dock Rail Impact

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,254,116	-572,118	-15.0%
Drayage Trip Legs per Container	3.3	2.8	-0.5	-15.0%
Total Drayage VMT	32,188,994	27,701,585	-4,487,408	-13.9%
Drayage VMT per Container	28.2	24.2	-3.9	-13.9%
Fleet Required (FTE Tractors)	1,286	1,082	-204	-15.9%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,451,509	-273,968	-15.9%
Creep Hours	991,532	833,196	-158,336	-16.0%
Transient Hours	339,489	274,045	-65,444	-19.3%
Cruise Hours	755,790	649,029	-106,761	-14.1%
Total Drayage Hours	3,812,289	3,207,780	-604,509	-15.9%
Drayage Hours per Container	3.3	2.8	-0.5	-15.9%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	32	27	-5.07	-15.9%
CO	181	152	-28.94	-16.0%
NOx	637	538	-98.72	-15.5%
PM_{10}	21	18	-3.20	-15.4%
$PM_{2.5}$	18	15	-2.70	-15.4%
CO_2	79,582	67,288	-12,294	-15.4%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	6,014,057	-1,098,780.9	-15.4%
Total Drayage Cost	$ 130,800,961	$ 108,056,113	$ (22,744,848)	-17.4%
Drayage Cost per Container	$ 114	$ 95	$ (20)	-17.4%

Stacked Terminals and Neutral Chassis Pools

The impacts of stacked terminals (as opposed to terminals where containers are parked on chassis) and neutral chassis pools are linked.

Changing to a stacked terminal without implementing a neutral chassis pool would be expected to increase total drayage activity, emissions, and cost by a small margin, as shown in Exhibit 92. In a stacked terminal a drayage driver must first locate a usable bare chassis then wait until the container can be transferred. As Exhibit 92 suggests, this would result in slightly fewer VMT driving around the container yard, but more idling hours locating a chassis and waiting for a transfer. This result is consistent with the observation that the shift from a parked (wheeled) terminal to a stacked terminal is motivated primarily by the need to increase throughput, not by the potential benefit to drayage operations. Foreign container terminals are almost invariably stacked due to both a shortage of land and the practice of using trucker-supplied, customer-supplied, or pooled chassis rather than steamship line chassis fleets.

Exhibit 92: Impacts of Stacked Terminal (No Neutral Chassis Pool)

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	32,188,994	31,930,762	-258,232	-0.8%
Drayage VMT per Container	28.2	27.9	-0.2	-0.8%
Fleet Required (FTE Tractors)	1,286	1,358	71	5.6%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,949,077	223,600	13.0%
Creep Hours	991,532	996,978	5,446	0.5%
Transient Hours	339,489	322,085	-17,405	-5.1%
Cruise Hours	755,790	755,790	0	0.0%
Total Drayage Hours	3,812,289	4,023,930	211,641	5.6%
Drayage Hours per Container	3.3	3.5	0.2	5.6%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	32	32	0.16	0.5%
CO	181	182	0.96	0.5%
NOx	637	639	2.47	0.4%
PM_{10}	21	21	0.07	0.4%
$PM_{2.5}$	18	18	0.06	0.4%
CO_2	79,582	79,878	296	0.4%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,139,303	26,464.4	0.4%
Total Drayage Cost	$ 130,800,961	$ 135,022,565	$ 4,221,604	3.2%
Drayage Cost per Container	$ 114	$ 118	$ 4	3.2%

The impact of a neutral chassis pool by itself is slightly positive, as shown in Exhibit 93. In a parked chassis system a neutral chassis pool reduces the need for time-consuming chassis flips (when a container must be shifted from the wrong chassis to the right one) and equipment repair delays (due to the better condition of the chassis supply).

Exhibit 93: Impact of Neutral Chassis Pool

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	32,188,994	32,172,932	-16,061	0.0%
Drayage VMT per Container	28.2	28.2	0.0	0.0%
Fleet Required (FTE Tractors)	1,286	1,261	-25	-1.9%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,657,643	-67,835	-3.9%
Creep Hours	991,532	985,834	-5,698	-0.6%
Transient Hours	339,489	339,113	-377	-0.1%
Cruise Hours	755,790	755,790	0	0.0%
Total Drayage Hours	3,812,289	3,738,379	-73,910	-1.9%
Drayage Hours per Container	3.3	3.3	-0.1	-1.9%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	32	32	-0.21	-0.7%
CO	181	179	-1.27	-0.7%
NOx	637	634	-3.27	-0.5%
PM_{10}	21	21	-0.10	-0.5%
$PM_{2.5}$	18	17	-0.08	-0.5%
CO_2	79,582	79,189	-393	-0.5%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,077,739	-35,099.6	-0.5%
Total Drayage Cost	$ 130,800,961	$ 129,212,622	$ (1,588,338)	-1.2%
Drayage Cost per Container	$ 114	$ 113	$ (1)	-1.2%

In combination, a neutral chassis pool turns the stacked terminal from a slight negative (in terms of activity and emissions) to a slight positive (Exhibit 94). The additional idling hours still result in a slightly higher overall cost. Because stacked terminals result in more idling time for drayage tractors, idle control strategies (see below) can yield additional benefits.

Exhibit 94: Combined Stacked Terminal and Neutral Chassis Pool

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	32,188,994	31,914,739	-274,255	-0.9%
Drayage VMT per Container	28.2	27.9	-0.2	-0.9%
Fleet Required (FTE Tractors)	1,286	1,304	18	1.4%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,799,159	73,681	4.3%
Creep Hours	991,532	988,870	-2,662	-0.3%
Transient Hours	339,489	321,992	-17,498	-5.2%
Cruise Hours	755,790	755,790	0	0.0%
Total Drayage Hours	3,812,289	3,865,811	53,522	1.4%
Drayage Hours per Container	3.3	3.4	0.0	1.4%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	32	32	-0.28	-0.9%
CO	181	179	-1.66	-0.9%
NOx	637	633	-4.27	-0.7%
PM_{10}	21	21	-0.13	-0.6%
$PM_{2.5}$	18	17	-0.11	-0.6%
CO_2	79,582	79,070	-512	-0.6%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,067,058	-45,780.0	-0.6%
Total Drayage Cost	$ 130,800,961	$ 131,637,775	$ 836,814	0.6%
Drayage Cost per Container	$ 114	$ 115	$ 1	0.6%

Automated Gates and Extended Gate Hours

Automating terminal gates can include one or more of the following initiatives:

- RFID or card swipe systems for driver and company identification.
- Optical Character Recognition (OCR) or video camera systems for identifying containers and chassis.
- Multi-step gate systems to separate routine, well-documented transactions from "trouble window" transactions.

In each case, the objective is to reduce the time required for the average gate transaction. The model reflects both the shorter time at the gate and the shorter queue time because the gate queue moves faster. As Exhibit 95 indicates, the effects in the port area can be substantial. While gates are automated primarily to increase gate and terminal throughput, automated gates can noticeably reduce the creep time in terminal queues, an estimated 36.6% in Exhibit 95. The estimated savings is about 0.4 hours (24 minutes) per container, which yields a 4-6% reduction in emissions and a 7.7% reduction in cost.

Exhibit 95: Impact of Automated Gates

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	32,188,994	31,531,826	-657,167	-2.0%
Drayage VMT per Container	28.2	27.6	-0.6	-2.0%
Fleet Required (FTE Tractors)	1,286	1,135	-151	-11.7%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,643,339	-82,139	-4.8%
Creep Hours	991,532	626,439	-365,093	-36.8%
Transient Hours	339,489	339,489	0	0.0%
Cruise Hours	755,790	755,790	0	0.0%
Total Drayage Hours	3,812,289	3,365,057	-447,232	-11.7%
Drayage Hours per Container	3.3	2.9	-0.4	-11.7%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	30	-1.87	-5.9%
CO	181	170	-11.10	-6.1%
NOx	637	608	-28.55	-4.5%
PM_{10}	21	20	-0.86	-4.1%
$PM_{2.5}$	18	17	-0.72	-4.1%
CO_2	79,582	76,153	-3,429	-4.3%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	6,806,364	-306,473.9	-4.3%
Total Drayage Cost	$ 130,800,961	$ 120,757,526	$ (10,043,434)	-7.7%
Drayage Cost per Container	$ 114	$ 106	$ (9)	-7.7%

Extended gate hours are also implemented to increase gate and terminal throughput, in this case by reducing congestion and gate queues in daylight hours. The model limits the impact of extended gate hours to 50% of the containers. Otherwise there would be more business in off-peak hours and an incentive for truckers to shift back to the day shift. The model implements extended gate hours by shortening terminal gate queue times and distances. As shown in Exhibit 96, the model impacts are very similar to those of automated gates. Both options reduce time in the queues, but automated gates also reduce time at the gates themselves.

Exhibit 96: Impact of Extended Gate Hours

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	32,188,994	31,531,826	-657,167	-2.0%
Drayage VMT per Container	28.2	27.6	-0.6	-2.0%
Fleet Required (FTE Tractors)	1,286	1,163	-123	-9.6%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,725,478	0	0.0%
Creep Hours	991,532	626,439	-365,093	-36.8%
Transient Hours	339,489	339,489	0	0.0%
Cruise Hours	755,790	755,790	0	0.0%
Total Drayage Hours	3,812,289	3,447,196	-365,093	-9.6%
Drayage Hours per Container	3.3	3.0	-0.3	-9.6%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	30	-1.65	-5.2%
CO	181	171	-9.79	-5.4%
NOx	637	612	-25.19	-4.0%
PM_{10}	21	20	-0.76	-3.7%
$PM_{2.5}$	18	17	-0.64	-3.6%
CO_2	79,582	76,557	-3,025	-3.8%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	6,842,506	-270,332.6	-3.8%
Total Drayage Cost	$ 130,800,961	$ 122,509,462	$ (8,291,498)	-6.3%
Drayage Cost per Container	$ 114	$ 107	$ (7)	-6.3%

Container Information and Appointment Systems

Container information systems are a means of reducing gate or terminal congestion, avoiding unproductive drayage trips, and reducing the number of “trouble window” transactions due to poor documentation or other problems. Container information or appointment systems such as VoyagerTrack or eModal provide drayage firms with accurate container status information, reducing the likelihood of driving to the terminal and finding a container with a Customs hold or other procedural delay. The model implements this option by reducing the frequency of “trouble window” visits. As shown in Exhibit 97, the emissions impacts are not dramatic in the generic model. These impacts could be much larger at port or terminals with higher initial frequencies of problem transactions.

Exhibit 97: Impacts of Container Information System

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	32,188,994	32,177,361	-11,633	0.0%
Drayage VMT per Container	28.2	28.2	0.0	0.0%
Fleet Required (FTE Tractors)	1,286	1,265	-21	-1.7%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,668,299	-57,179	-3.3%
Creep Hours	991,532	985,069	-6,463	-0.7%
Transient Hours	339,489	339,489	0	0.0%
Cruise Hours	755,790	755,790	0	0.0%
Total Drayage Hours	3,812,289	3,748,647	-63,642	-1.7%
Drayage Hours per Container	3.3	3.3	-0.1	-1.7%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	32	32	-0.18	-0.6%
CO	181	180	-1.08	-0.6%
NOx	637	634	-2.79	-0.4%
PM_{10}	21	21	-0.08	-0.4%
$PM_{2.5}$	18	17	-0.07	-0.4%
CO_2	79,582	79,247	-335	-0.4%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,082,883	-29,955.7	-0.4%
Total Drayage Cost	$ 130,800,961	$ 129,434,575	$ (1,366,386)	-1.0%
Drayage Cost per Container	$ 114	$ 113	$ (1)	-1.0%

Virtual Container Yard

A virtual container yard (VCY) is designed to increase the frequency with which empty import containers are reused for export loads, thereby reducing the need to dray empty import containers back to the port and empty export containers out to customers.

As there is almost no practical experience with VCYs their potential impacts are necessarily somewhat speculative. Full implementation of the VCY option doubles the model's rate of reuse, in line with the limited number of studies on the subject.

The benefits of a VCY as illustrated in DrayFLEET depend on several factors.

- **The pre-VCY frequency of reuse.** The DrayFLEET default rate of reuse is 1%, which the VCY option doubles to 2%. While very modest, such a small rate of reuse is typical of many ports. If this number is higher to start with, the VCY will have a greater impact.

- **Distance to shippers and receivers.** Since the VCY option reduces the numbers of trips necessary to reposition empty containers, its impact will be greater where the distances are longer.

- **Crosstown drayage distance.** Reusing an empty container requires a "crosstown" dray from the importer who emptied the container to the exporter who will fill it. These trips offset the reductions in trips to the port, and the longer they are the greater the offset.

Exhibit 98 shows an example of minimal VCY impact. With the five-mile analysis scope, a 10-mile crosstown trip, and the default 1% pre-VCY reuse frequency the VCY would reduce activity measures by about 0.6%, emissions by 0.5%, and cost by 0.5%.

Exhibit 98: VCY Impacts - Minimal

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,807,213	-19,022	-0.5%
Drayage Trip Legs per Container	3.3	3.3	0.0	-0.5%
Total Drayage VMT	32,188,994	31,998,487	-190,506	-0.6%
Drayage VMT per Container	28.2	28.0	-0.2	-0.6%
Fleet Required (FTE Tractors)	1,286	1,278	-8	-0.6%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	1,715,088	-10,390	-0.6%
Creep Hours	991,532	983,203	-8,328	-0.8%
Transient Hours	339,489	337,805	-1,684	-0.5%
Cruise Hours	755,790	752,526	-3,263	-0.4%
Total Drayage Hours	3,812,289	3,788,623	-23,666	-0.6%
Drayage Hours per Container	3.3	3.3	0.0	-0.6%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	32	32	-0.16	-0.5%
CO	181	180	-0.93	-0.5%
NOx	637	634	-3.13	-0.5%
PM_{10}	21	21	-0.10	-0.5%
$PM_{2.5}$	18	17	-0.09	-0.5%
CO_2	79,582	79,192	-389	-0.5%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,078,045	-34,793.1	-0.5%
Total Drayage Cost	$ 130,800,961	$ 130,179,624	$ (621,336)	-0.5%
Drayage Cost per Container	$ 114	$ 114	$ (1)	-0.5%

Exhibit 99 shows a more moderate example, with the generic 25-mile analysis scope and a 10% pre-VCY container reuse rate. In this more encouraging case, drayage activity measures are reduced by 9–11%, emissions by 9.8–10.0%, and overall cost by 9.4%.

Exhibit 99: VCY Impacts - Moderate

Activity Outputs	Scenario	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,464,822	-361,413	-9.4%
Drayage Trip Legs per Container	3.3	3.0	-0.3	-9.4%
Total Drayage VMT	68,413,994	60,931,932	-7,482,062	-10.9%
Drayage VMT per Container	59.9	53.3	-6.5	-10.9%
Fleet Required (FTE Tractors)	1,756	1,555	-201	-11.4%
Annual Duty Cycle Totals				
Idle Hours	1,957,060	1,734,922	-222,138	-11.4%
Creep Hours	1,089,182	923,527	-165,656	-15.2%
Transient Hours	597,318	537,791	-59,527	-10.0%
Cruise Hours	1,559,766	1,411,920	-147,846	-9.5%
Total Drayage Hours	5,203,327	4,608,160	-595,167	-11.4%
Drayage Hours per Container	4.6	4.0	-0.5	-11.4%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	55	50	-5.49	-10.0%
CO	311	280	-31.02	-10.0%
NOx	1,154	1,041	-113.43	-9.8%
PM_{10}	38	34	-3.73	-9.8%
$PM_{2.5}$	32	29	-3.15	-9.8%
CO_2	145,037	130,808	-14,229	-9.8%
Fuel Use and Total Cost				
Fuel - Gallons	12,963,067	11,691,312	-1,271,754.4	-9.8%
Total Drayage Cost	$ 185,045,398	$ 167,563,445	$ (17,481,953)	-9.4%
Drayage Cost per Container	$ 162	$ 147	$ (15)	-9.4%

Technology Impacts

The EPA SmartWay program offers freight carriers technical and financial information on a range of truck and engine technologies and practices designed to conserve fuel and reduce emissions. Many of the applicable options have been built into DrayFLEET, as shown in Exhibit 100. These measures have different impacts on drayage emissions and fuel use, as illustrated in the examples that follow. Because these technologies reduce emissions across all operating modes (idle, creep, transient, and cruise), the percentage reductions are largely independent of model scope.

Exhibit 100: DrayFLEET Technology and Strategy Options

Technology Retrofits		
☐ Particulate Filter/Trap	% of eligible fleet retrofit	50%
☐ Oxidation Catalyst	% of eligible fleet retrofit	50%
☐ Flow-Through Filter	% of eligible fleet retrofit	50%
Idle Reduction		
☐ Idling Control Strategies	% reduction in idle	50%
Fuel Conservation		
☐ Single-Wide Tires	% of fleet	50%
☐ Automatic Tire Inflation	% of fleet	50%
☐ Tare Weight Reduction	% of fleet	50%
	lbs of weight saved	2,000
☐ Low Friction Engine Lubricant	% of fleet	50%
☐ Low Friction Drive Train Lubricant	% of fleet	50%
☐ Direct Drivetrain	% of fleet	50%
☐ Single Axle Drive (vs. Dual Axle)	% of fleet	50%
☐ Speed Management Policy (55 mph)	% of fleet	50%

Exhibit 101 shows the model cost impacts of the various technology and strategy options. These factors are based on EPA and industry information as of late 2007 and early 2008, and will likely shift with time.

Exhibit 101: Technology Cost Factors

Drayage Fleet Inuts	Capital Cost		Annual Maintenance	
	Default	Scenario	Default	Scenario
Technology Retrofits				
Particulate Filter/Trap	$ 7,000	$ 7,000	$ 100	$ 100
Oxidation Catalyst	$ 1,200	$ 1,200	$ -	$ -
Flow-Thorugh Filter	$ 5,500	$ 5,500	$ -	$ -
Idle Reduction				
Idle Control Strategy	$ -	$ -	$ -	$ -
Fuel Conservation				
Single Wide Wheels & Tires	$ 5,600	$ 5,600	$ -	$ -
Automatic Tire Inflation	$ 900	$ 900		$ -
Low Friction Engine Lubricant	$ -	$ -	$ 198	$ 198
Low Friction Drive Train Lubricant	$ -	$ -	$ 33	$ 33
Direct Drivetrain	$ -	$ -	$ -	$ -
Single Axle Drive (vs. Dual Axle)	$ -	$ -	$ -	$ -
Speed Management Policy (55mph)	$ -	$ -	$ -	$ -
Weight Reduction - Lbs	2,000	2,000	$ -	$ -
Average Upgrade Cost	$ -	$ 600	$ -	$ -

Technology Retrofits

Particulate filters, oxidation catalysts, and flow-through filters all reduce hydrocarbons (HC), carbon monoxide (CO), and particulate matter ($PM_{2.5}$ and PM_{10}), but have no direct impact on NOx.

Exhibit 102 shows the emissions and fuel use impacts of a 50% application rate for particulate filters, using the five-mile port-area model scope as described above.

Exhibit 102: Emissions Impacts of Particulate Filters - Five-Mile Scope

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	20	-11.79	-37.1%
CO	181	116	-65.19	-36.1%
NOx	637	638	1.18	0.2%
PM_{10}	21	13	-7.69	-37.0%
$PM_{2.5}$	18	11	-6.58	-37.5%
CO_2	79,582	79,980	398	0.5%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,148,403	35,564.2	0.5%
Total Drayage Cost	$ 130,800,961	$ 131,852,413	$ 1,051,452	0.8%
Drayage Cost per Container	$ 114	$ 115	$ 1	0.8%

The particulate filters reduce HC, CO, and PM emissions by 36-37%. The model recognizes the slight increase in fuel consumption experienced with DPFs – 0.5% in the example. This additional fuel consumption leads to slight increases in NOx and CO_2 emissions. The additional cost reflects the cost of the additional fuel, the DPF capital costs, and the DPF maintenance costs.

Exhibit 103 shows comparable results for a 50% application rate of oxidation catalysts.

Exhibit 103: Emissions Impacts of Oxidation Catalysts - Five-Mile Model Scope

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	27	-5.26	-16.5%
CO	181	166	-14.55	-8.1%
NOx	637	637	0.00	0.0%
PM_{10}	21	19	-1.71	-8.3%
$PM_{2.5}$	18	16	-1.47	-8.4%
CO_2	79,582	79,582	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,112,838	0.0	0.0%
Total Drayage Cost	$ 130,800,961	$ 130,945,798	$ 144,838	0.1%
Drayage Cost per Container	$ 114	$ 115	$ 0	0.1%

The oxidation catalysts reduce HC by 16.5%, CO by 8.1%, and PM by 8.3-8.4%. Oxidation catalysts do not measurably affect fuel consumption, so the small increase in cost is due to their capital cost.

Exhibit 104 shows the impact of a 50% application rate for flow-through filters. The flow-through filters reduce emissions by more than the oxidation catalysts but less than the DPFs. There is a 0.5% cost increase due to the capital expense of installation.

Exhibit 104: Emissions Impacts of Flow-Through Filters - Five-Mile Scope

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	23	-9.21	-29.0%
CO	181	130	-50.93	-28.2%
NOx	637	637	0.00	0.0%
PM_{10}	21	16	-4.28	-20.6%
$PM_{2.5}$	18	14	-3.66	-20.9%
CO_2	79,582	79,582	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	7,112,838	0.0	0.0%
Total Drayage Cost	$ 130,800,961	$ 131,464,799	$ 663,839	0.5%
Drayage Cost per Container	$ 114	$ 115	$ 1	0.5%

Idling Control Strategies

Idling control strategies have particular importance in port drayage because such a large portion of the total activity cycle is spent idling. As Exhibit 88 shows, idling accounts for 38% of the drayage hours in the generic model with a 25-mile scope and 45% of the hours with a five-mile scope. Exhibit 105 shows the emissions impacts of a 50% reduction in idling for the five-mile model scope.

Exhibit 105: Emissions Impacts of Idling Control Strategies

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	29	-2.32	-7.3%
CO	181	167	-13.74	-7.6%
NOx	637	601	-35.37	-5.6%
PM_{10}	21	20	-1.07	-5.1%
$PM_{2.5}$	18	17	-0.90	-5.1%
CO_2	79,582	73,211	-6,371	-8.0%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	6,543,431	-569,407.7	-8.0%
Total Drayage Cost	$ 130,800,961	$ 128,523,330	$ (2,277,631)	-1.7%
Drayage Cost per Container	$ 114	$ 112	$ (2)	-1.7%

Cutting engine idling time in half can, by the model's estimate, reduce emissions by 5.1% to 7.6%, reduce fuel use and CO_2 by 8.0%, and reduce cost by 1.7%. If the idling reduction is accomplished through driver training, there is no capital cost.

As shown in Exhibit 106, stacked terminals combined with neutral chassis pools can reduce emissions by 0.6% to 0.9%, with the neutral chassis pool offsetting some of the additional idling form the stacked terminal. By simultaneously introducing a 50% reduction in engine idling via control strategies, the emissions benefits can be increased almost ten-fold, and the cost increases reversed.

Exhibit 106: Idling Control in Combination with Stacked Terminal and Neutral Chassis Pools

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	3,826,235	3,826,235	0	0.0%
Drayage Trip Legs per Container	3.3	3.3	0.0	0.0%
Total Drayage VMT	32,188,994	31,914,739	-274,255	-0.9%
Drayage VMT per Container	28.2	27.9	-0.2	-0.9%
Fleet Required (FTE Tractors)	1,286	1,304	18	1.4%
Annual Duty Cycle Totals				
Idle Hours	1,725,478	899,580	-825,898	-47.9%
Creep Hours	991,532	988,870	-2,662	-0.3%
Transient Hours	339,489	321,992	-17,498	-5.2%
Cruise Hours	755,790	755,790	0	0.0%
Total Drayage Hours	3,812,289	2,966,231	-846,058	-22.2%
Drayage Hours per Container	3.3	2.6	-0.7	-22.2%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	32	29	-2.70	-8.5%
CO	181	165	-15.99	-8.8%
NOx	637	596	-41.14	-6.5%
PM_{10}	21	20	-1.24	-6.0%
$PM_{2.5}$	18	16	-1.04	-6.0%
CO_2	79,582	72,427	-7,155	-9.0%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	6,473,336	-639,502.5	-9.0%
Total Drayage Cost	$ 130,800,961	$ 129,262,885	$ (1,538,076)	-1.2%
Drayage Cost per Container	$ 114	$ 113	$ (1)	-1.2%

Fuel Conservation Strategies

The other options shown in Exhibit 100 are fuel conservation options. These options reduce fuel consumption and therefore reduce emissions as a function of fuel use. Individually their impacts are fairly small, particularly in the close vicinity of the port where operating speeds are slow and much of the time is spent idling. A speed management strategy aimed at enforcing a 55 mph limit, for example, has no impact when speeds are under 40 mph in an urban setting.

As Exhibit 107 suggests, in combination (at 50% implementation rates) these options can reduce fuel use in the five-mile model scope by 10.5%, and cost by 1.6% (the fuel cost savings being offset by capital and maintenance cost increases).

Exhibit 107: Fuel Conservation Impact - Five-Mile Scope

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	32	31	-0.93	-2.9%
CO	181	175	-5.49	-3.0%
NOx	637	623	-14.13	-2.2%
PM_{10}	21	20	-0.43	-2.1%
$PM_{2.5}$	18	17	-0.36	-2.0%
CO_2	79,582	71,197	-8,385	-10.5%
Fuel Use and Total Cost				
Fuel - Gallons	7,112,838	6,363,424	-749,414.7	-10.5%
Total Drayage Cost	$ 130,800,961	$ 128,736,394	$ (2,064,566)	-1.6%
Drayage Cost per Container	$ 114	$ 113	$ (2)	-1.6%

The benefits are somewhat higher in the 25-mile model scope, as shown in Exhibit 108

Exhibit 108: Fuel Conservation Impacts - 25-mile Scope

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	55	54	-1.28	-2.3%
CO	311	303	-7.61	-2.4%
NOx	1,154	1,135	-19.58	-1.7%
PM_{10}	38	37	-0.59	-1.6%
$PM_{2.5}$	32	32	-0.50	-1.5%
CO_2	145,037	128,884	-16,153	-11.1%
Fuel Use and Total Cost				
Fuel - Gallons	12,963,067	11,519,324	-1,443,742.3	-11.1%
Total Drayage Cost	$ 185,045,398	$ 180,543,991	$ (4,501,408)	-2.4%
Drayage Cost per Container	$ 162	$ 158	$ (4)	-2.4%

Data and Sources

The primary sources for activity model input data are the port authority, the marine terminals, and the other activity centers (off-dock rail terminals, container depots, and shipper/receiver facilities).

Port Data

Port authorities ordinarily track the inbound (import) and outbound (export) volumes of loaded and empty containers. These data are almost always kept in TEU (Twenty-foot Equivalent Units), but may also be available in containers. The way in which data are kept is often determined by the terms of the contractual agreements between the port authority, the marine container terminals, and the container shipping lines. Where wharfage, dockage, and other fees are based on TEU, the data will be kept accordingly. If the fees are based on container counts or vary by container size (20' versus 40' or 45'), data will usually be maintained accordingly. Data on empty container flows may not be as readily available and sometimes may not be as accurate.

If actual container counts are not available special care must be taken with the container-per-TEU conversion factor. In Southern California with a preponderance of 40' containers and a significant flow of 45' containers, the conversion factor is about 1.85 TEU per container. In the Gulf trades or others with a greater proportion of 20' containers the conversion factor is closer to 1.5 TEU per container. Attempts to convert metric tons to TEU on containers are unlikely to be reliable due to wide variations in loading practices and widespread inaccuracies in reported container weights.

Marine Terminal Data

Container terminal operating systems such as Navis SPARCS collect information on gate activity. The gate data is entered by the clerks who check inbound and outbound trucks, or through automated systems such as swipe cards or Optical Character Recognition (OCR) camera systems. When a drayage driver pulls a container from the terminal interchange documents are completed to transfer legal custody of the container and chassis (and the contents, if loaded). Movement of loaded containers, empty containers, and bare chassis to and from the marine terminals thus tends to be well documented, but some reconciliation between interchange documentation and gate records may be required. Bobtail trips have not been documented as carefully in the past, but should be more accurately recorded with increased security concerns.

In theory, then, marine terminal operators should be able to obtain complete, accurate information on gate flows and transactions from their information systems. In practice the accuracy and accessibility of gate information will vary with the accuracy of inputs, the rigor with which the system is maintained, and the experience of those accessing the data.

Rail Terminal Data

Comprehensive data on gate transactions is likewise kept by rail intermodal terminal operators and their systems, of which OASIS is a leading example. Although rail terminals are owned and ultimately controlled by the railroads, they are ordinarily operated by contractors such as PARSEC or Pacrail. Clerical functions at the gates and any automated systems are supervised by the contractor, as is data input. While gate transaction data might be obtained through a railroad representative, issues of accuracy, completeness, and interpretation may need to involve the contract operators.

Complications follow where rail terminals handle domestic traffic as well as port containers.

- Terminal operating systems do not distinguish between domestic "backhaul" loads in marine containers and export loads in the same containers. A domestic load in a marine container leaving the off-dock rail terminal will later appear at the marine terminal as an empty (unless street-turned as an export load).

- Although it is possible, rail terminal records do not routinely distinguish between bobtails arriving (or leaving) for international business and bobtails arriving (or leaving) for domestic business.

Container Depot Data

Most container depots are privately operated, either by one of a few regional (such as Fastlane in Southern California) or national companies (such as Unicon) or by local entrepreneurs. They store containers for ocean carriers and leasing companies. Depots also maintain and repair containers, but the activity model does not distinguish trips for repair or maintenance from trips for storage. Container depots keep electronic records of their transactions, but being private concerns their cooperation in providing data is strictly voluntary.

Some container depots are operated by stevedoring companies (marine terminal operators) or by drayage firms. Data availability from these other depot types may be mixed.

The key data items for container depots would be:

- the volume of business, translated into inbound and outbound truck trips if possible.

- turn times for truckers, including queuing time (if any), gate time, and time in the depot yard.

- insights into the frequency of "trouble window" visits or other delays.

Distance between marine terminals, depots, and other facilities can be independently determined once depot locations have been verified or obtained from port records.

Shipper and Receiver Data

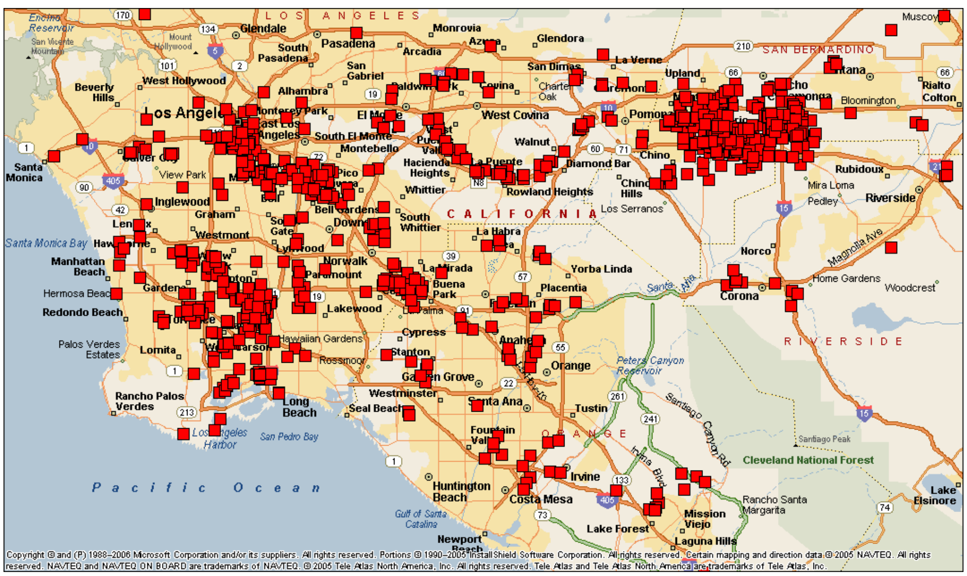
Obtaining reliable distance and volume information for shipper (export) and receiver (import) trips can be a considerable challenge. The actual locations and container volumes are known only to the shippers and consignees themselves, and perhaps to the drayage firms that serve them. Because ocean carrier tariffs are a mix of store-door rates (where the carrier arranges for drayage) and local rates (where the customer arranges for drayage) the ocean carrier may not have complete knowledge. Moreover, many large shippers or consignees use multiple ocean carriers and drayage firms and may have multiple shipping and receiving points, adding to the data challenge.

PIERS data identify shippers and consignees and their shipment volumes but do not necessarily identify correct shipping and receiving locations. PIERS data are derived from Customs declarations, and tend to list company headquarters where documentation is maintained and duties paid – the so called "headquarters bias". This tendency means that PIERS data do not reliably reveal the actual origins or destinations of container movements for a given port, but they do provide a starting point for additional analysis.

Port marketing and sales departments can be a source of insight on the actual locations of port customers and for customer contact information.

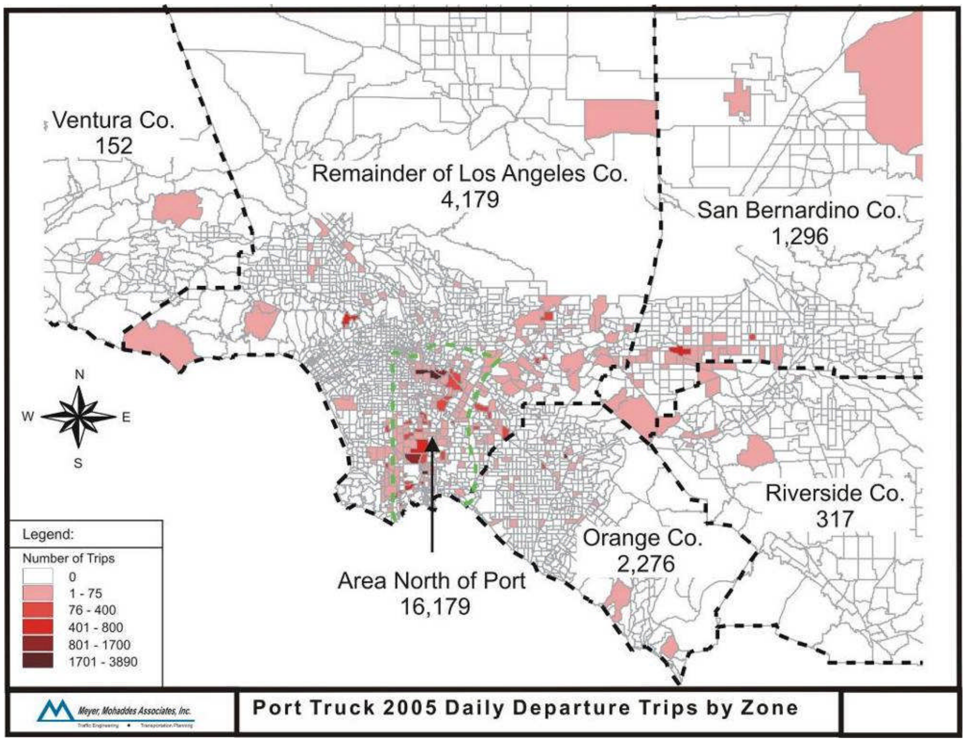
It is unlikely that port customers would be evenly distributed around the port. Export manufacturers and import distribution centers tend to cluster in industrial districts. Exhibit 109, for instance, shows the locations of identifiable distribution centers in the greater Los Angeles area.

Exhibit 109: Los Angeles Area Distribution Center Locations



Some major ports have undertaken drayage driver surveys to determine the pattern of drayage trips. Exhibit 110 provides an example of such survey results, aggregating the drayage trips by region.

Exhibit 110: Port of LA/LB Truck Trips from Survey



With trips allocated to ZIP codes or to representative points within regions, such data can yield a weighted average distance to shipper/consignee locations.

In the absence of such data a next-best alternative would be to identify major customer clusters, such as one shown below for the Port of New York/New Jersey (Exhibit 111), and weight the distances by estimated volumes (Exhibit 112). Discussions with major drayage firms can also elicit estimates of representative drayage distances.

In some cases the drayage trips may take place outside of the defined air quality (e.g. non-attainment) area. In these cases, a decision will need to be made whether to limit the distance to the edge of the non-attainment area. Local air quality officials should be consulted to make sure the appropriate boundary is selected.

Exhibit 111: PANYNJ Trade Clusters

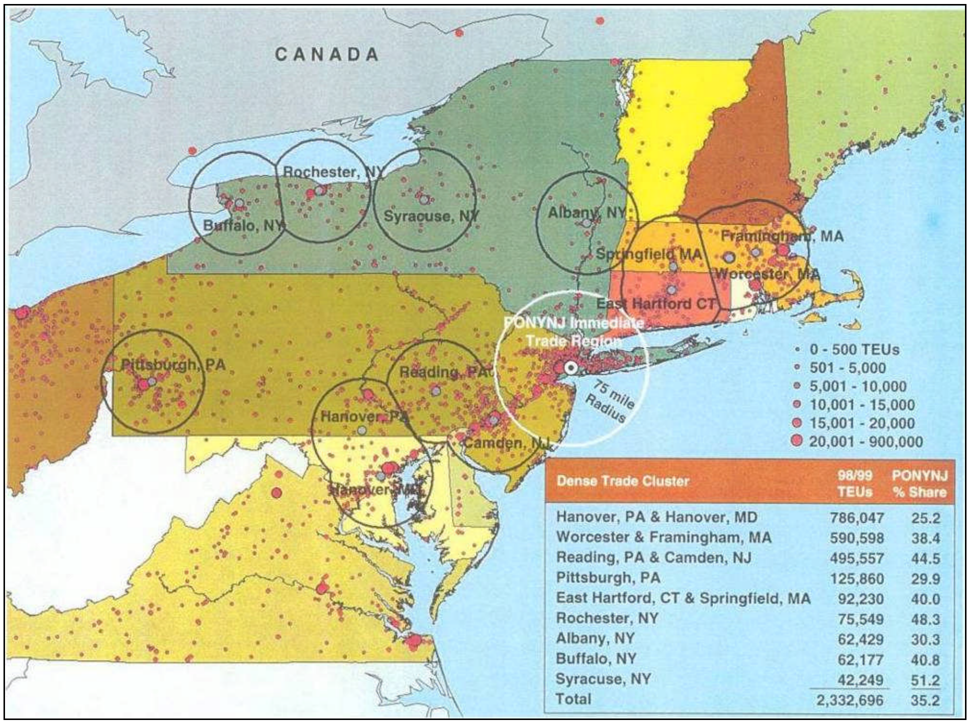
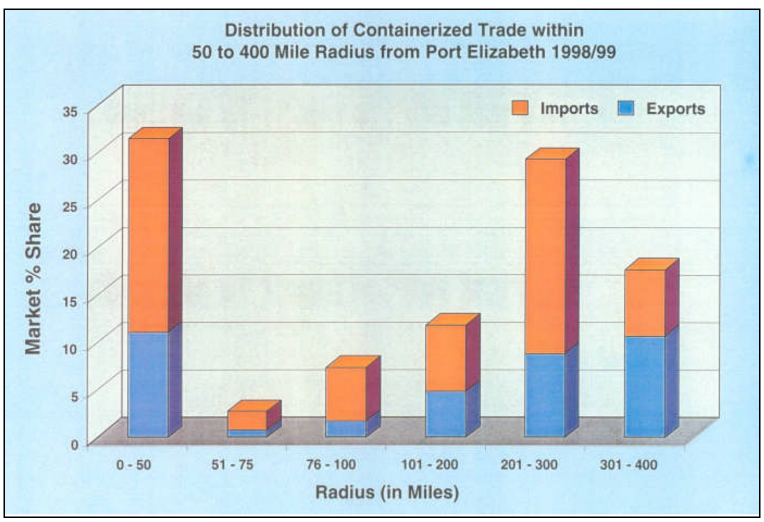


Exhibit 112: PANYNJ Distances and Weights



Street Turn and Crosstown Data

There is ordinarily no organization that keeps data on street turns and crosstown trips, so estimates are required. Two factors are at stake: the frequency of street turns (reuse of import containers for export loads) and other cross-town trips, and the distance commonly traveled. In both instances, major drayage firms would be the best sources for estimates.

Los Angeles/Long Beach Case Study

LALB Drayage Overview

Port drayage (highway trucking of marine containers) in Southern California poses a prominent and difficult problem within California's goods movement system. Emissions from port drayage operations endanger the health of surrounding communities and have produced a regional backlash against international trade and the growth of the State's ports. The Ports of Los Angeles and Long Beach have launched ambitious efforts to reduce emissions from drayage and are considering additional steps. The California Air Resources Board is likewise proposing strong measures to curb drayage emissions.

The importance of the drayage issue and the community sensitivity to port activity in Southern California have led to numerous studies of drayage and related subjects, several of which are discussed in the literature review. There is thus much more documentation available on drayage in Southern California than on drayage in other regions. Not surprisingly, however, this abundance of data leads to disagreements between sources.

Diesel-powered drayage tractors handle roughly 84% of all marine container traffic to and from the Ports of Los Angeles and Long Beach at present, and are expected to handle at least 75% for the foreseeable future. Although roughly half of the containers eventually move to and from the region by rail, most rail-bound containers are still drayed between port and rail terminals by local truckers.

A major reason for the emissions problem is the use of over 10,000 older diesel tractors originally built for long-haul highway service and often ill-suited for retrofit or filtration. The low profits and fragmentation of the industry are serious barriers to solutions that require higher capital costs. Implementation of 2007 diesel emissions standards is expected to be uneven at best.

- National truckload fleets – the source of many used drayage tractors – avoided buying 2007 tractors by buying larger than normal numbers of 2006 models.

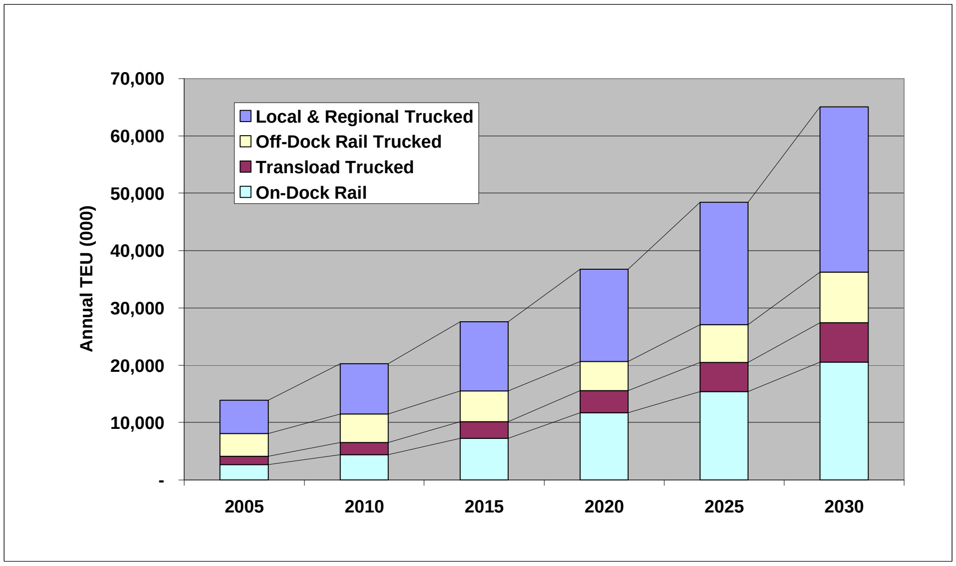
- Tighter standards in 2010 will likely encourage national fleets to postpone retirement of 2007-2009 models that would otherwise have gone into drayage service.

Los Angeles and Long Beach together form the largest and busiest container port complex in North America. As Exhibit 113 shows, the Los Angeles/Long Beach port complex includes fourteen terminals which are served by several on-dock rail terminals.

Exhibit 113: LA/LB Container Terminals

In 2007, 15.7 million TEU (about 8.5 million containers) passed through the two ports. The rapid growth of U.S. imports from Asia has led to a corresponding increase in port drayage, and is expected to continue at 6-7% per year for the next two decades despite flat growth in 2007. This growth is driven both by strong local market growth and by politically sensitive growth in inland markets served via the Southern California ports. As Exhibit 114 indicates, by 2020 the growth in local business alone will eclipse the present local and inland business combined. The region will therefore depend on drayage tractors to deliver more containers than at present even if all the inland business were diverted to other ports.

Exhibit 114: Forecast San Pedro Bay Cargo Growth



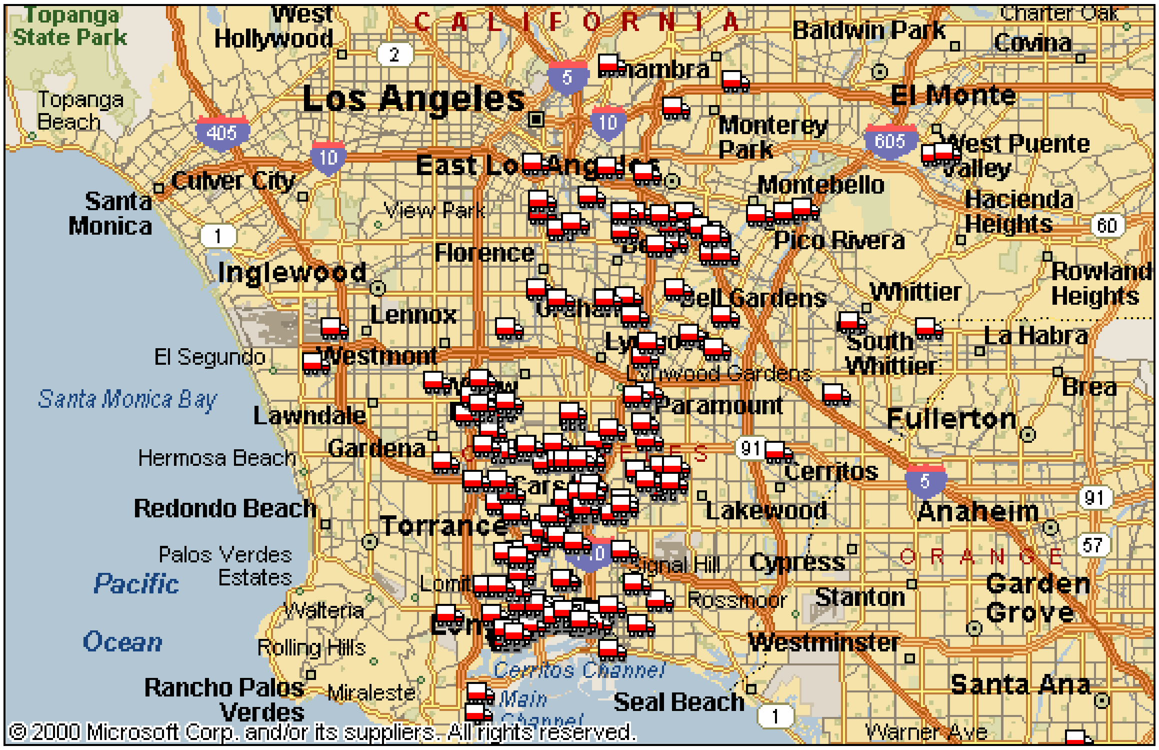
Source: San Pedro Bay Long-Term Cargo Forecast, December 2007

Facility Locations

Port drayage trips radiate from the relatively compact and well-defined port areas of Long Beach and Los Angeles. With few exceptions, each port drayage trip originates or terminates at a marine container terminal or nearby container depot. A very large fraction of these trips use Interstate 710 (I-710) and account for the largest and most visible segment of trucking activity on this highly congested route. Of the port drayage trips on I-710, a significant fraction move to and from three rail intermodal facilities. Once isolated from other development, the Ports of Los Angeles and Long Beach are now surrounded by residential and commercial land uses sensitive to emissions, congestion, and noise. Likewise, I-710 and the rail intermodal facilities are bordered by residential and commercial areas. These adjoining land uses both increase the impact of diesel truck operations and constrain facility expansion to alleviate congestion or increase capacity.

Exhibit 115 shows that drayage firms are clustered north of the port and south of downtown Los Angeles.

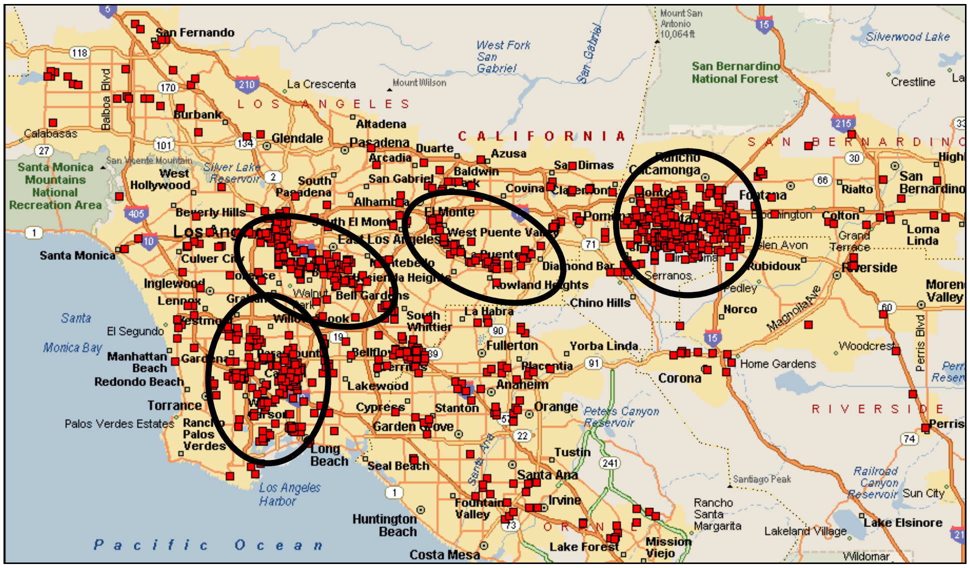
Exhibit 115: Drayage Firm Locations



Southern California port drayage is almost universally performed by owner-operators driving under contract to drayage firms. The availability of used diesel tractors at relatively low cost is a foundation of the current drayage business. The supply of owner-operators willing to endure long hours and poor working conditions for relatively low pay has been propped up by immigration and the supply of low-cost tractors. The ease of entry produces near-atomistic competition, keeps drayage rates and profits at a minimum, and hinders any investment in newer tractors more suited to drayage service.

Exhibit 116 shows the locations of over 1000 regional distribution centers (DCs). The same Ontario/Mira Loma concentration shown in the port survey data is apparent in this map. The study team developed a preliminary analysis of the potential for an inland port/rail shuttle serving this DC concentration as an indication of the overall potential of the inland port concept in reducing truck VMT and emissions.

Exhibit 116: Regional Distribution Centers



As Exhibit 116 suggests, there are four major clusters of regional distributions centers as potential destinations for drayage trips:

- an area immediately north of the ports, typically 10-15 miles distant;
- a second group running along Interstate 5 southeast of downtown Los Angeles, typically around 20 miles from the Ports;
- a third group in a crescent along State Route 60, typically about 25 miles from the Ports; and
- a very large fourth group centered around Mira Loma in the Inland Empire, roughly 60 miles from the ports.

Exhibit 117 shows estimated drayage times to inland areas under congested highway conditions (30 mph on highways and 20 mph on surface streets). Under those conditions, the 56.5-mile drayage times to the large concentration of DCs in the Ontario Airport/Mira Loma area are 120-150 minutes.

Exhibit 117: Port to DC Congested Travel Times

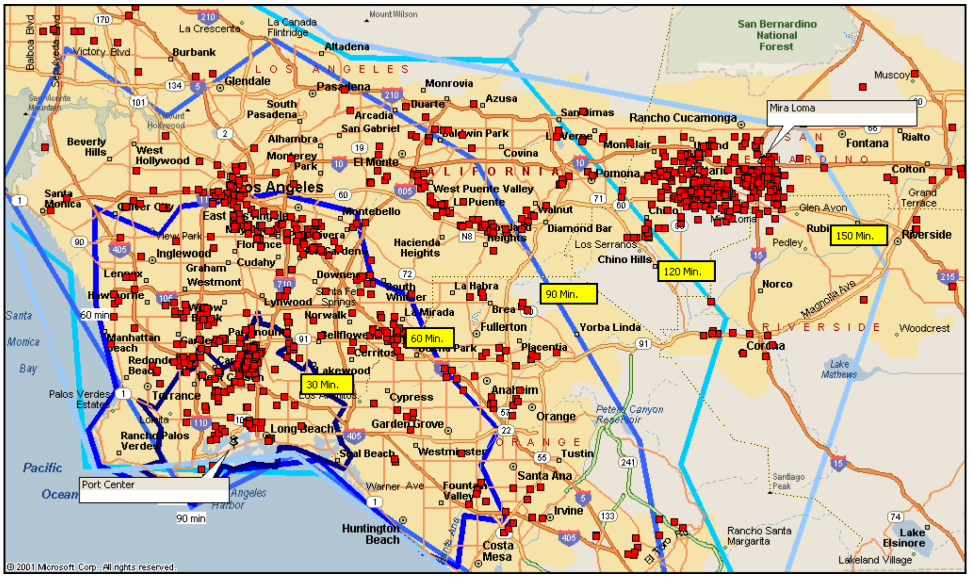


Exhibit 118 shows the approximate locations of container depots in the port area (actual locations may have changed since the data were gathered). Most are clustered in the area north of the ports bounded by I-110, I-405, and I-710. This area has historically been home to numerous light and heavy industrial uses.

Exhibit 118: Container Depot Locations

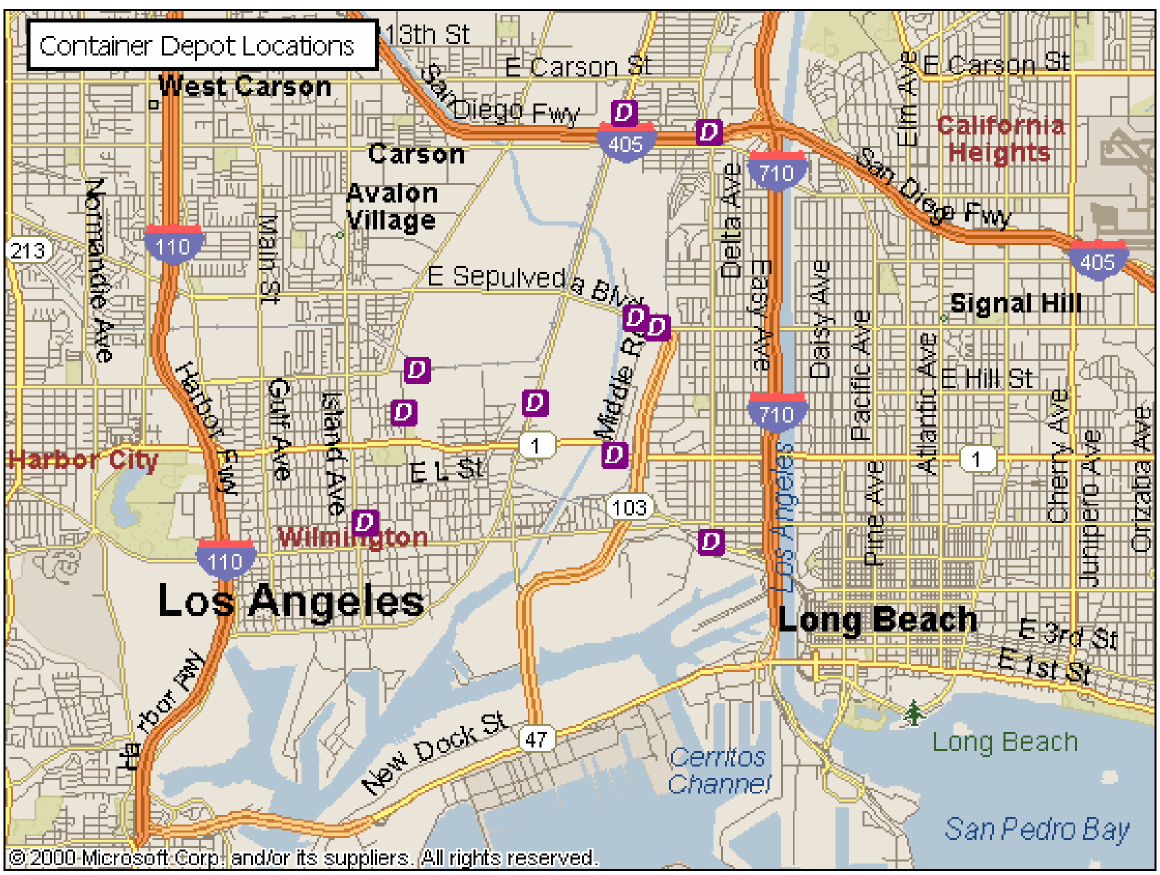
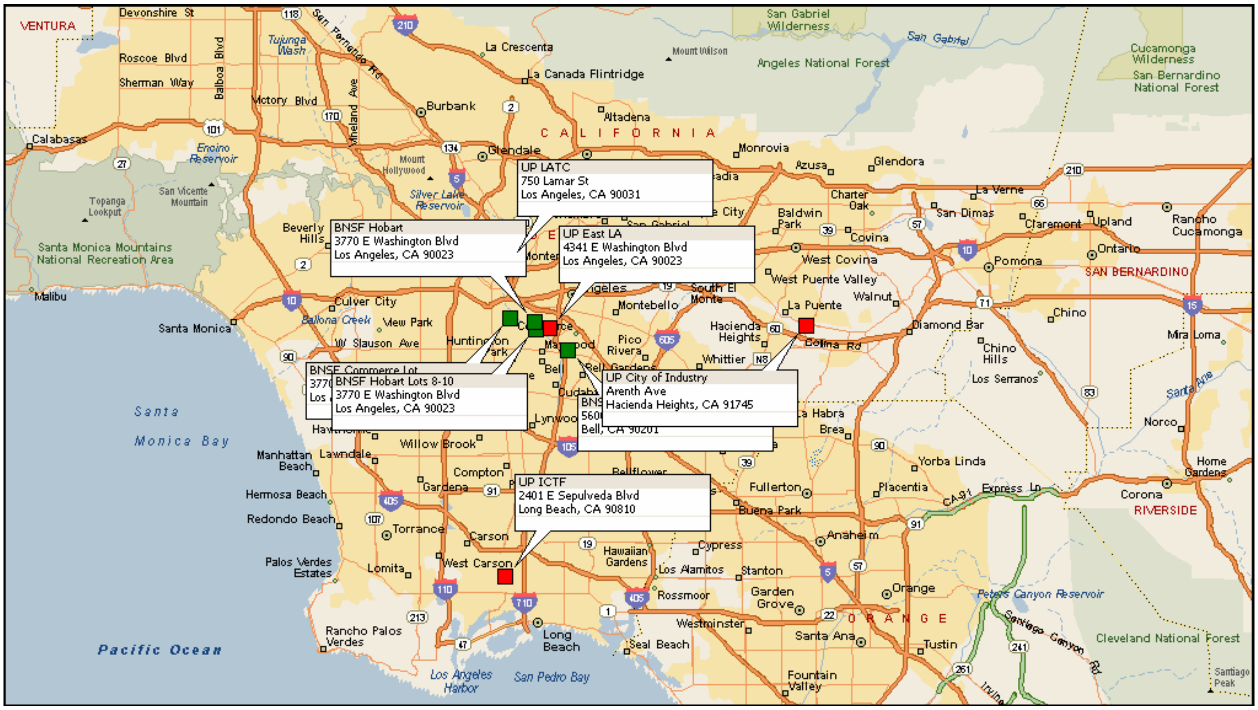


Exhibit 119 below shows the locations of the rail intermodal terminals and remote lots that handle port container business for the Ports of Los Angeles and Long Beach. The closest, UP's ICTF, is about 4 miles from the port terminals. The rest are about 20 miles away.

Exhibit 119: Southern California Rail Intermodal Terminals



Port Drayage Patterns

The overwhelming factor in Southern California port drayage is volume. The drayage patterns to and from each individual facility are not complex. The marine terminals at Los Angeles and Long Beach are largely conventional, wheeled terminals in which draymen locate or drop containers on chassis in large container yard parking lots. The sheer number of facilities and the enormous volume of business they handle, however, create the need for a huge number of drayage trips in every conceivable combination.

The exhibits below were developed by Port of Long Beach staff to help explain the movement patterns to the public.

Imports. As Exhibit 120 indicates, drayage trucks leaving marine terminals with loaded import containers will go one of three ways: to a near-dock rail yard, to an off-dock rail yard, or to a receiver/consignee ("local store/factory" on the diagram, actually most often a local distribution center). From a drayage modeling standpoint, the distinction between near-dock and off-dock rail yards is one of distance and time, and has been accommodated within the model by a weighted average of drayage trips to various rail facilities. Note that on-dock rail facilities do not involve over-the-road drayage, and are not covered by the drayage model. The distance and time to local destinations (distribution centers) may vary from a few miles and minutes for a port-area transloader to as much as 400 miles for points in Northern California, Nevada, and Arizona. Here again, the model represents this mix of trips as a weighted average.

Exports. Export flows (Exhibit 121) are generally reversed. From the perspective of port drayage, export containers either originate at local shippers (e.g. manufacturers, distribution centers, or consolidators), or originate at near-dock and off-dock rail yards. Here too, the "local" export shippers may be in the immediate port area or in an adjacent state, and are represented in the model by a weighted average of trips and distances. The near-dock and off-dock rail yard trips also yield a weighted average, while the on-dock rail arrivals do not require over-the-road drayage.

Empty Containers. The empty container movements (Exhibit 122) result from the loaded container trips. Once unloaded, empty import containers are returned to the marine terminals. Empty containers must be brought from the marine terminals to be filled with exports. Some containers may be stored in off-dock locations (container depots). Other empties move to and from the off-dock and near-dock rail yards. A few empty import containers are reused for export loads, and as noted on Exhibit 122 "virtual container yards" are being explored for their potential to increase reuse.

O**ther Trips.** Not surprisingly, there are frequent needs to move tractors without containers or chassis ("bobtails"), to shift bare chassis without containers, and to reposition containers or chassis between terminals for various reasons. Although not part of the import/export cycle and not shown on the Port of Long Beach diagrams, these trips are accommodated within the DrayFLEET models.

Exhibit 120: LALB Import Container Flow

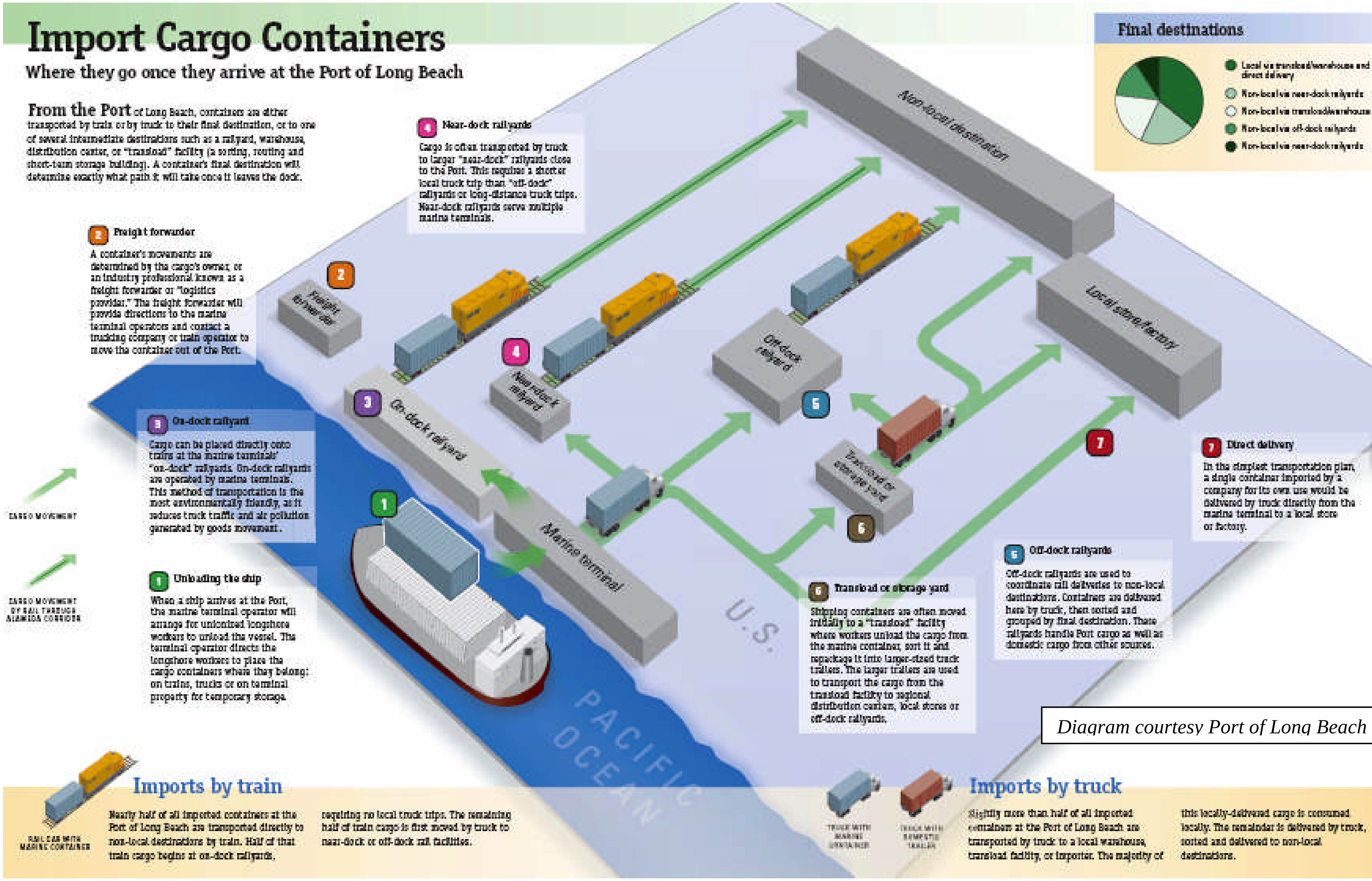


Diagram courtesy Port of Long Beach

Exhibit 121: LALB Export Container Flow

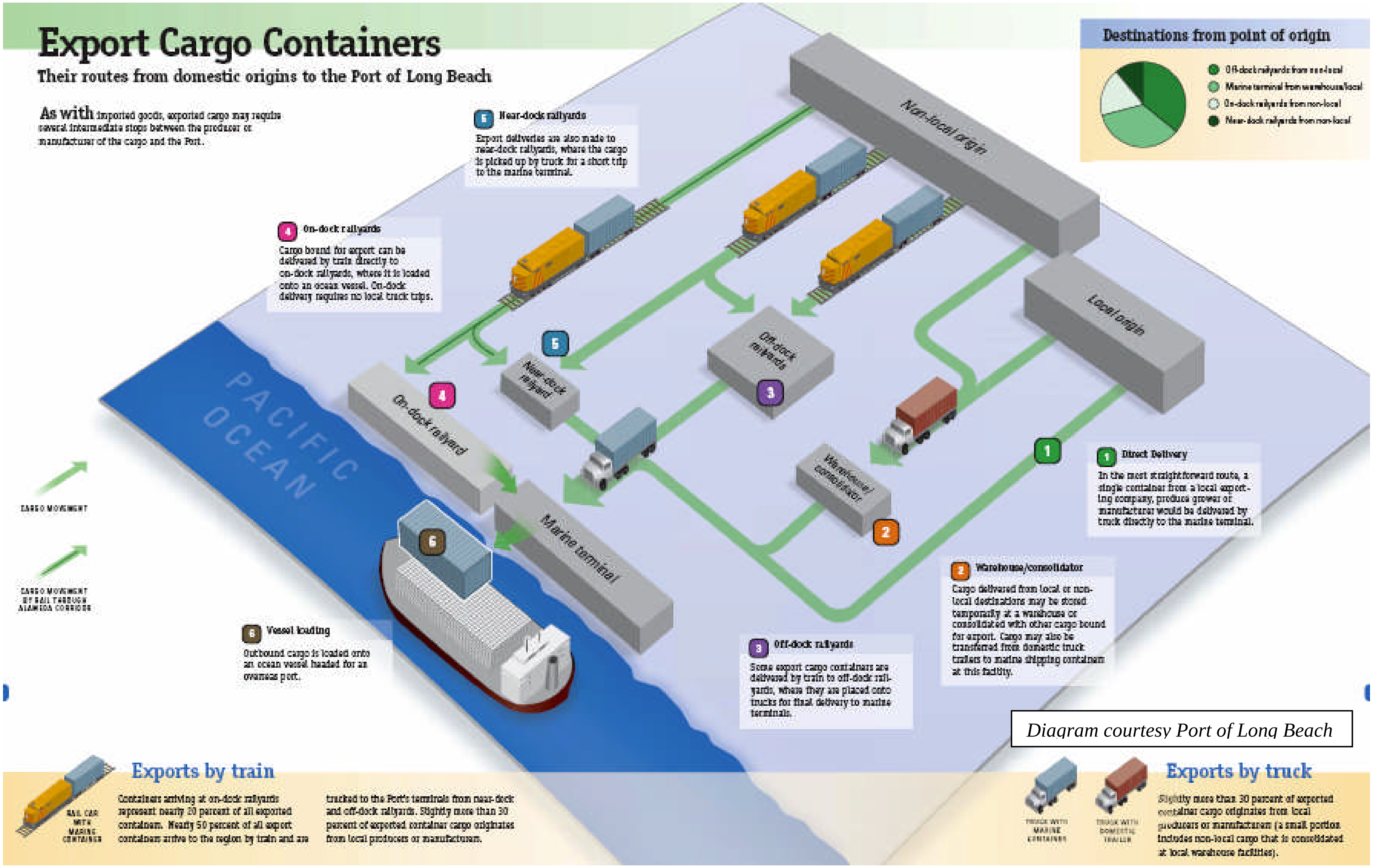


Diagram courtesy Port of Long Beach

Exhibit 122: LALB Empty Container Flow

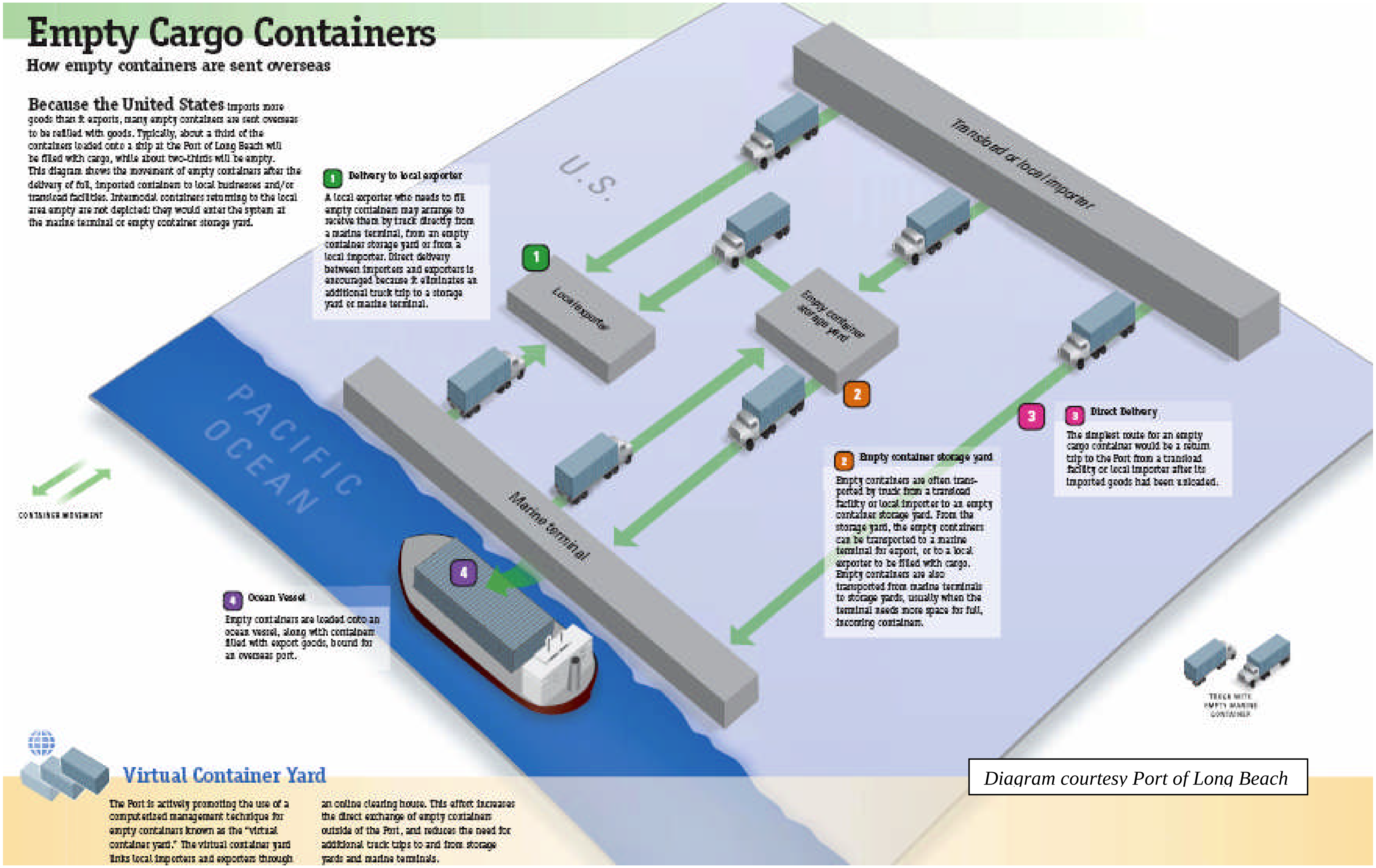


Diagram courtesy Port of Long Beach

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Port Drayage Trips

Exhibit 123 displays daily and annual estimated 2005 port truck trips derived from port driver surveys.

Exhibit 123: Estimated Truck Trips from Port Driver Survey13

2005 Truck Trips	Bobtails		Chassis		Loads		Empties		Total	
	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports
Per Day Totals	10,507	10,023	3,148	2,179	4,840	11,740	8,384	3,242	26,878	27,185
Annual Total	2,927,114	2,792,536	877,145	607,128	1,348,437	3,270,873	2,335,643	903,269	7,488,340	7,573,806

2010 Truck Trips	Bobtails		Chassis		Loads		Empties		Total	
	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports	Arrival/ Export	Departure/ Imports
Per Day Totals	12,527	11,879	3,639	2,717	5,562	16,097	12,397	3,962	34,125	34,655
Annual Total	3,489,976	3,309,494	1,013,952	756,854	1,549,450	4,484,659	3,453,861	1,103,899	9,507,238	9,654,906
Share of Total	19%	19%	6%	4%	9%	22%	16%	6%	50%	50%

Previous port trucking studies have divided the flows by county, with the area immediately north of the ports separated out from the rest of Los Angeles County. This study follows that convention. The data for daily loaded container truck trips are summarized accordingly in Exhibit 124.

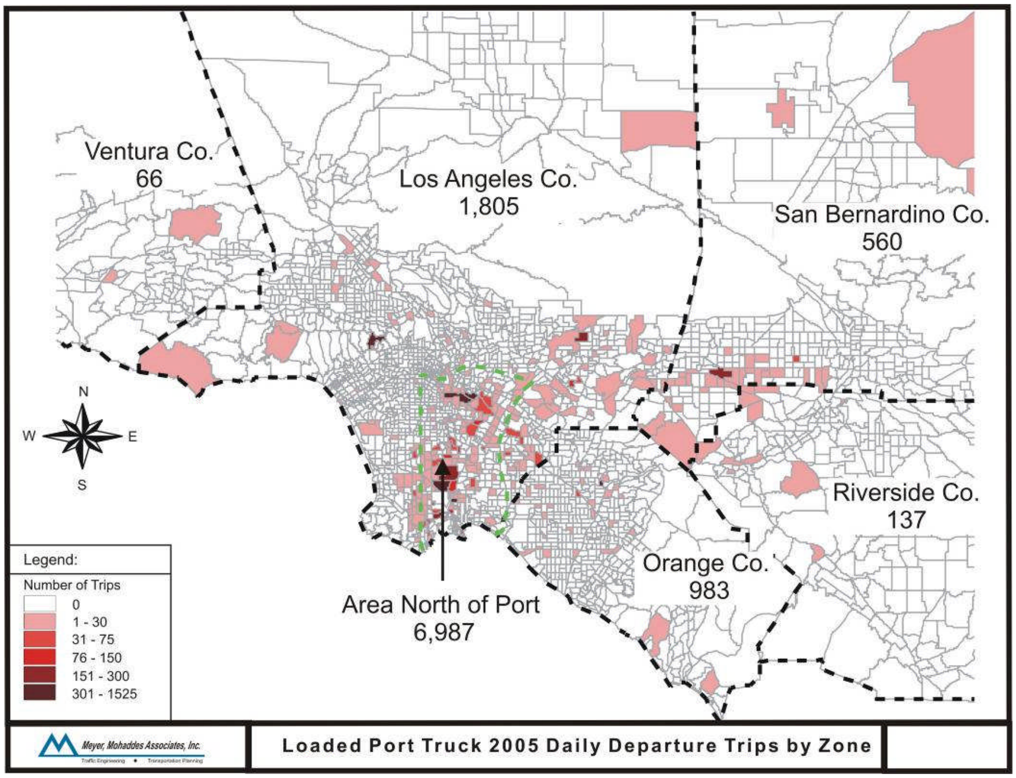
Exhibit 124: Regional Loaded Port Truck Shares

2005 Loaded Trucks	Port Area	Other LA Co.	Inland Empire	Ventura & Orange Cos.	Total
Import Loads (Departures)	66%	17%	7%	10%	100%
Export Loads (Arrivals)	58%	20%	8%	14%	100%
Total Loads	**64%**	**18%**	**7%**	**11%**	**100%**

Exhibit 125 shows the port survey data for loaded truck moves allocated to Transportation Analysis Zones. The concentration of activity immediately north of the ports is obvious. Within the Inland Empire of San Bernardino and Riverside Counties, port truck traffic is concentrated around the Ontario Airport and in the adjacent Mira Loma area. Exhibit 126 displays the same data for total trips, including empty containers, bare chassis, and bobtails. Exhibit 127 and Exhibit 128 are parallel tables for estimated 2010 trips.

[13] Note the nomenclature conventions, which are based on the marine terminal gate perspective. “Arrivals” are inbound at the gate and include export loads, export empties, inbound empty chassis, and inbound bobtails. “Departures” are outbound from the gate and include import loads, empty containers for export loading, outbound empty chassis, and outbound bobtails.

Exhibit 125: 2005 Loaded Truck Departures (Imports) and Arrivals (Exports)



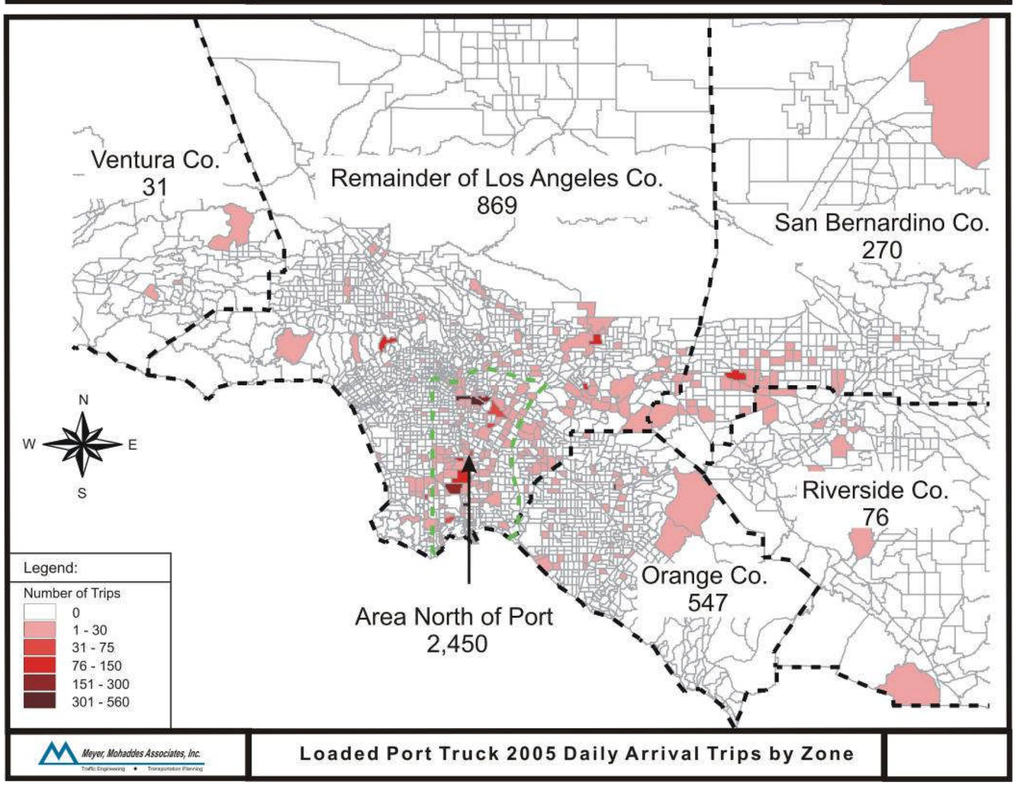
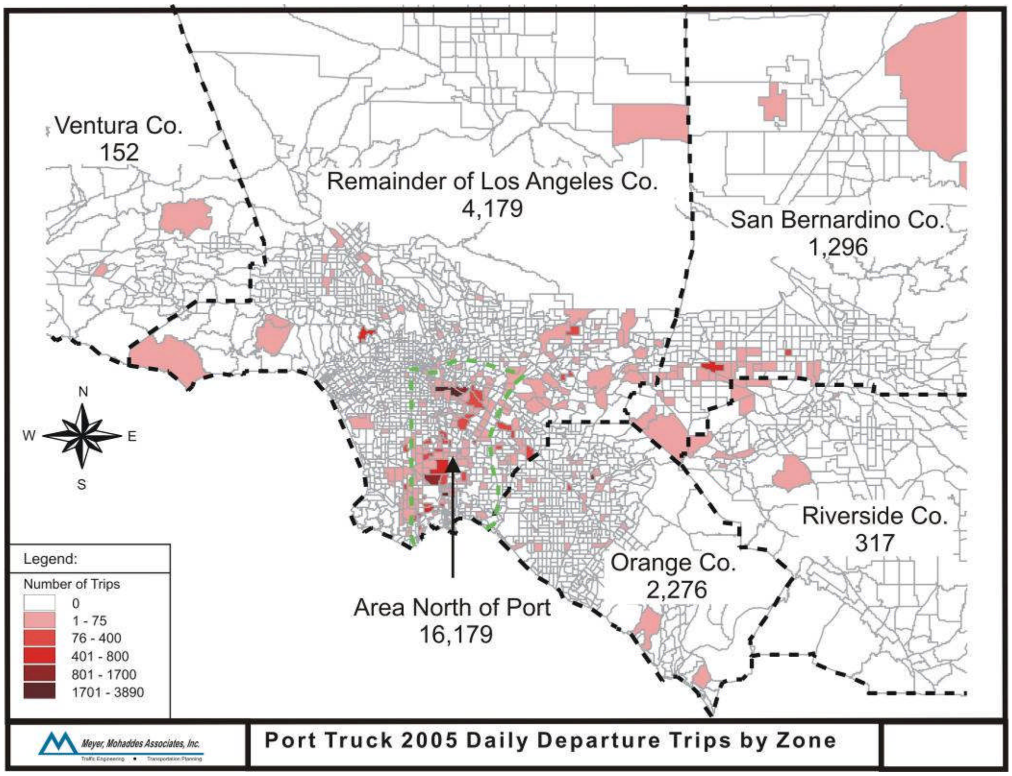


Exhibit 126: 2005 Total Departures (from Port Gates) and Arrivals (to Port Gates)



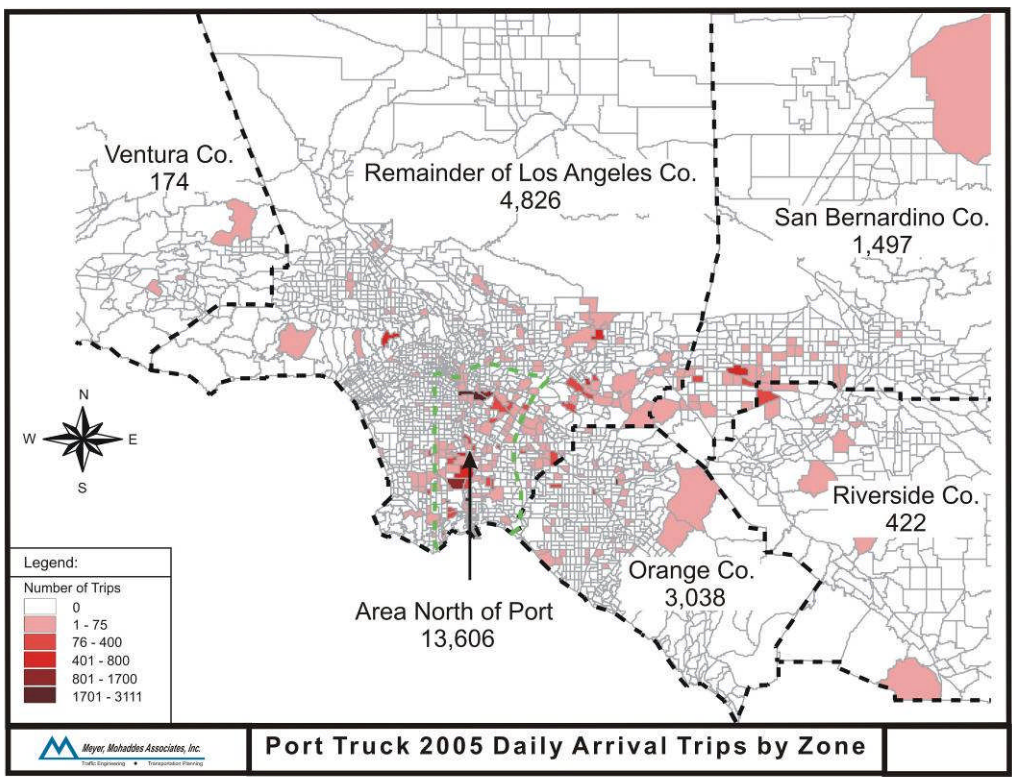
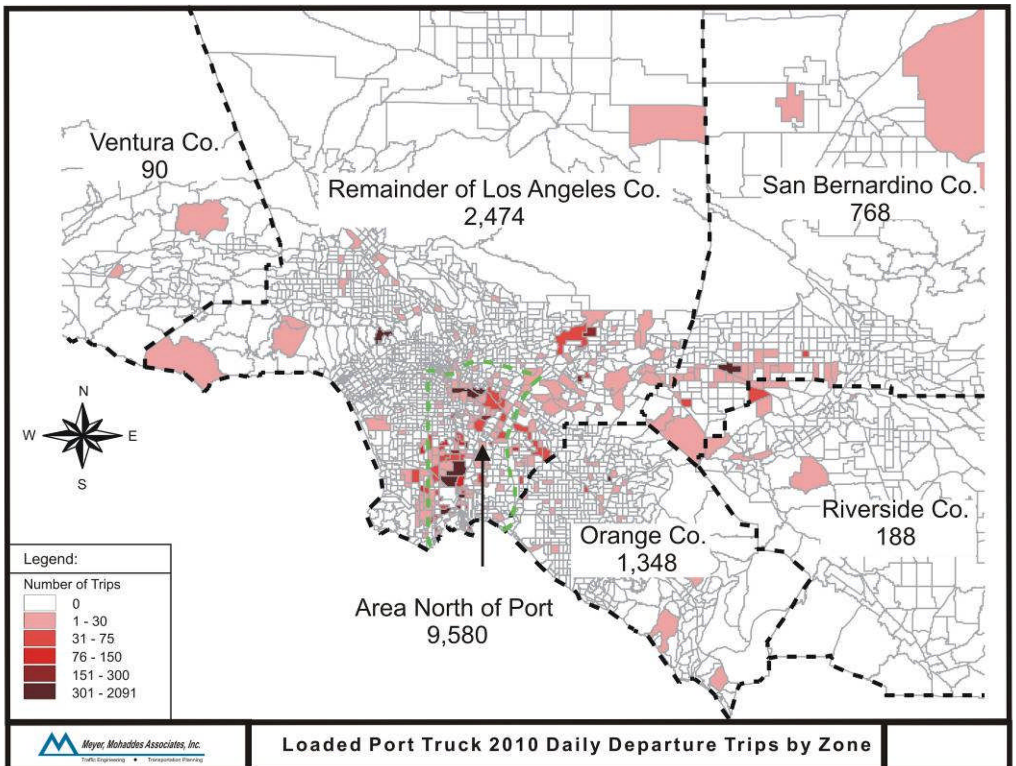


Exhibit 127: 2010 Loaded Truck Departures (Imports) and Arrivals (Exports)



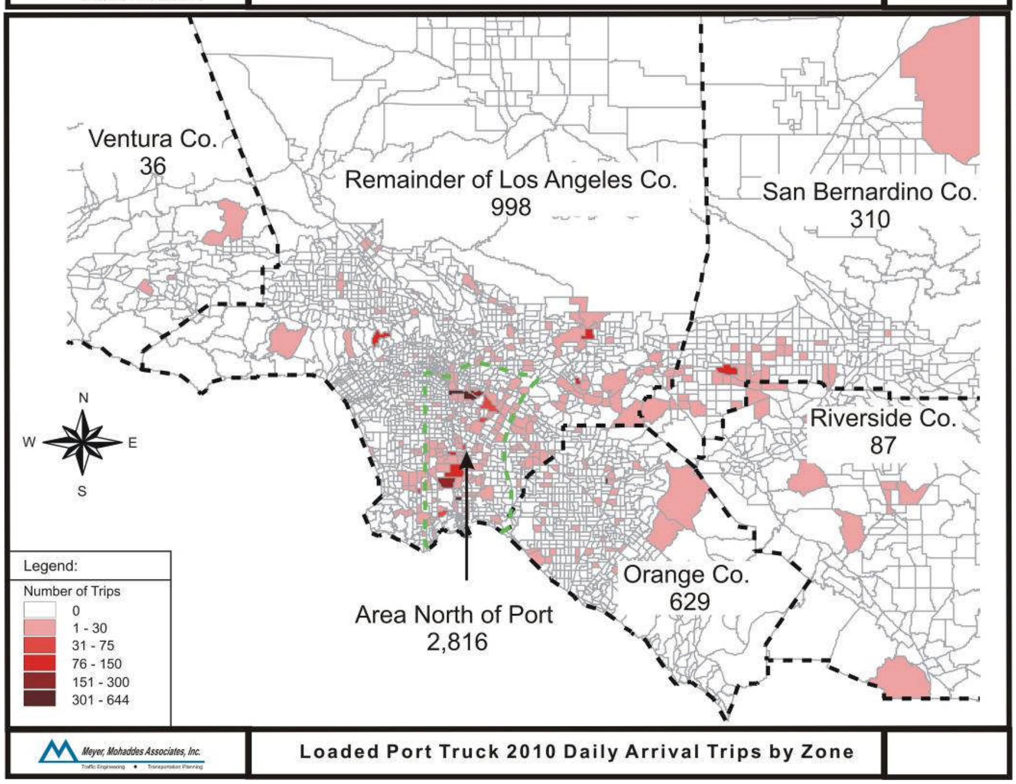
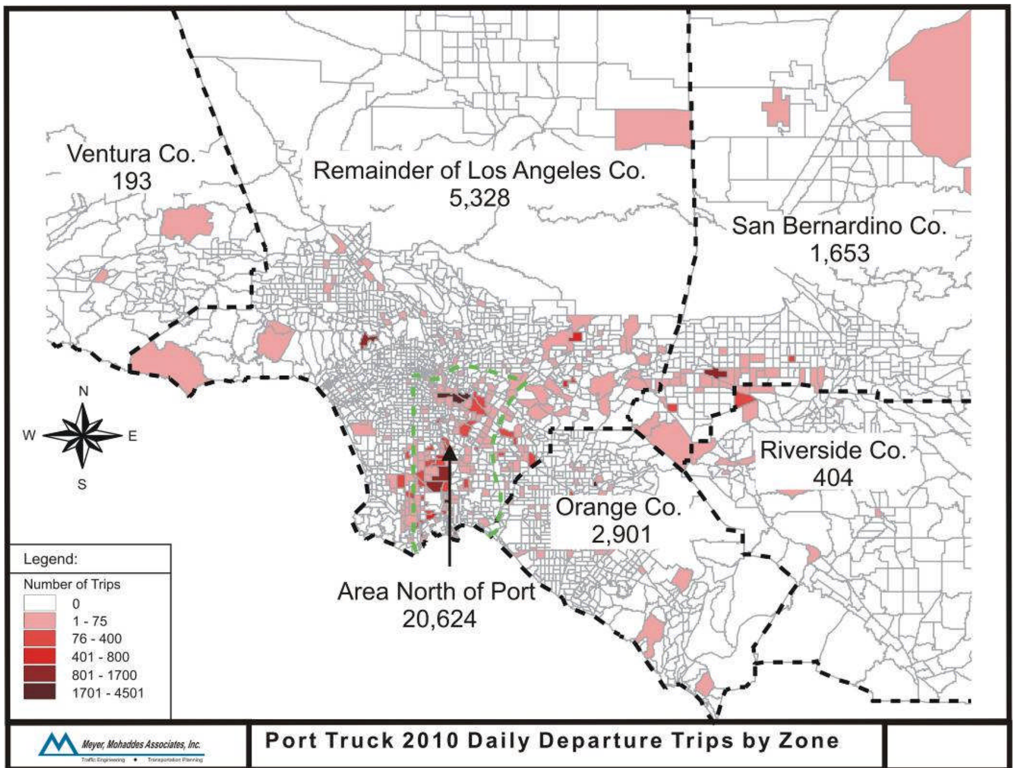
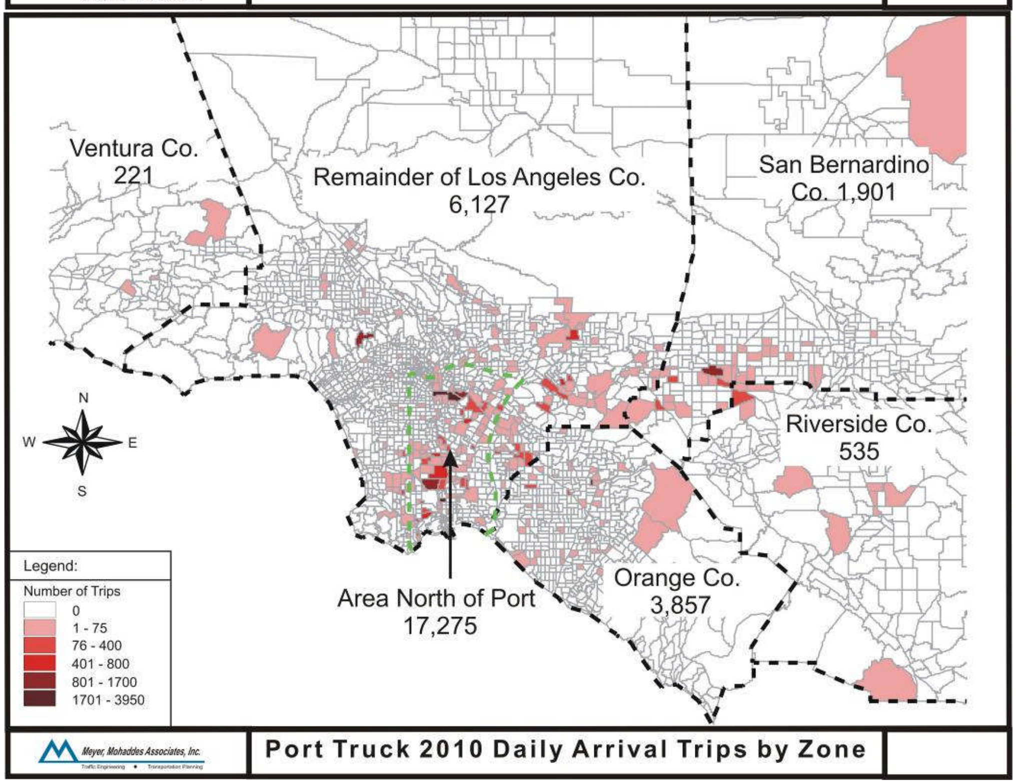


Exhibit 128: 2010 Total Departures (from Port Gates) and Arrivals (to Port Gates)





LALB Trip Lengths

The table below (Exhibit 129) summarizes the estimated and modeled trip lengths for the key trip types involved in empty container movements.

Exhibit 129: LA/LB Trip Length Summary

Trip Type	Average Miles
Eastbound	
Off-Dock Intermodal	14
Local for Export Loading	15
SSL Off-Hires to Depots	4
Westbound	
Off-Dock Intermodal	14
Local from Import Loads	15
Local from WB Domestic Loads	30
Repo Off-Hires from Depots	4
Local Empties from Transloads	10
Bobtails	15
Cross-Town	
Local Off-Hires to Depots	11
IM Off-Hires to Depots	10
Re-used empties for exports	15

Marine Terminal Data

There have been several surveys of drayage transaction times in Southern California with areas of both agreement and disagreement. No one source is definitive.

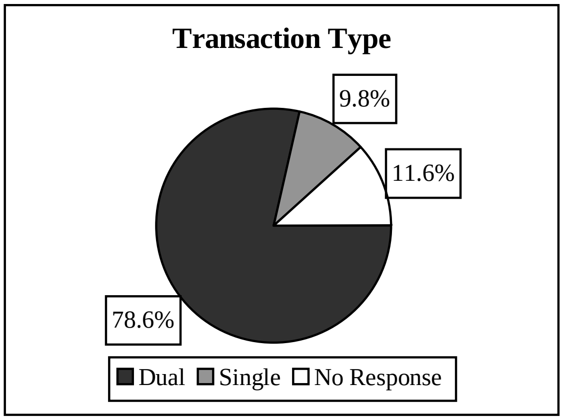
The California Trucking Association (CTA) surveyed its members regarding transaction times at marine terminals in Southern California. The CTA Intermodal Benchmarking Surveys were taken in April and August of 2002 to rate the efficiency of port terminals. CTA received a total of 777 responses from drivers in the two surveys. The responses are summarized in Exhibit 130.

Exhibit 130: CTA Terminal Transaction Times Survey Results

Term. Op.	# Of Responses	Average Reported Actvity Time in Minutes							
		Outside Gate	Container Yard	Trouble Window	Equip. Issues	Maint. Shop	Chassis Flip	Out Gate Line	Total Trans. Time
April 2002 CTA Survey									
APL	4	16	10	-	-	-	14	15	52
China Shipping	2	43	74	-	-	17	-	24	97
CMA	3	98	9	-	-	-	51	-	105
Cosco	42	49	42	52	93	34	35	28	145
Evergreen	16	50	88	-	-	-	108	30	221
Hanjin	14	19	39	28	-	-	39	14	99
Hyundai	101	15	20	30	15	-	67	14	104
Italian Line	1	25	-	-	-	-	135	-	180
ITS	1	15	15	-	-	-	60	10	100
K-Line	6	30	30	-	-	-	25	16	84
Maersk	5	34	47	-	-	-	63	10	82
MOL	2	45	68	-	-	-	75	5	130
Norasia	1	40	20	30	-	-	-	-	210
NYK	3	56	3	-	-	-	30	15	92
OOCL	4	47	30	-	-	-	33	10	111
Senator	2	30	53	28	-	-	30	70	129
Yang Ming	5	71	39	-	-	-	36	20	154
ZIM	2	7	8	-	-	-	20	6	41
ALL	**215**	**30**	**32**	**42**	**67**	**30**	**59**	**19**	**121**
August 2002 CTA Survey									
APL	20	25	18	-	-	-	42	9	71
CBCT	1	5	20	5	-	-	-	-	30
China Shipping	6	52	21	30	-	-	77	27	158
CMA	4	36	5	-	-	-	67	15	144
Columbus	2	73	10	-	-	-	77	8	120
Cosco	211	16	20	78	98	14	53	21	91
CSV	2	146	32	-	-	-	-	-	173
Evergreen	48	23	16	21	20	48	44	15	75
Hanjin	56	37	33	-	151	-	49	20	123
Hapag Lloyd	4	31	45	-	2	-	162	14	206
Hyundai	61	16	10	-	-	25	44	10	43
Italian Line	1	10	20	-	-	-	20	10	60
K-Line	46	37	17	-	295	-	46	19	119
Maersk	12	18	43	19	-	-	115	21	117
MOL	6	19	9	102	-	-	15	8	66
Norasia	15	20	16	-	-	-	37	9	65
NYK	5	50	32	-	-	-	16	14	88
OOCL	9	22	20	-	-	-	-	10	51
P&O	10	41	23	-	-	5	44	30	115
Senator	2	36	-	-	-	-	180	25	139
Sinotrans	5	34	62	-	-	-	70	9	122
Yang Ming	27	35	18	61	71	-	51	18	103
ZIM	9	14	19	-	-	18	44	10	91
ALL	**562**	**25**	**20**	**52**	**106**	**18**	**52**	**17**	**92**
Weighted Average	**777**	**26**	**23**	**49**	**95**	**21**	**54**	**18**	**100**

The average total transaction time was 100 minutes. The minimum transaction time would include the outside gate waiting (26 minutes), the container yard time (23 minutes), and the outgate line (18 minutes) for a total of 67 minutes. The average total time was longer because many, if not most, trips entailed multiple transactions. As Exhibit 131 shows, for the initial survey 78.6% reported dual transactions. If the 11.6% “no response” answers were divided proportionately, overall there would be 88.9% dual transactions. These surveys were taken before the implementation of PierPASS.

Exhibit 131: LA/LB Drayage Transaction Types



The April survey found that 11 of the 215 trips, or 5%, had to go to the trouble window for various reasons.

Additional driver surveys were taken after the implementation of PierPASS. An initial survey by Stonebridge Associates covered 365 drivers working for 125 companies and found that:

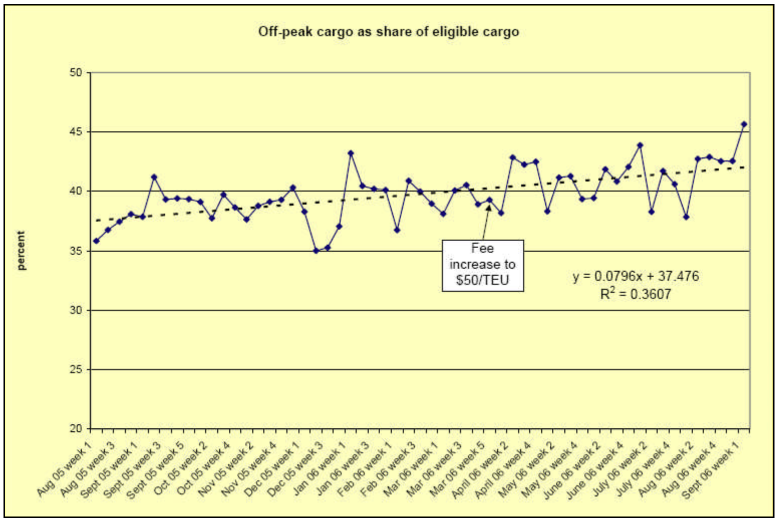
- There were no significant differences in turn times between day and night gates.
- Day and night gate turn times both averaged over 2 hours.
- A small majority of drivers saw an improvement in freeway congestion.

A second, follow-up survey was conducted in December of 2005 and included 506 drivers working for 195 companies. That survey found that:

- Drivers serving night gates do not get additional turns.
- Drivers who work two or more Saturday gates monthly averaged significantly more turns.

As Exhibit 132 indicates, by late 2006 about 43% of the eligible drayage movements occurred during off-peak hours.

Exhibit 132: Use of Off-Peak Terminal Hours

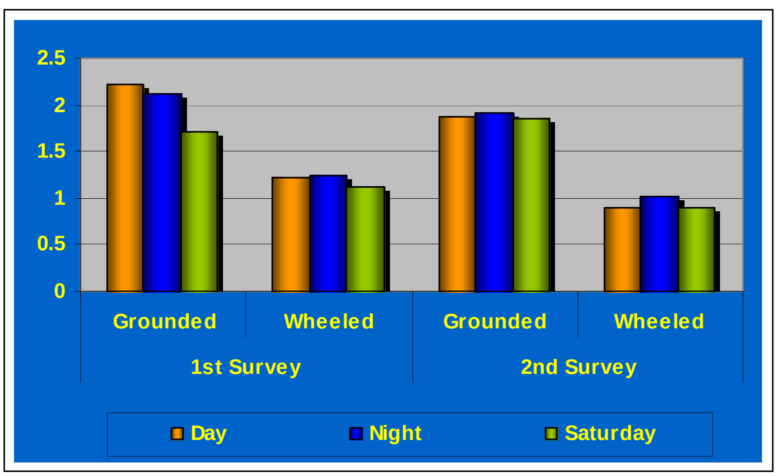


Source: Impacts of the Long Beach and Los Angeles Ports PierPASS Program, TRB Research Issues in Freight Transportation, Giuliano and O'Brien, October 2007

There are, however, several classes of container movements exempt from the PierPASS charges, notably empty container returns.

After PierPASS, the average combined speed of terminal operations improved by 20 percent during the day, 13 percent at night and 3 percent on Saturdays (Exhibit 133).

Exhibit 133: Reduction in Turn Times (Hours) Due to Extended Gates



Weighted by the 57/43 split of trips from Exhibit 132, the terminal time reduction would average about 17%. Applied to the times in Exhibit 130, this reduction would yield the post-PierPASS times shown below.

Exhibit 134: Impact of PierPASS Extended Gates on Terminal Times

Term. Op.	Average Reported Actvity Time in Minutes							
	Outside Gate	Container Yard	Trouble Window	Equip. Issues	Maint. Shop	Chassis Flip	Out Gate Line	Total Trans. Time
CTA Weighted Average	**26**	**23**	**49**	**95**	**21**	**54**	**18**	**100**
Post PierPASS Average	**22**	**19**	**41**	**79**	**18**	**45**	**15**	**83**

The reduced terminal turn times benefit all movements, not just those that occurred in off-peak hours.

Data from Long Beach port terminals collected for the 2005 air emissions inventory are given in Exhibit 135.

Exhibit 135: Reported Long Beach Terminal Operating Characteristics

	Speed (mph)	Distance (miles)	Ingate Time (min)	CY Time (min)	Outgate Time (min)
Maximum	15	1.5	14	50	15
Minimum	5	0.5	10	20	-
Average	6	0.8	11	35	10

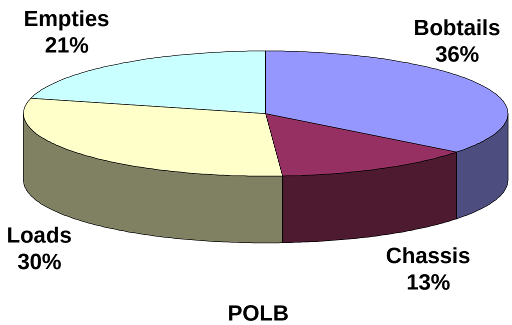
Source: Port of Long Beach 2005 Air Emissions Inventory

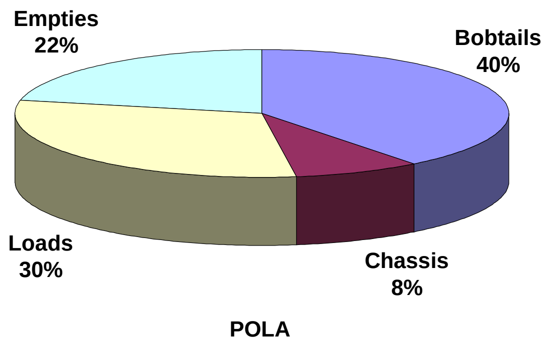
The times cited are shorter across the board than the drivers' estimates, most likely because the drivers' estimates were for complete transaction cycles and included queuing time outside the terminal. The data in Exhibit 135, however, have the advantage of being broken down into components.

Trip Type Mix

Bobtails and empty chassis movements add significantly to the total drayage VMT and emissions volume, yet data on bobtails and bare chassis are scarce. Exhibit 136 shows trip type percentages from a December 2005 report on drayage trip reduction strategies.

Exhibit 136: Trip Type Shares





Source: Port Trip Reduction Strategies, Cambridge Systematics, December 2005

The combined data yield an average distribution of 38% bobtails, 10% chassis, 30% loads, and 22% empties.

As Exhibit 137 shows, the 2005 driver survey data agree closely, and were probably a primary input to the reduction study.

Exhibit 137: 2005 LA/LB Truck Trip Shares from Driver Surveys

	Bobtails	%	Chassis	%	Loads	%	Empties	%	Total
OB/Export	2,927,114	39%	877,145	12%	1,348,437	18%	2,335,643	**31%**	7,488,339
IB/Import	2,792,536	37%	607,128	8%	3,270,873	43%	903,269	**12%**	7,573,806
Total	5,719,650	**38%**	1,484,273	**10%**	4,619,310	**31%**	3,238,912	**22%**	15,062,145

This split also compares well with on-road modeling results from the Port Emissions Inventory, which showed 30% bobtails, 4% chassis (lower, presumably because empty chassis movements did not go far from the terminals), and 57% loads or empties.

LALB DrayFLEET Calibration

Exhibit 138 displays the primary inputs for an LALB DrayFLEET model version. Inputs values were taken from the studies and other sources cited above.

Exhibit 138: DrayFLEET Model Calibrated for LALB Drayage

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0E of 06/26/2008

Port	Los Angeles/Long Beach
Terminal(s)	All
Scenario	2007 Base Case
Date	7/23/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	15,667,504	15,667,504
Average TEU per Container	1.85	1.85
Inbound Share	53%	53%
Inbound Empty Share	2%	2%
Outbound Empty Share	57%	57%
Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	14	14
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	15	15
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	40%	40%
Automated Gates (% of gate transactions)	50%	50%
Extended Gate Hours (% off-peak, 50% max)	30%	30%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	19,511,263	0	0.0%
Drayage Trip Legs per Container	2.3	2.3	0.0	0.0%
Total Drayage VMT	268,111,709	268,111,709	0	0.0%
Drayage VMT per Container	31.7	31.7	0.0	0.0%
Fleet Required (FTE Tractors)	7,122	7,122	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	7,707,571	7,707,571	0	0.0%
Creep Hours	4,060,244	4,060,244	0	0.0%
Transient Hours	2,708,141	2,708,141	0	0.0%
Cruise Hours	6,634,950	6,634,950	0	0.0%
Total Drayage Hours	21,110,907	21,110,907	0	0.0%
Drayage Hours per Container	2.5	2.5	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	297	297	0.00	0.0%
CO	1,735	1,735	0.00	0.0%
NOx	6,900	6,900	0.00	0.0%
PM_{10}	232	232	0.00	0.0%
$PM_{2.5}$	201	201	0.00	0.0%
CO_2	643,061	643,061	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	57,475,380	57,475,380	0.0	0.0%
Total Drayage Cost	$ 796,921,267	$ 796,921,267	$ -	0.0%
Drayage Cost per Container	$ 94	$ 94	$ -	0.0%

Key factors in distinguishing the LALB version from other ports include:

- Volume – the ports handled over 15 million TEU in 2007, equivalent to about 8.4 million containers.

- Dramatic imbalance, with about 57% of the outbound movement being empty.
- No barge movements or transshipment, and a minimum of inter-terminal drayage.
- No separate empty lots at marine terminals (unlike the other three case studies).
- About 45% rail intermodal movement, of which 40% (18% of the total) is handled on-dock.
- Wheeled operations – draymen routinely pickup and drop containers on their chassis.
- Longer off-dock rail terminal trips – with one 4 miles away and the others 20 miles away, the weighted average distance is about 14 miles.
- Shorter average shipper/receiver drayage trips – the major market shown in Exhibit 116 is served by truck, but the overwhelming majority of trips beyond are made by rail.

The primary outputs (Exhibit 139) suggest the enormous volume of drayage activity in the Los Angeles basin.

Exhibit 139: LALB Primary Outputs

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	19,511,263	0	0.0%
Drayage Trip Legs per Container	2.3	2.3	0.0	0.0%
Total Drayage VMT	268,111,709	268,111,709	0	0.0%
Drayage VMT per Container	31.7	31.7	0.0	0.0%
Fleet Required (FTE Tractors)	7,122	7,122	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	7,707,571	7,707,571	0	0.0%
Creep Hours	4,060,244	4,060,244	0	0.0%
Transient Hours	2,708,141	2,708,141	0	0.0%
Cruise Hours	6,634,950	6,634,950	0	0.0%
Total Drayage Hours	21,110,907	21,110,907	0	0.0%
Drayage Hours per Container	2.5	2.5	0.0	0.0%

- Over 19 million annual drayage trip legs covering over 260 million vehicle miles.
- 21 million hours of driver and tractor time.

The emissions totals are similarly high, due to the enormous volume.

Exhibit 140: LALB Emissions Estimates

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	297	297	0.00	0.0%
CO	1,735	1,735	0.00	0.0%
NOx	6,900	6,900	0.00	0.0%
PM_{10}	232	232	0.00	0.0%
$PM_{2.5}$	201	201	0.00	0.0%
CO_2	643,061	643,061	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	57,475,380	57,475,380	0.0	0.0%
Total Drayage Cost	$ 796,921,267	$ 796,921,267	$ -	0.0%
Drayage Cost per Container	$ 94	$ 94	$ -	0.0%

- Much greater total emissions than the other case studies, including 6,900 annual tons of NOx.
- Consumption of about 57 million gallons of diesel fuel creating 643,061 annual tons of CO_2.
- A total annual drayage cost of about $800 million.

The model estimates that 7,122 full-time equivalent tractors would be required to perform all this work. This number can be compared with the Ports' estimate of 16,800 "frequent and semi-frequent" trucks and about 24,000 "non-frequent" trucks. These numbers are more consistent than may first appear, since many of the 16,800 "frequent and semi-frequent" trucks also engage in domestic rail intermodal drayage of much of their time.

The driver labor cost figure of $12.00 per hour is roughly the center point of the $11.60 to $12.70 per hour range found by port-sponsored studies.

Southern California Intermodal Gateway Impacts

The proposed Southern California Intermodal Gateway (SCIG) would be a new off-dock rail terminal about 4 miles from the port terminals, supplanting Hobart yard which is 20 miles away. The DrayFLEET model can be used to estimate the drayage activity, emissions, and cost impact, in this instance by changing a single input value. As shown in Exhibit 141 development of SCIG would reduce the weighted average distance to off-dock rail terminals from about 14 miles to about 9 miles.

Exhibit 141: Impact of Closer Off-Dock Rail

	Default	Scenario
Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	14	9
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	15	15
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	40%	40%
Automated Gates (% of gate transactions)	50%	50%
Extended Gate Hours (% off-peak, 50% max)	30%	30%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	19,511,263	0	0.0%
Drayage Trip Legs per Container	2.3	2.3	0.0	0.0%
Total Drayage VMT	268,111,709	259,017,607	-9,094,102	-3.4%
Drayage VMT per Container	31.7	30.6	-1.1	-3.4%
Fleet Required (FTE Tractors)	7,122	6,935	-187	-2.6%
Annual Duty Cycle Totals				
Idle Hours	7,707,571	7,615,081	-92,490	-1.2%
Creep Hours	4,060,244	4,021,244	-39,000	-1.0%
Transient Hours	[illegible]	2,605,169	-102,972	-3.8%
Cruise Hours	6,634,950	6,313,856	-321,094	-4.8%
Total Drayage Hours	21,110,907	[illegible]	-555,556	-2.6%
Drayage Hours per Container	2.5	2.4	-0.1	-2.6%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	297	285	-12.08	-4.1%
CO	1,735	1,665	-69.88	-4.0%
NOx	6,900	6,605	-295.12	-4.3%
PM_{10}	232	222	-10.04	-4.3%
$PM_{2.5}$	201	193	-8.72	-4.3%
CO_2	643,061	615,370	-27,691	-4.3%
Fuel Use and Total Cost				
Fuel - Gallons	57,475,380	55,000,385	-2,474,995.0	-4.3%
Total Drayage Cost	$ 796,921,267	$ 775,240,276	$ (21,680,992)	-2.7%
Drayage Cost per Container	$ 94	$ 92	$ (3)	-2.7%

Because of the very large volumes involved the estimated impacts would be dramatic:

- A reduction of 9.1 million VMT and 555,556 annual tractor and driver hours.
- Annual emissions reductions ranging from 12 tons of HC to nearly 300 tons of NOx.
- Annual fuel savings of 2.4 million gallons, reducing CO_2 output by over 27,000 tons
- An annual drayage cost saving of over $21 million.

In this case the largest percentage reduction in drayage hours is in the cruise mode, since 20-mile trips would be replaced with 4-mile trips.

On-Dock Rail Impacts

The San Pedro Bay ports are encouraging greater use of on-dock rail facilities to reduce long-term reliance on highway drayage to off-dock rail terminals. The percentage of rail intermodal handled on-dock is a key factor in the Initiatives Inputs section of DrayFLEET. Exhibit 142 shows the impacts of increasing the share of on-dock rail from 40% to 60%.

Exhibit 142: Impacts of Greater On-Dock Rail

Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	14	14
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	15	15
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	40%	60%
Automated Gates (% of gate transactions)	50%	50%
Extended Gate Hours (% off-peak, 50% max)	30%	30%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	18,041,005	-1,470,257	-7.5%
Drayage Trip Legs per Container	2.3	2.1	-0.2	-7.5%
Total Drayage VMT	268,111,709	251,505,549	-16,606,159	-6.2%
Drayage VMT per Container	31.7	29.7	-2.0	-6.2%
Fleet Required (FTE Tractors)	7,122	6,572	-550	-7.7%
Annual Duty Cycle Totals				
Idle Hours	7,707,571	7,093,977	-613,594	-8.0%
Creep Hours	4,060,244	3,736,073	-324,171	-8.0%
Transient Hours	2,708,141	2,471,723	-236,419	-8.7%
Cruise Hours	6,634,950	6,178,381	-456,570	-6.9%
Total Drayage Hours	21,110,907	19,480,154	-1,630,754	-7.7%
Drayage Hours per Container	2.5	2.3	-0.2	-7.7%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	297	275	-22.34	-7.5%
CO	1,735	1,604	-130.96	-7.5%
NOx	6,900	6,393	-506.65	-7.3%
PM_{10}	232	215	-16.94	-7.3%
$PM_{2.5}$	201	187	-14.71	-7.3%
CO_2	643,061	595,996	-47,065	-7.3%
Fuel Use and Total Cost				
Fuel - Gallons	57,475,380	53,268,846	-4,206,533.4	-7.3%
Total Drayage Cost	$ 796,921,267	$ 732,673,305	$ (64,247,962)	-8.1%
Drayage Cost per Container	$ 94	$ 87	$ (8)	-8.1%

Here too, the large volumes of containers involved produce large impacts:

- Elimination of about 1.5 million annual drayage trips and 16.6 million VMT
- A savings of 1.6 million hours of driver and tractor time.
- Emissions reductions of 32 tons of PM, 507 tons of NOx, 131 tons of CO, and 22 tons of HC.
- Fuel savings of 4.2 million gallons, with about 47,000 fewer tons of CO_2.
- An annual drayage cost savings of $64 million.

Note that the DrayFLEET model does not cover the additional rail trips required to access the on-dock rail terminals. Separate modeling efforts would be required to analyze the complex tradeoffs involved.

Information and Appointment Systems

VoyagerTrack and eModal are two port community information system has been implemented at many of the LALB terminals. Both are designed to improve efficiency and decrease congestion by providing a single point of contact for multiple terminals. Both offer detailed container, vessel, and terminal information, a trucker status service, and a scheduling option. Draymen can:

- Query container and booking status at participating terminals, avoiding non-productive trips and maximizing driver effectiveness.
- Pay terminal and demurrage fees online using credit cards, debit cards, or electronic checks, avoiding terminal delays.
- Schedule appointments at participating terminals, thereby avoiding periods of known or expected congestion.

The appointment options are most effective when terminals ration appointment slots, so that only a given, manageable number of transactions are scheduled for the chosen time period, and when truckers abide by the appointments they have made. The benefits can be diluted when truckers do not make appointments or fail to show up as planned.

It is difficult to measure non-productive trips, since terminal systems do not ordinarily track bobtail arrivals to see if they have found the container they were seeking. Over time, the use of container information systems should have reduced the number of bobtail trips as a percentage of the total, but data on bobtail movements are sparse.

The model does reflect the reduced number of “trouble window” transactions which would otherwise result from drivers arriving before an import container have been cleared by Customs and Border Protection, with unpaid demurrage or other fees, or with incomplete paperwork.

The DrayFLEET model can be used to estimate the impacts of appointment and information systems by “backing out” their default 90% use rate to 0%. Exhibit 143 shows the estimated impacts of a one-minute savings in average gate transaction time.

Exhibit 143: Impacts of Appointment & Information Systems

Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	14	14
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	15	15
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00
Initiative Inputs	**Default**	**Scenario**
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	40%	40%
Automated Gates (% of gate transactions)	50%	50%
Extended Gate Hours (% off-peak, 50% max)	30%	30%
Container Info System (% used)	90%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	19,511,263	0	0.0%
Drayage Trip Legs per Container	2.3	2.3	0.0	0.0%
Total Drayage VMT	268,111,709	268,164,274	52,565	0.0%
Drayage VMT per Container	31.7	31.7	0.0	0.0%
Fleet Required (FTE Tractors)	7,122	7,219	97	1.4%
Annual Duty Cycle Totals				
Idle Hours	7,707,571	7,965,426	257,855	3.3%
Creep Hours	4,060,244	4,089,447	29,203	0.7%
Transient Hours	2,708,141	2,708,141	0	0.0%
Cruise Hours	6,634,950	6,634,950	0	0.0%
Total Drayage Hours	21,110,907	21,397,965	287,058	1.4%
Drayage Hours per Container	2.5	2.5	0.0	1.4%
Emissions Outputs	**Default**	**Scenario**	**Change**	**% Change**
Pollutant (annual tons)				
HC	297	298	1.01	0.3%
CO	[illegible]	1,741	6.21	0.4%
NOx	6,900	6,917	17.11	0.2%
PM	232	232	0.52	0.2%
$PM_{2.5}$	201	202	0.45	0.2%
CO_2	643,061	644,573	1,512	0.2%
Fuel Use and Total Cost				
Fuel - Gallons	57,475,380	57,610,529	135,149.0	0.2%
Total Drayage Cost	$ 796,921,267	$ 803,084,522	$ 6,163,254	0.8%
Drayage Cost per Container	$ 94	$ 95	$ 1	0.8%

By reducing the 90% usage rate down to zero, the model estimates that drayage drivers and tractors would have spent an additional 257,855 hours idling and 29,203 hours in creep mode, with emissions increases of 0.2%-0.4% and an increase in total drayage cost of 0.8%.

Combined and Potential Impacts. The port terminals at Los Angeles and Long Beach have implemented a number of the initiatives discussed above, but as the inputs in the LALB model show, use of automated gates, appointment systems, etc. is not yet universal. The benefits of implementation thus far, however, are substantial. Exhibit 144 shows the effect of “zeroing out” the LALB initiatives, focusing on the immediate port area by setting a five-mile limit on drayage to customers or rail facilities[14]. By the results shown in Exhibit 144, the various initiatives have:

- Reduced drayage trips by 15.1% and hours by 25.5%

[14] This modeling exercise effectively “moves” the LALB rail terminals closer to the ports, since some are more than five miles away.

- Reduced 2007 emissions by 16.6% to 18.9%
- Reduced fuel use by 16.8% and cost by 22.3%

Exhibit 144: LALB Combined Initiatives Impact - Five Mile Limit

Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	0%
On-Dock Rail (% of rail on-dock)	40%	0%
Automated Gates (% of gate transactions)	50%	0%
Extended Gate Hours (% off-peak, 50% max)	30%	0%
Container Info System (% used)	90%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	0%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	19,511,263	22,451,777	2,940,515	15.1%
Drayage Trip Legs per Container	2.3	2.7	0.3	15.1%
Total Drayage VMT	169,539,823	193,968,171	24,428,348	14.4%
Drayage VMT per Container	20.0	22.9	2.9	14.4%
Fleet Required (FTE Tractors)	5,720	7,181	1,461	25.5%
Annual Duty Cycle Totals				
Idle Hours	7,015,578	8,596,046	1,580,468	22.5%
Creep Hours	3,768,454	5,646,815	1,878,361	49.8%
Transient Hours	1,937,722	2,285,782	348,060	18.0%
Cruise Hours	4,232,580	4,756,630	524,050	12.4%
Total Drayage Hours	16,954,334	21,285,274	4,330,939	25.5%
Drayage Hours per Container	2.0	2.5	0.5	25.5%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	208	246	38.65	18.6%
CO	1,217	1,447	229.96	18.9%
NOx	4,705	5,506	800.86	17.0%
PM_{10}	157	183	26.14	16.6%
$PM_{2.5}$	137	159	22.69	16.6%
CO_2	437,023	510,428	73,405	16.8%
Fuel Use and Total Cost				
Fuel - Gallons	39,060,167	45,620,955	6,560,788.0	16.8%
Total Drayage Cost	$ 632,063,845	$ 773,199,816	$ 141,135,971	22.3%
Drayage Cost per Container	$ 75	$ 91	$ 17	22.3%

Because these initiatives are not yet universal, there is the potential for further reductions. Exhibit 145 uses the DrayFLEET model to estimate the theoretical potential impact if all modeled port initiatives were 100% implemented at LALB (except extended gate hours, which reach maximum at 50%). The defaults for port initiatives were initially reset to 0%, then a scenario was created with maximum implementation. Compared to a "no initiative" default, the combined initiatives would save:

- 34.2% of drayage trips (largely from on-dock rail, which may never become universal) and 40.3% of drayage hours
- 33% to 36% of emissions
- 33.9% of the fuel
- 39.5% of the cost

Exhibit 145: LALB - Potential Impact of Combined Initiatives – Five Mile Limit

	Default	Scenario
Rail Intermodal Share	45%	45%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	15	15
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	0%	100%
On-Dock Rail (% of rail on-dock)	0%	100%
Automated Gates (% of gate transactions)	0%	100%
Extended Gate Hours (% off-peak, 50% max)	0%	50%
Container Info System (% used)	0%	100%
Virtual Container Yard (% available)	0%	100%
Neutral Chassis Pool (% used)	0%	100%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	22,451,777	14,765,756	-7,686,021	-34.2%
Drayage Trip Legs per Container	2.7	1.7	-0.9	-34.2%
Total Drayage VMT	191,702,242	130,436,081	-61,266,161	-32.0%
Drayage VMT per Container	22.6	15.4	-7.2	-32.0%
Fleet Required (FTE Tractors)	6,734	4,019	-2,715	-40.3%
Annual Duty Cycle Totals				
Idle Hours	8,529,438	5,288,629	-3,240,809	-38.0%
Creep Hours	4,387,966	1,908,532	-2,479,434	-56.5%
Transient Hours	2,285,782	1,324,108	-961,675	-42.1%
Cruise Hours	4,756,630	3,391,117	-1,365,514	-28.7%
Total Drayage Hours	19,959,816	11,912,385	-8,047,431	-40.3%
Drayage Hours per Container	2.4	1.4	-1.0	-40.3%

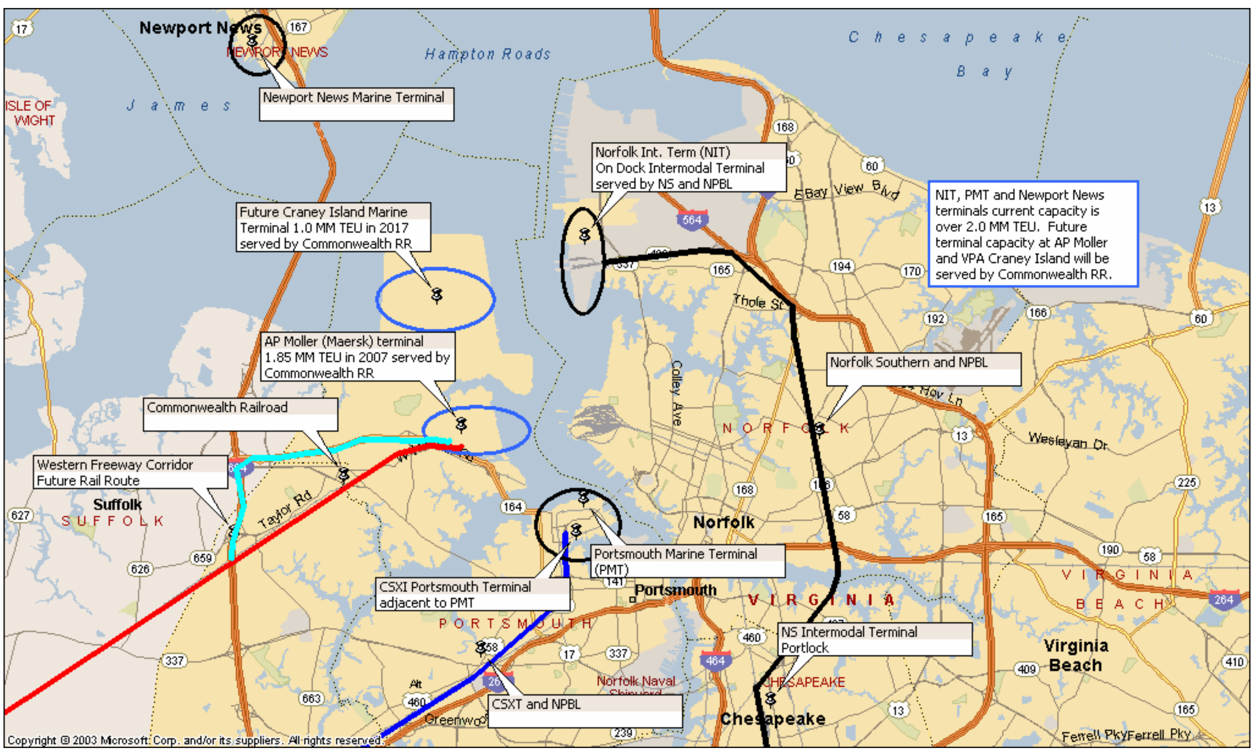
Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	239	153	-86.13	-36.0%
CO	1,403	893	-509.96	-36.3%
NO_x	5,385	3,544	-1,841.01	-34.2%
PM_{10}	180	119	-60.60	-33.7%
$PM_{2.5}$	156	103	-52.61	-33.7%
CO_2	499,723	330,173	-169,549	-33.9%
Fuel Use and Total Cost				
Fuel - Gallons	44,664,125	29,510,172	-15,153,953.4	-33.9%
Total Drayage Cost	$ 743,208,222	$ 449,740,628	$ (293,467,595)	-39.5%
Drayage Cost per Container	$ 88	$ 53	$ (35)	-39.5%

Virginia Case Study

Overview

The Port of Virginia (Exhibit 146) includes Norfolk International Terminals, Newport News Marine Terminal, Portsmouth Marine Terminal, and the Virginia Inland Port in Front Royal. Combined with a new private terminal (AP Moeller) that opened in 2007, these four facilities make up The Port of Virginia. This case study focuses on the container terminals owned by the Virginia Port Authority (VPA). Included are Norfolk International Terminals (NIT) and Portsmouth Marine Terminal (PMT), the two marine container terminals. Newport News Marine terminal (NNMT) is primarily a break bulk and project cargo terminal, but does handle a minimal amount of container business that is covered in this study. The Virginia Inland Port is linked to NIT by rail rather than by over-the-road drayage, and its activity is reflected in the rail intermodal share. The recently opened Maersk Terminal (APM) is not part of VPA, and not covered in this report.

Exhibit 146: Port of Virginia



VPA handled 2,046,285 TEU in 2006 and 2,128,366 in 2007. The container counts were 1,177,628 in 2006 and 1,221,591 in 2007, yielding a stable ratio of 1.74 TEU per container. About 25% are empty. This is the port industry standard for measuring containerized cargo volumes. Almost all international containers moving through ports are either twenty-foot or forty-foot containers.

The distribution of containerized cargo at VPA is as follows.

- 27% by rail
- 8% by barge
- 10–20% local Norfolk
- 45%–55% long distance drayage.

The three VPA container terminals are operated by Virginia International Terminals (VIT). VIT is an affiliate of VPA providing one common operator across all VPA marine terminals and a consistent source of information. The VPA/VIT container terminals at Norfolk have a distinctive operating system that is reflected in drayage movement patterns and the DrayFLEET model version for Norfolk. In common with many Asian and European container terminals, containers at PMT and NIT are lifted on and off the chassis at designated transfer zones. The drayage drivers and tractors do not enter the container stacks in the main container yard. At PMT and NIT, this process is accomplished with straddle carriers, which shuttle between the transfer zones and the container stacks.

The relative magnitude of the truck traffic associated with each facility is shown in Exhibit 147

Exhibit 147: VPA Truck Movement Proportions

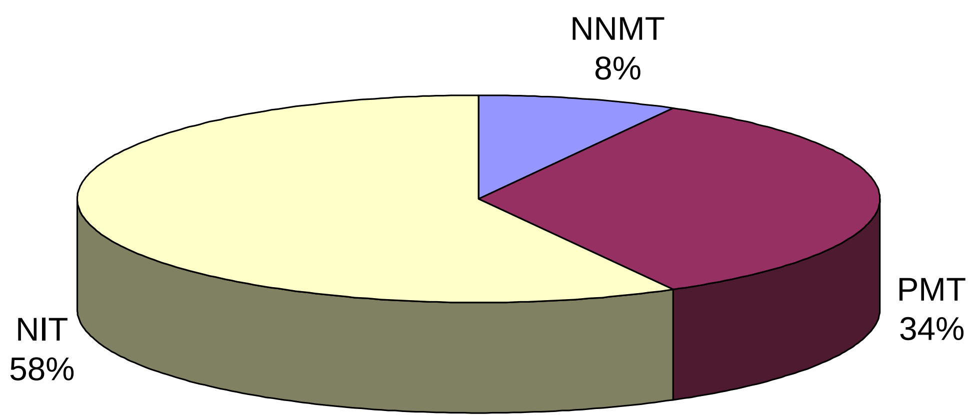


Exhibit 148 through Exhibit 151 show volumes for the VIT gates, container yard, trucker flow, and rail intermodal flow for October 2006 through May 2007. The Gate flow is the total of Truck and Container Yard (empties). The charts show the success of the VPA's gate demand management strategy in diverting about 20% of the truck flow away from the main gates by the use of the Container Yard facilities.

Exhibit 148: VIT Terminal Gate Flow, October 2006 – May 2007

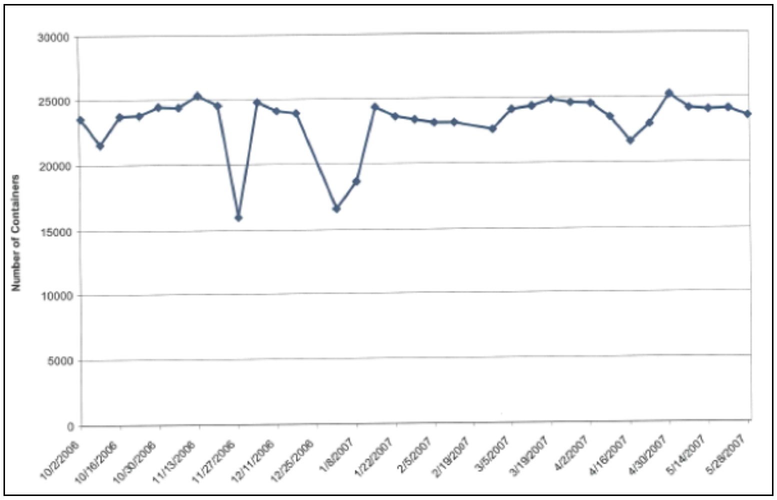


Exhibit 149: VIT Terminal Container Yard (Empty) Flow, October 2006 – May 2007

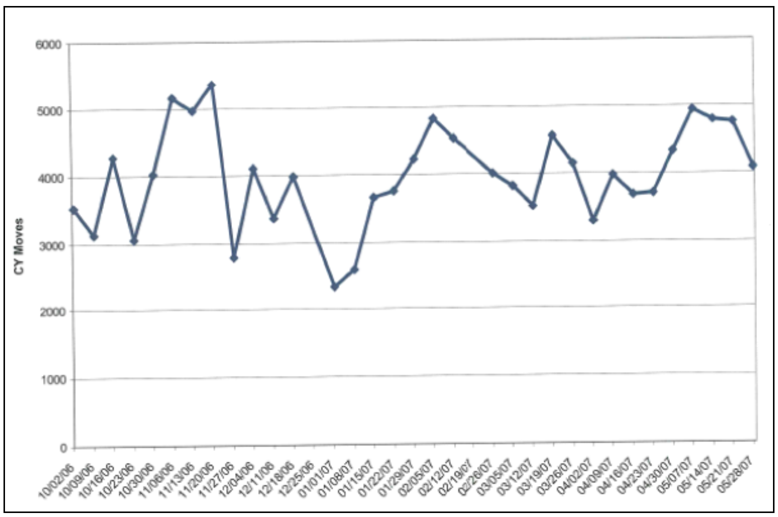


Exhibit 150: VIT Terminal Truck Flow, October 2006 – May 2007

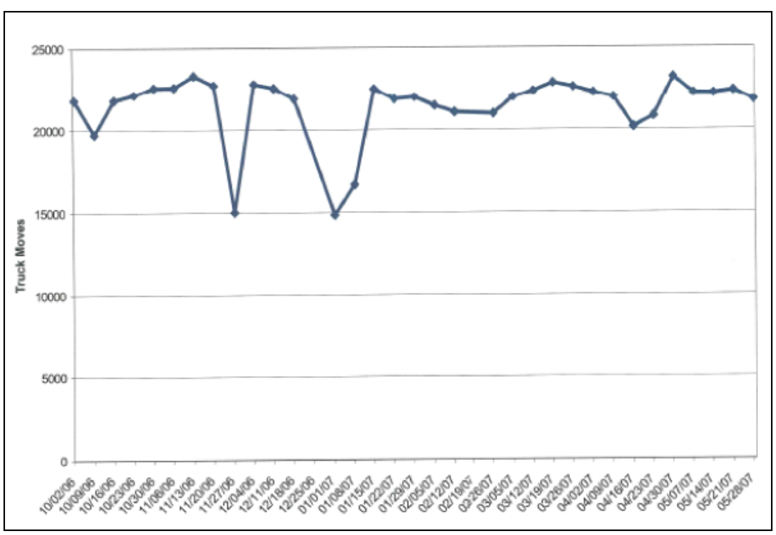
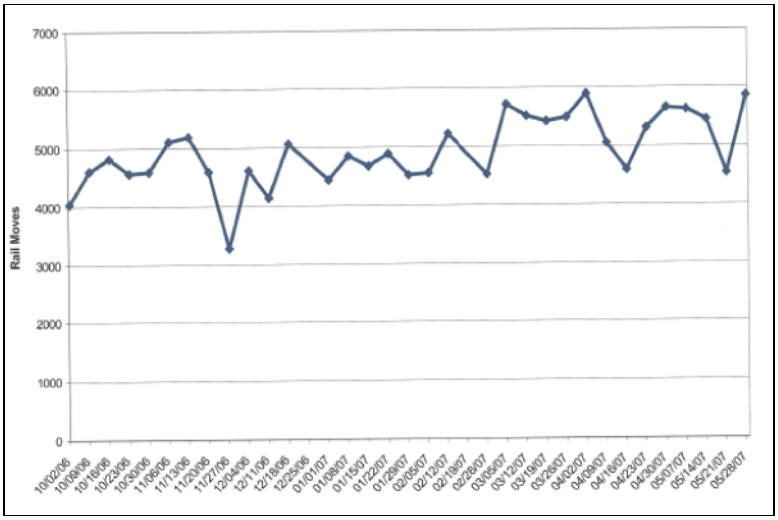


Exhibit 151 illustrates the magnitude and current trend of the rail segment.

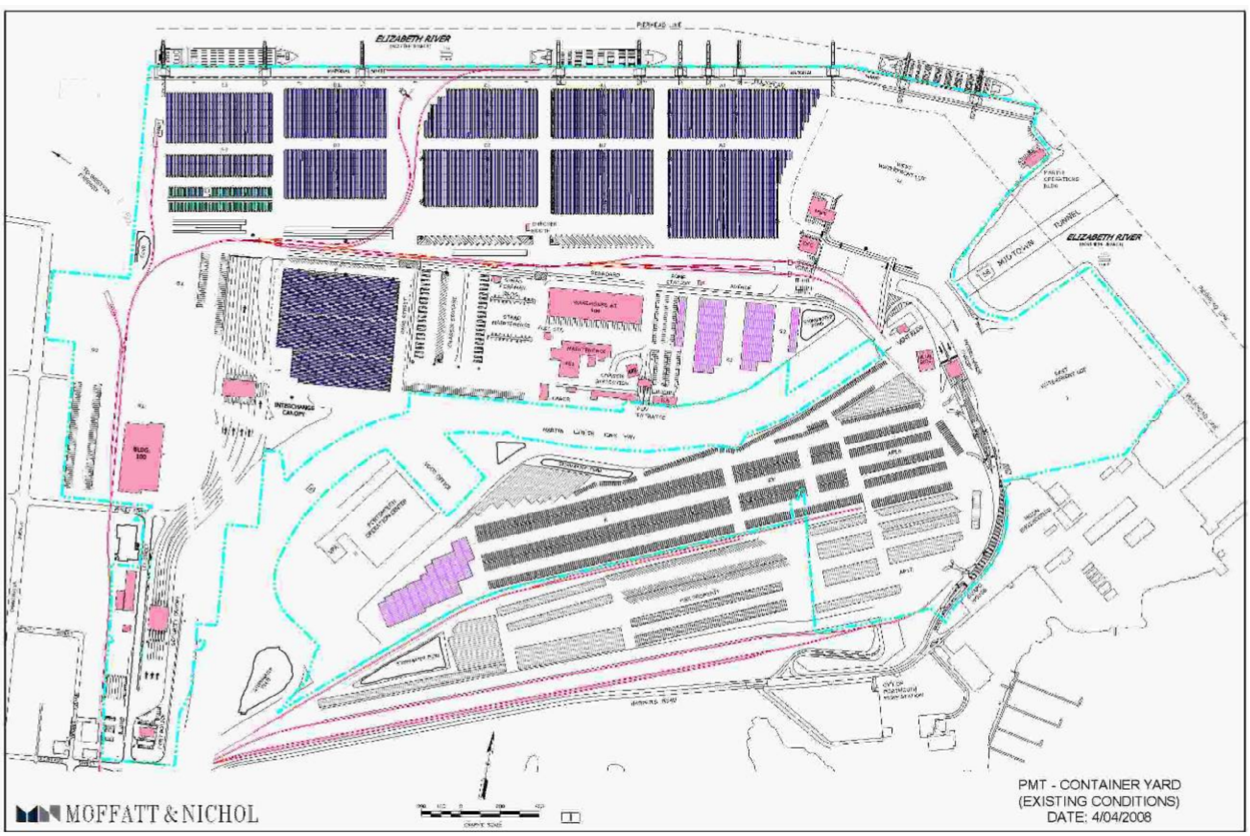
Exhibit 151: VIT Rail Intermodal Volume October 2006 – May 2007



Portsmouth Marine Terminal

Portsmouth Marine Terminal (PMT, Exhibit 152) is the more compact of the two main marine container terminals, and is located close to the center of the Norfolk port area.

Exhibit 152: Portsmouth Marine Terminal

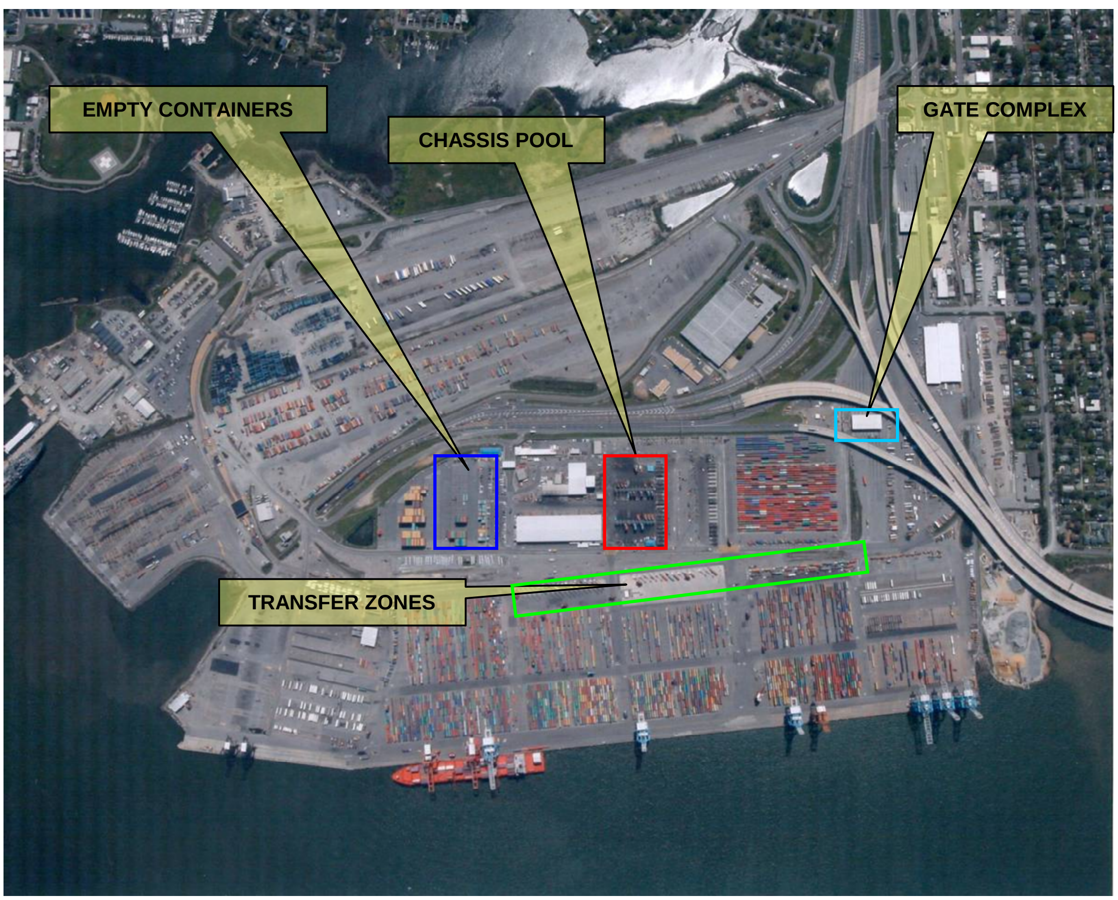


CSX serves a small intermodal terminal across the street from the PMT (at the bottom of Exhibit 152). This is nearly, but not quite, an on-dock facility.

Exhibit 153 and Exhibit 154 show the key features of PMT from a drayage perspective.

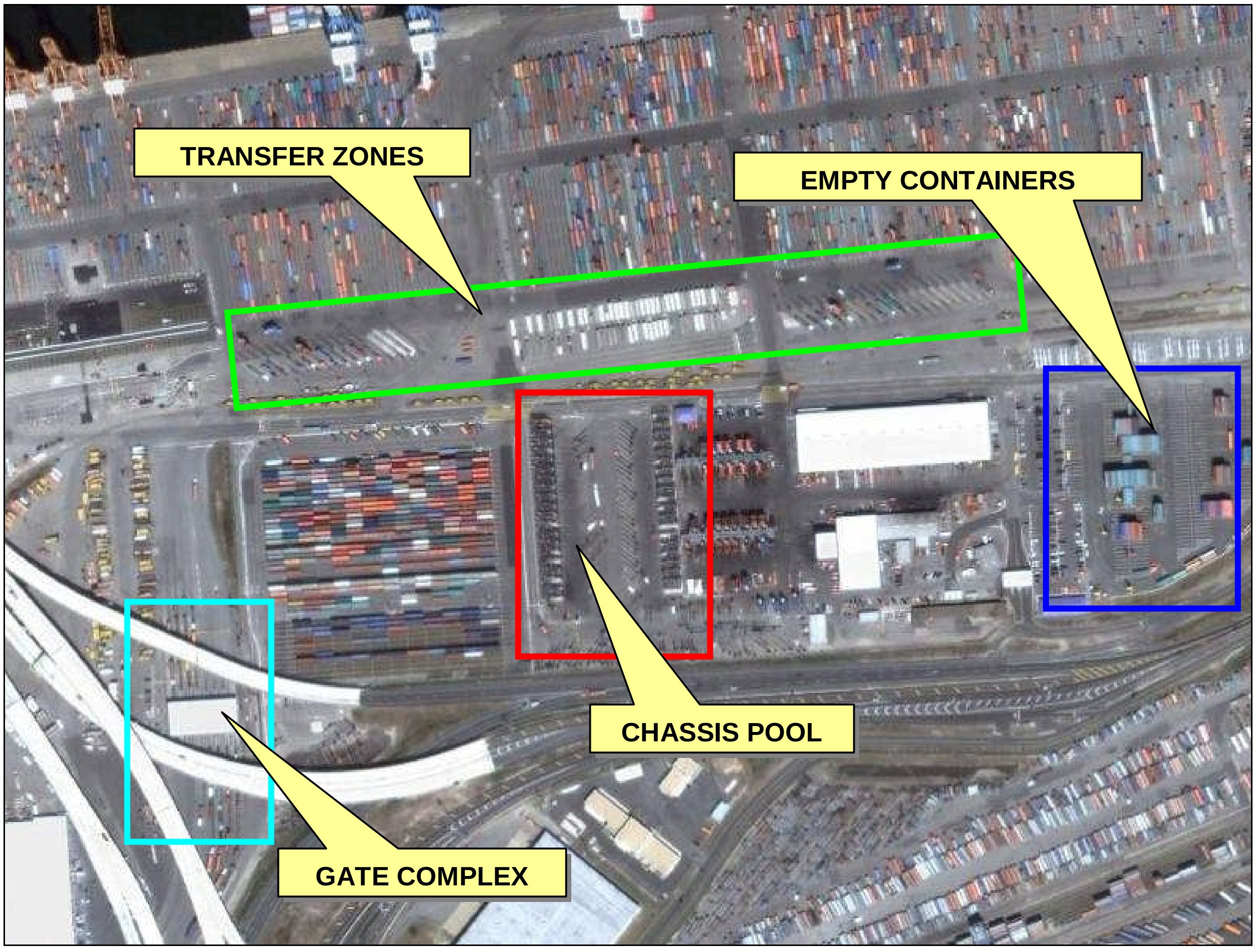
- Truckers arriving to pick up or drop off loads pass through the gate complex. Gate operations reportedly take 2 minutes.
- Bare chassis are stored in racks and on the ground at the pool location. Truckers needing a chassis will pick one up before going to the transfer zone. Truckers returning a bare chassis will drop it here. This process should be quick – 10 minutes for pickup, 5 minutes for drop-off.
- Truckers wait in the transfer zone to receive loaded containers or to have loaded containers lifted off the chassis (or both). The transfer zone exchange is quick, averaging 6 minutes according to VPA data.
- Truckers picking up or dropping off empty containers normally do so at the empty container yard (“PCY” at PMT, “NCY” at NIT). The empty container yard can be accessed without passing through the terminal gates complex.

Exhibit 153: PMT Terminal Features



Source: Port of Virginia

Exhibit 154: PMT Terminal Features Zoom



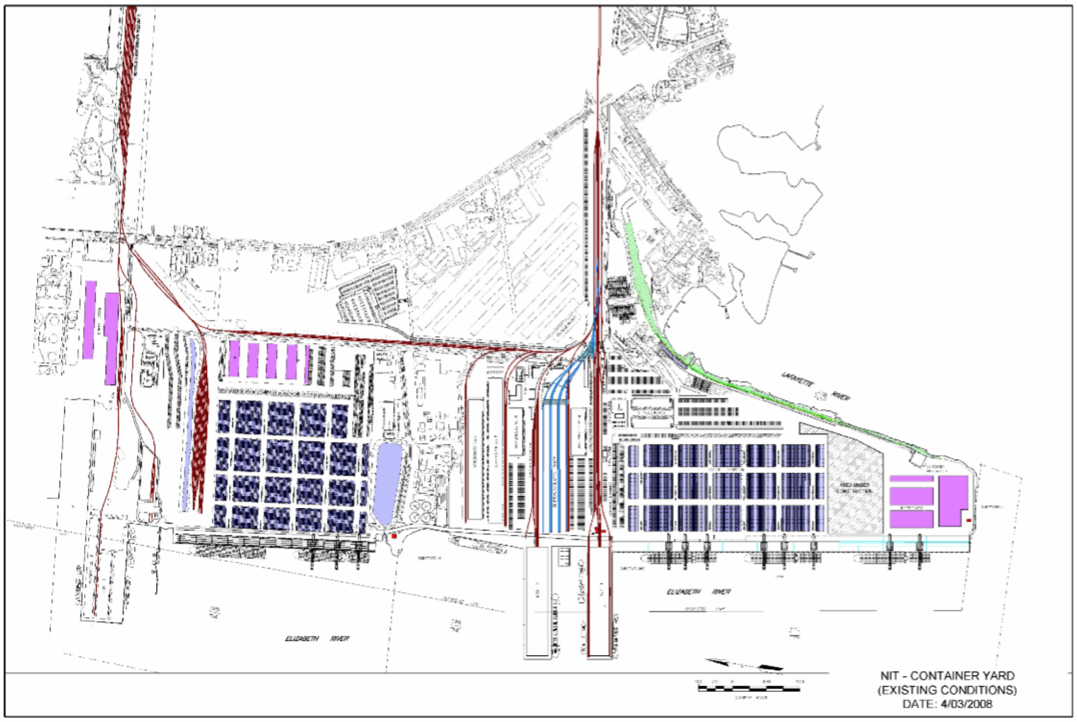
The full drayage activity cycle can also include movements to or from the chassis pool site and the empty container storage yard, as required by the transaction. The use of designated transfer zones reduces the distance traveled by outside draymen within the marine terminal. The total drayage turn time may be more or less than at a wheeled terminal, depending on multiple factors.

Norfolk International Terminals

The NIT complex (Exhibit 155) includes multiple cargo handling operations. NIT is a stacked terminal, with containers stored off their chassis. NIT operates basically the same as PMT, but is configured differently.

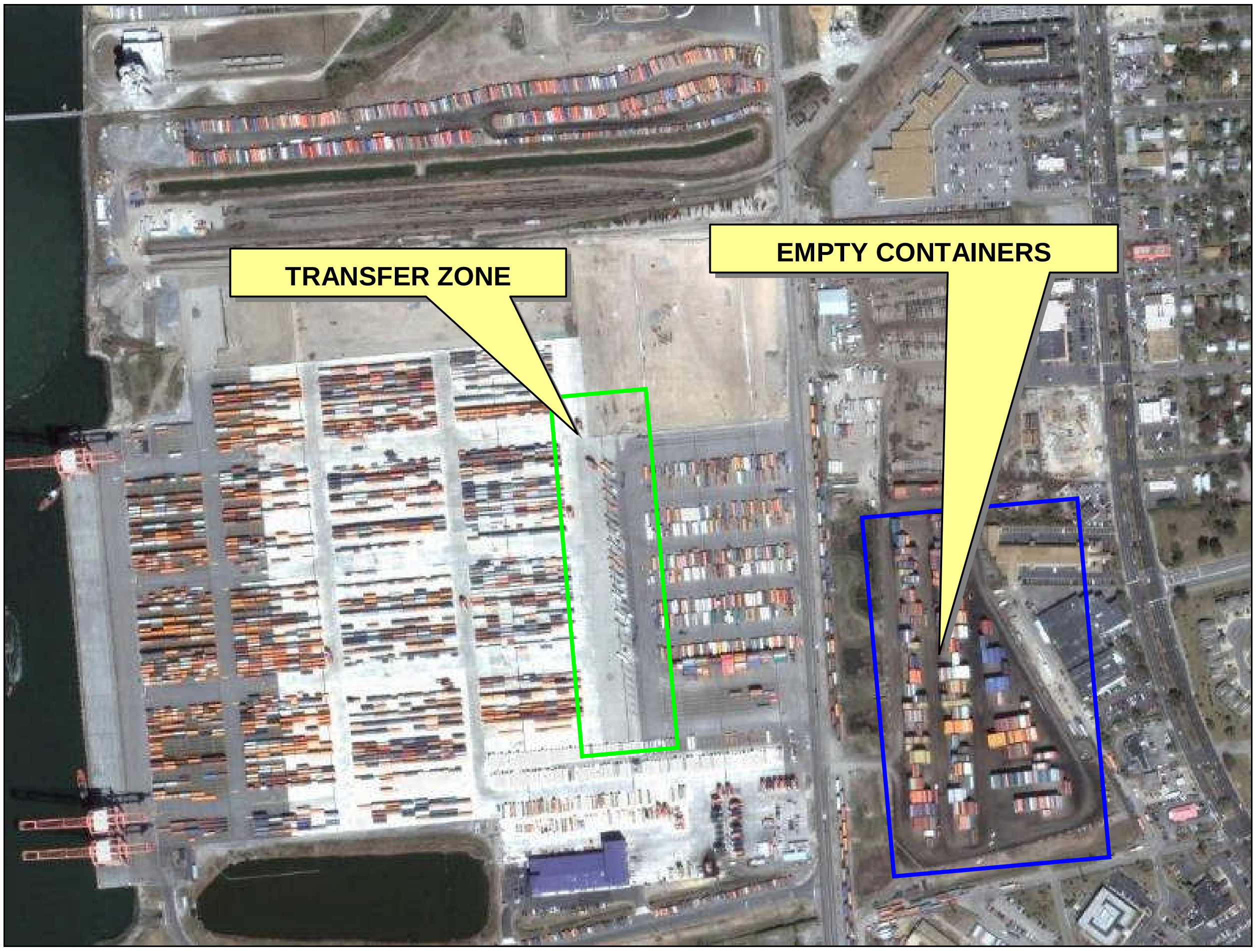
NIT also incorporates an on-dock rail intermodal terminal served by Norfolk Southern (NS). Technically, CSX can serve the facility but has not found it practical. CSX's small eastbound flow for NIT is drayed from their facility outside PMT.

Exhibit 155: Norfolk International Terminal



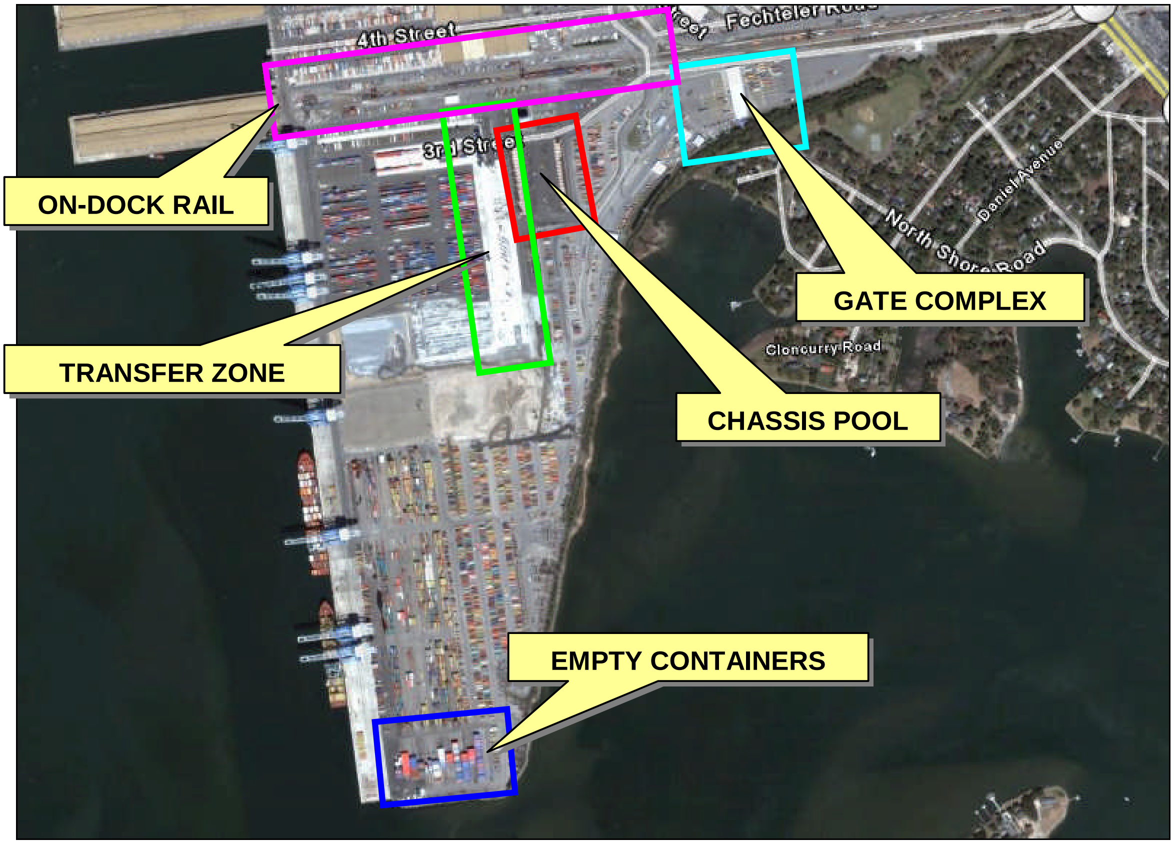
The north portion (NNIT, Exhibit 156) has its own transfer zone and empty container storage. The south portion (SNIT, Exhibit 157) has the single gate complex serving all of NIT and the NS-served on-dock rail transfer facility, as well as its own transfer zone, empty container storage, and chassis pool.

Exhibit 156: North NIT Aerial View



Source: Google Earth

Exhibit 157: South NIT Aerial View



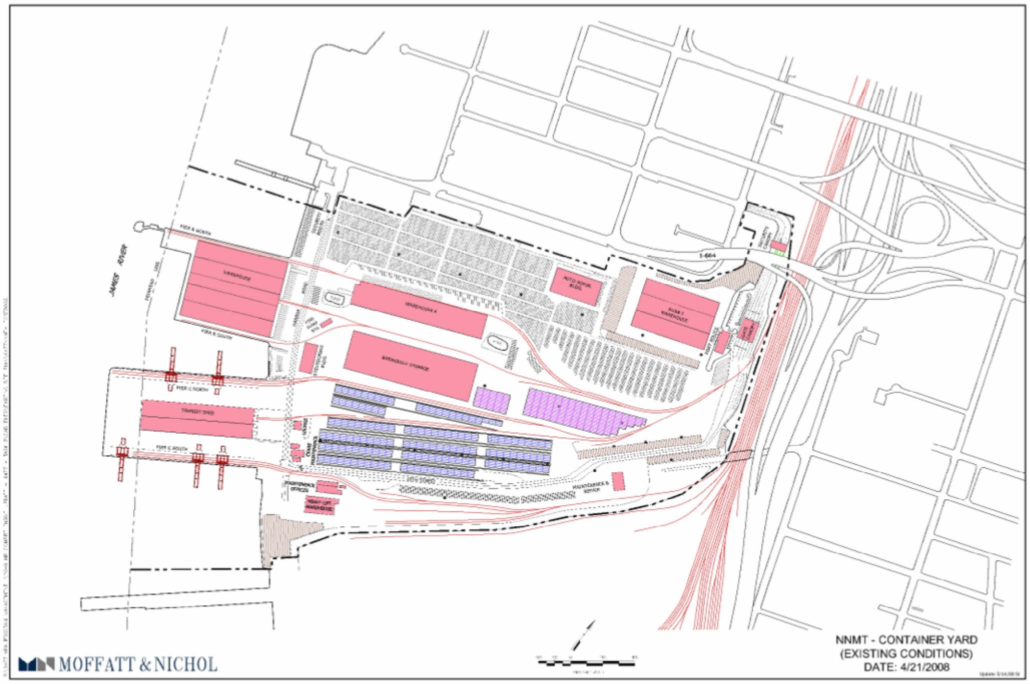
Source: Google Earth

NIT is in the process of reconfiguration. While the key elements shown in the exhibits are always present, their size and location can vary. This variation is particularly true of the empty container storage yards, which can be easily relocated.

Newport News Terminal

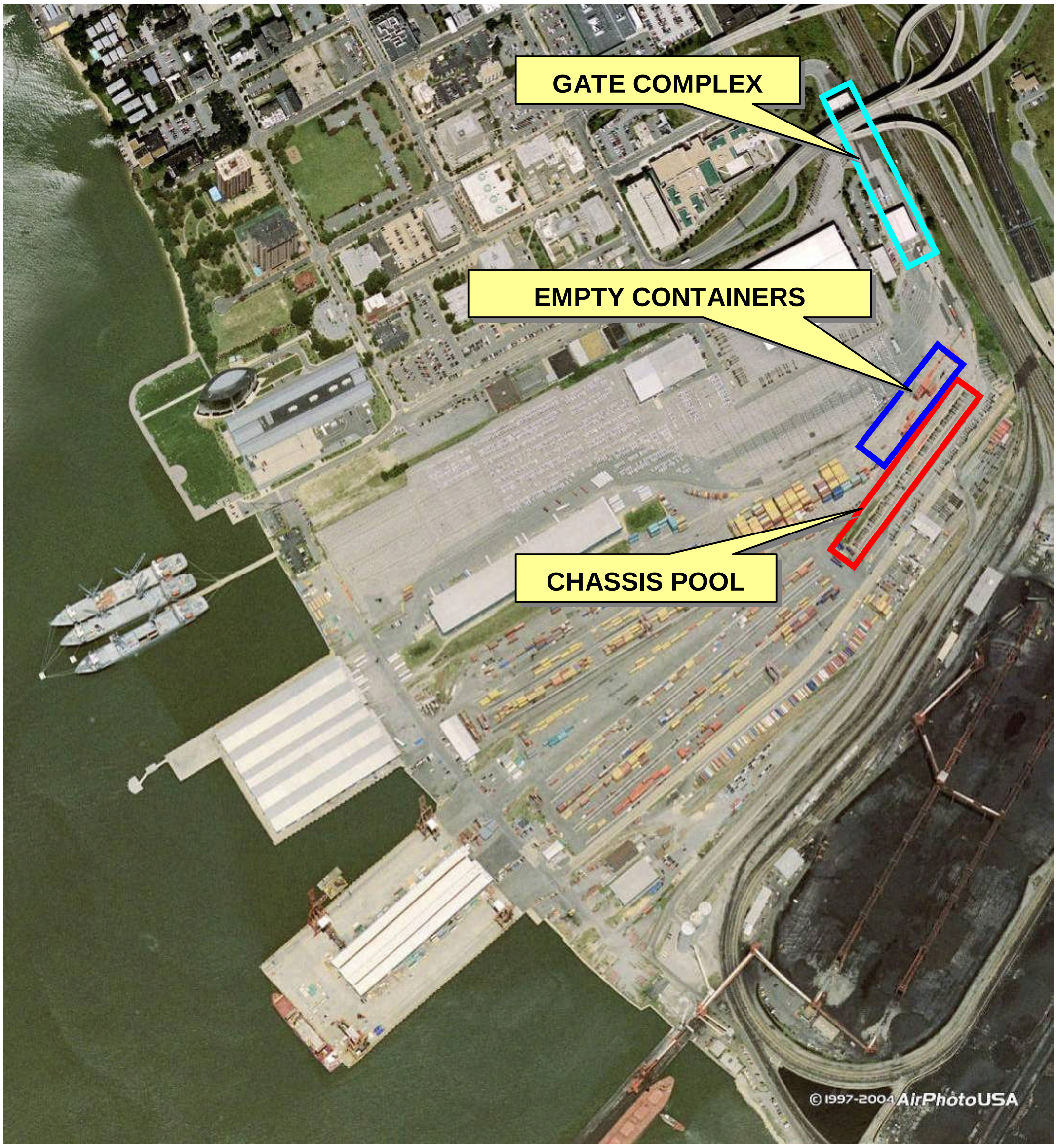
Newport News Marine Terminal (Exhibit 158) is a smaller, simpler operation.

Exhibit 158: Newport News Marine Terminal



As Exhibit 159 shows, it has some of the same basic elements: a gate area, chassis storage, and empty container storage. These elements are closer together, and sized for NNMT's container volume. At NNMT, containers are transferred to and from trucks by reach stackers in the container yard.

Exhibit 159: Newport News Aerial View



Source: Air Photo USA

Drayage Operations

The Norfolk marine terminals serve a substantial market beyond the immediate urban area. The population of the Norfolk metropolitan area is approximately 1.6 million, but the port also provides primary marine facility access for the Commonwealth of Virginia's 7.6 million people as well as for much of Eastern North Carolina and Maryland. The port also records significant truck volume moving to Western North Carolina, Tennessee and Kentucky. Norfolk port drayage operations are therefore characterized by a greater frequency of medium range (100-250 mile) movements than a more compact hinterland such as urban New York/New Jersey.

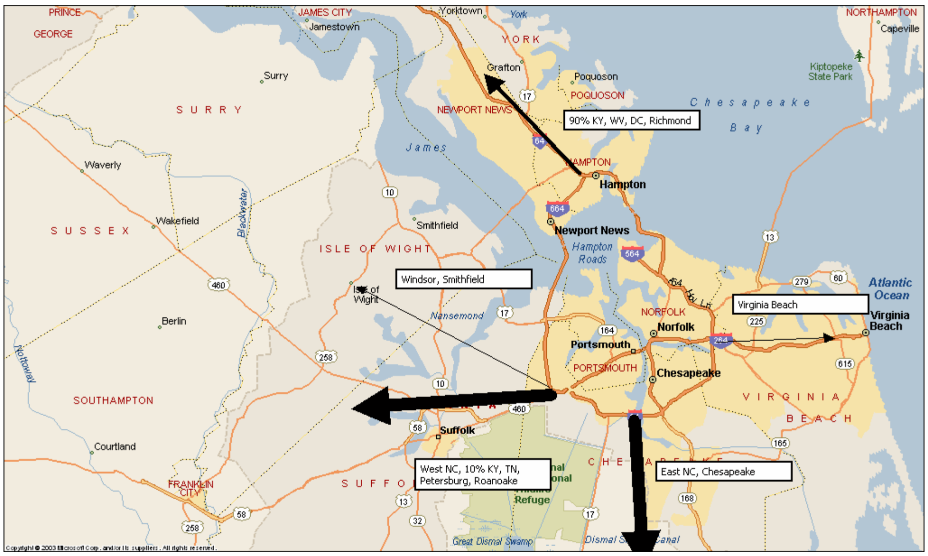
Some of the major metropolitan areas in VPA's primary service zone are shown in Exhibit 160.

Exhibit 160: Key VPA Service Points

City	Distance	Population
Richmond, VA	92 Miles	1.2 Million
Raleigh, NC	183 Miles	1.0 Million
Washington, DC	194 Miles	5.3 Million
Greensboro, NC	238 Miles	.7 Million

The VPA has measured the relative traffic flows outside the metropolitan area. The relative magnitude of those flows is identified in Exhibit 161.

Exhibit 161: Relative Medium Distance Drayage Flows



Transaction Time Data

Load/load turn times vary between under 40 to 55 minutes depending on the terminal and time of day and year. As Exhibit 162 indicates, average overall trucker turn times at PMT have averaged about 50 minutes, with a slowdown in November and faster turn times in January–February. By contrast, the turn times at NIT show a downward trend, with averages of about 58 minutes in 2007 declining to about 53 minutes in mid-2007 (Exhibit 163).

Exhibit 162: PMT Average Trucker Turn Times June 2005–May 2007

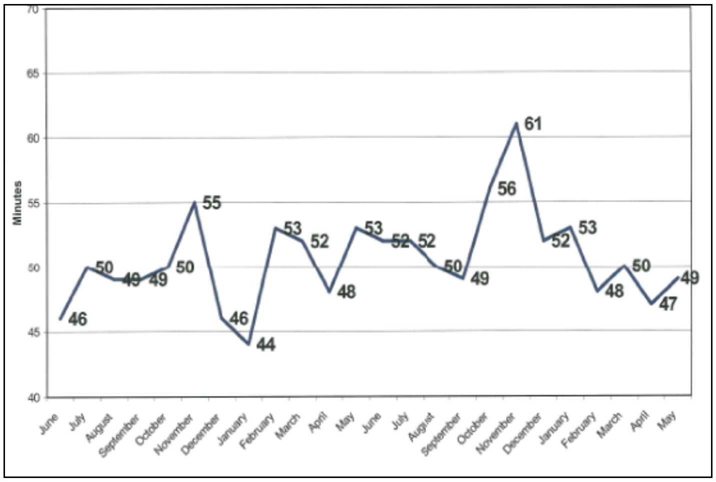
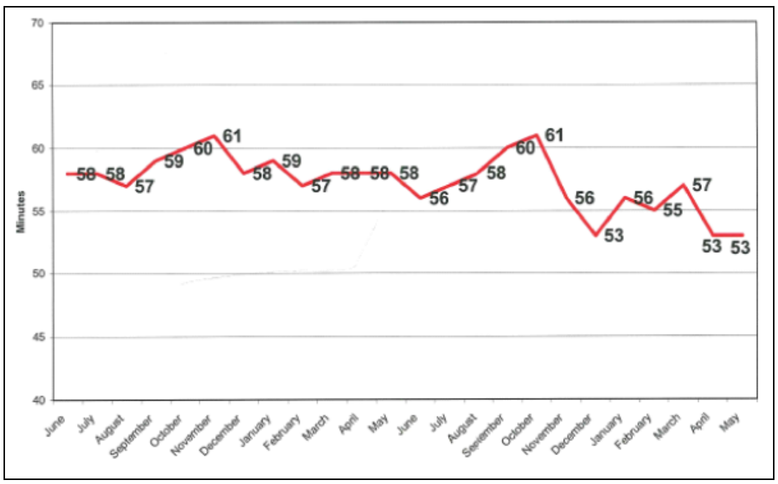


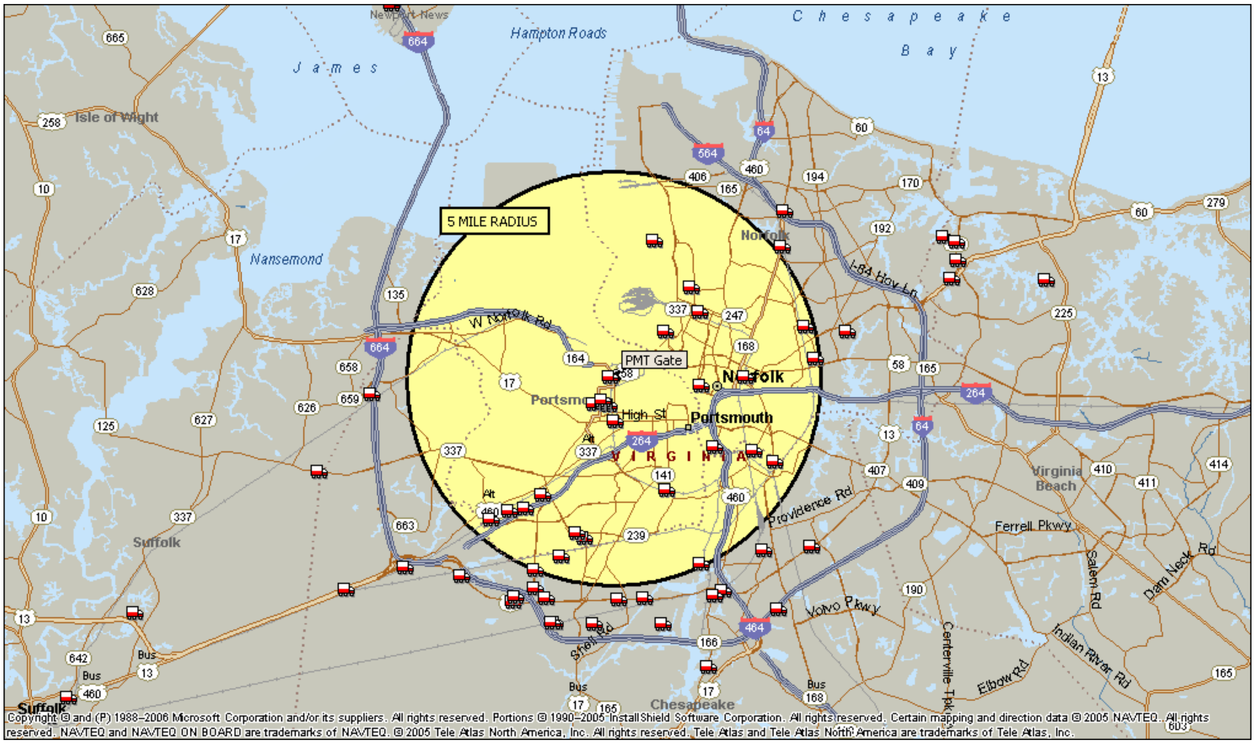
Exhibit 163: NIT Average Trucker Turn Times June 2005–May 2007



Norfolk Area Drayage Firms

As Exhibit 164 illustrates, Norfolk area port drayage firms are grouped in industrial and commercial areas surrounding the port terminals, typically about five miles from the PMT gate.

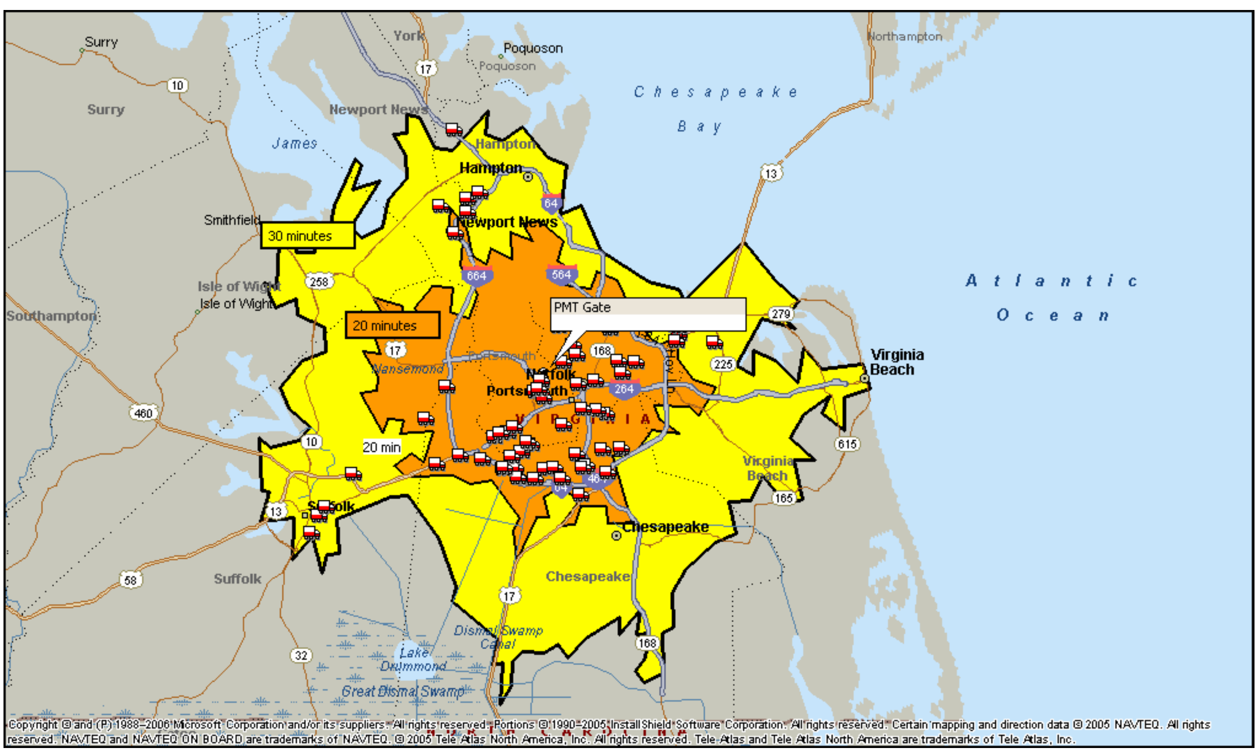
Exhibit 164: Norfolk Area Drayage Firms



Source: VPA Directory

Most are within 20 minutes of the PMT gate, which is roughly in the center of the port area. The rest are within 30 minutes (Exhibit 165)

Exhibit 165: Norfolk Drivetime Zones



Gate and Terminal Cameras

Gate and container yard/transfer zone cameras are in place at the Port of Virginia terminals and accessible to drayage dispatchers over the Internet (Exhibit 166). The cameras show current activity at each critical location (Exhibit 167, Exhibit 168), enabling drayage dispatchers and drivers to avoid congestion where possible. It is not possible to avoid congested periods completely, since drivers must meet customer requirements such as inbound import delivery within a scheduled window or delivery of an export load to the terminal in time for an outbound sailing. Drivers do, however, have some discretion over such trips as empty returns or obtaining an empty container for export loading.

Exhibit 166: VIT Map Showing Terminals and Gate Camera Links

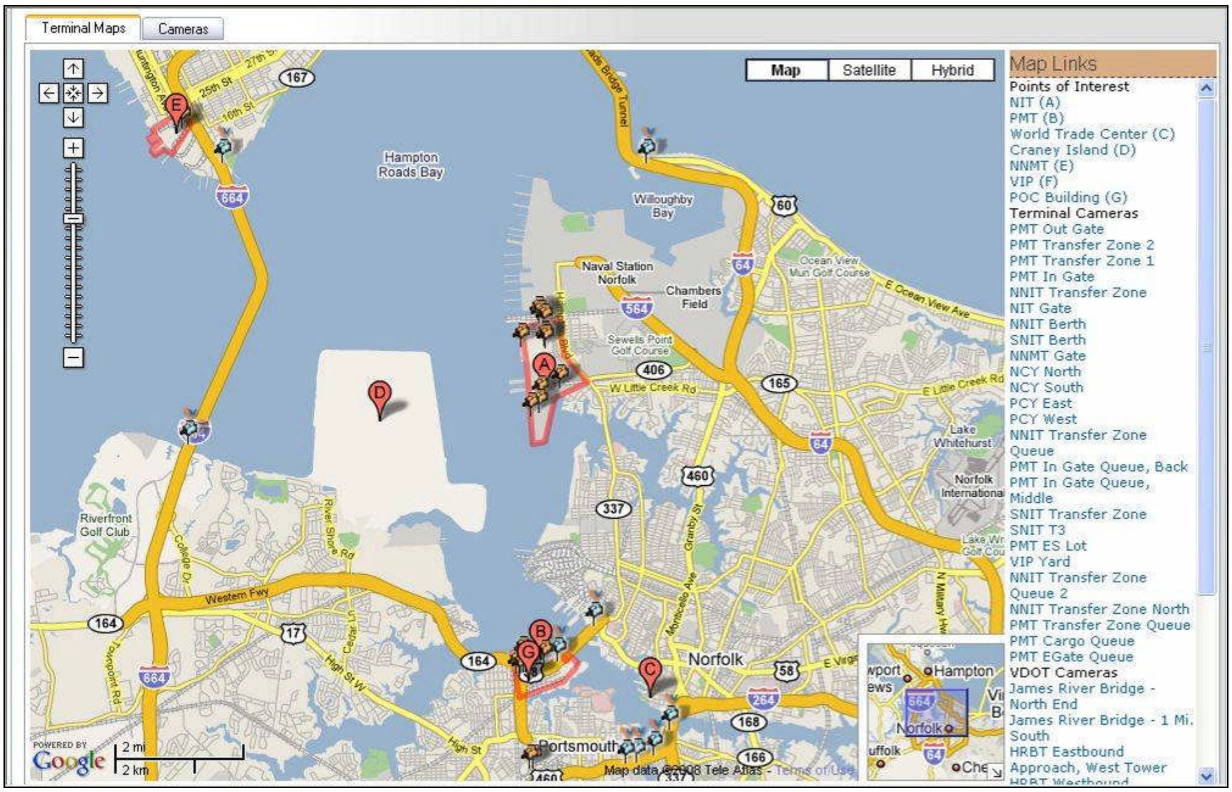


Exhibit 167: VIT Gate Camera Internet Access

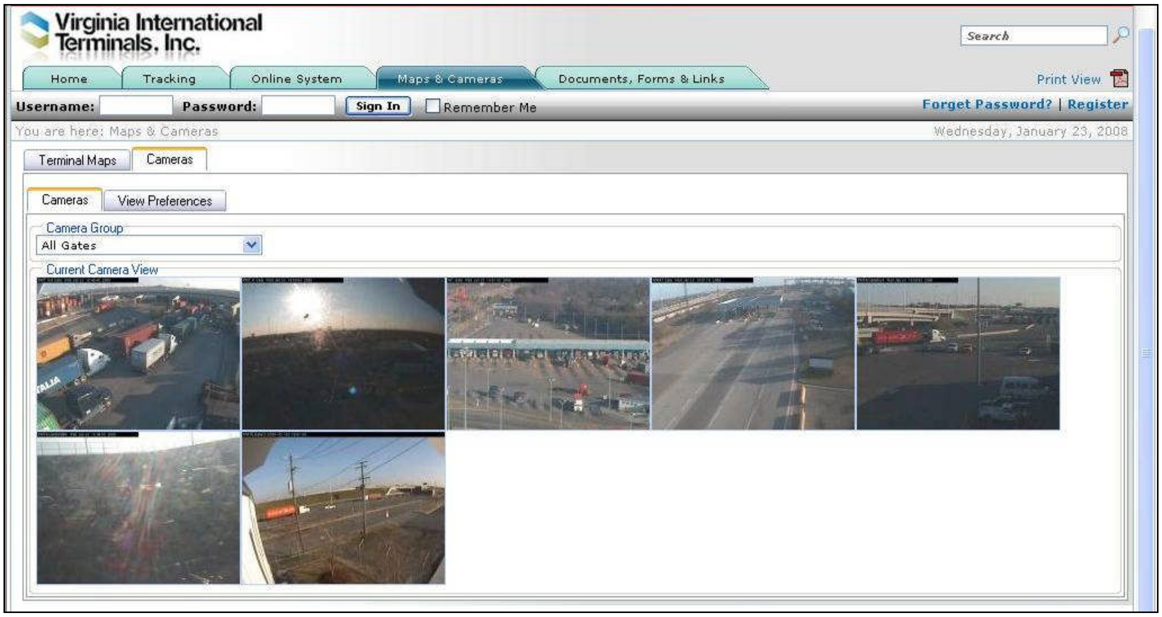


Exhibit 168: NIT Gate Camera Image Sample

eModal

The eModal port community information system has been implemented at all of the VPA terminals. As noted elsewhere, eModal was designed to improve efficiency and decrease congestion by providing a single point of contact for multiple terminals. eModal offers detailed container, vessel, and terminal information, a trucker status service, and a scheduling option. Draymen can:

- Query container and booking status at participating terminals, avoiding non-productive trips and maximizing driver effectiveness.

- Pay terminal and demurrage fees online using credit cards, debit cards, or electronic checks, avoiding terminal delays.

Neutral Chassis Pool

VIT, the private non-stock operating company of the Virginia Port Authority, and OCEMA, the Ocean Carrier Equipment Management Association, teamed up to create the Hampton Roads Chassis Pool II (HRCP II) at The Port of Virginia, which includes Norfolk International Terminals, Newport News Marine Terminal, and Portsmouth Marine Terminal. This neutral chassis pool resulted in a 23 percent reduction in the equipment inventory and a 27 percent increase in asset utilization – comparable to the results obtained in NYNJ. VIT manages HRCP II for 27 ocean carriers serving The Port of Virginia. The steamship lines supply chassis in proportion to the amount of business they move through the marine terminals. Draymen have the flexibility to use any participating company's chassis instead of having to spend time matching a particular ocean carrier's chassis with its container.

Neutral chassis pools also typically maintain chassis to a higher standard, so draymen are less likely to be delayed by having to locate a roadworthy chassis in a parking lot full of questionable equipment, and less likely to be delayed by the need to repair the best available chassis. There should be no need for time-consuming chassis "flips" – transferring a container from one chassis to another.

Virtual Container Yard

Off Terminal Container Solutions is an Internet-based program that facilitates street turns. OTCS is a Virtual Container Yard (VCY) that gives participating motor carriers the ability to post and view containers that are available for street turns.

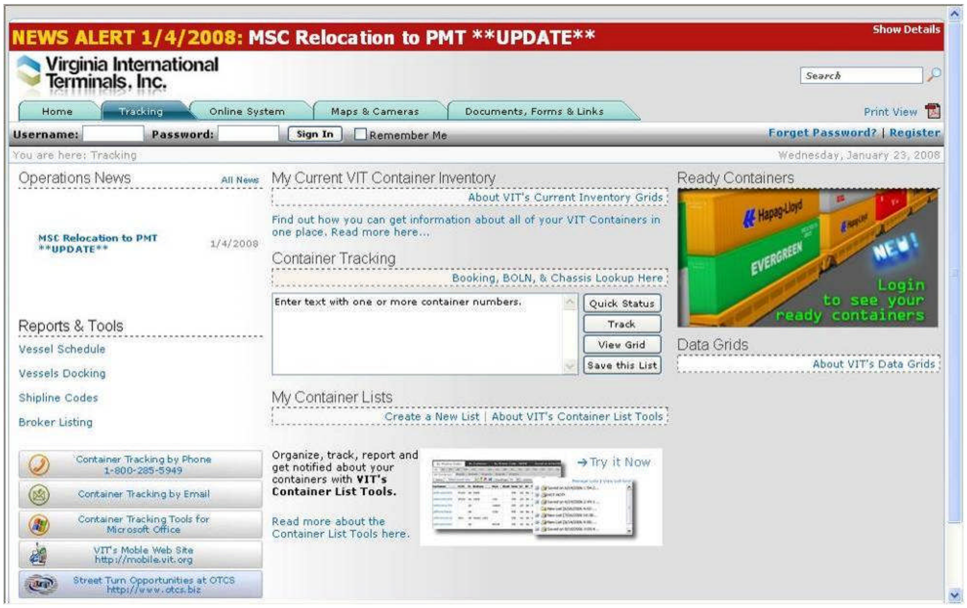
This VCY is viewed as less than completely successful to date. The dispersion of exporters and importers over relatively large distances and the fragmented structure of the drayage industry are seen as barriers to achieving greater benefits.

The VPA has not yet been successful in increasing the number of "street turns" because the Norfolk-based draymen, who make most of these medium-range movements, must return both the driver and neutral chassis to Norfolk without significant delay. Motor carrier dispatch and round trip pricing practices are established accordingly.

VIT Container Tracking

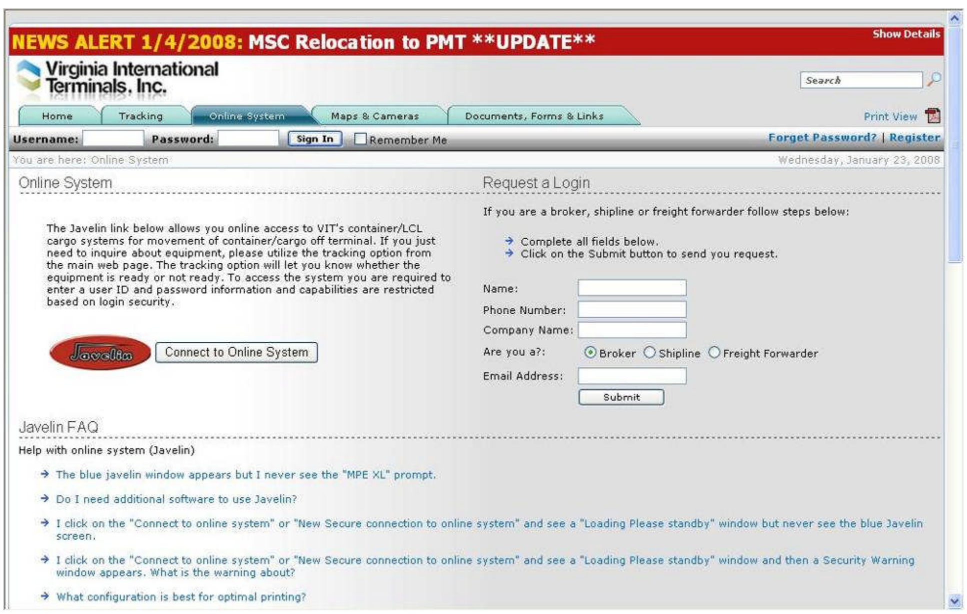
The VIT operations at Norfolk provide an instructive example of container information system implementation. VIT offers multiple access points to its container tracking and information systems. The VIT Container Inventory information is updated every fifteen (15) minutes and represents the current inventory of VIT's host system. (Exhibit 169)

Exhibit 169: VIT Container Inventory System Access



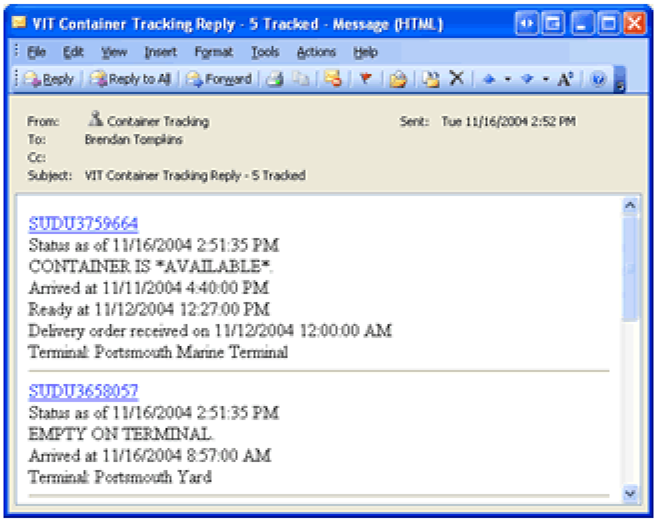
The system is accessible on-line via Javelin, emulation software that enables remote users to access VIT's computer system.

Exhibit 170: On-Line Access via Javelin Software



Information is also available via email (Exhibit 171).

Exhibit 171: VIT Container Tracking Message via Email


VIT Container Tracking Reply - 5 Tracked - Message (HTML)

From: Container Tracking
Sent: Tue 11/16/2004 2:52 PM
To: Brendan Tompkins
Cc:
Subject: VIT Container Tracking Reply - 5 Tracked

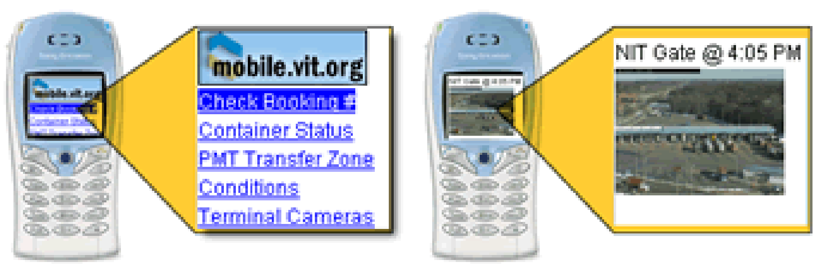
SUDU3759664
Status as of 11/16/2004 2:51:35 PM
CONTAINER IS *AVAILABLE*.
Arrived at 11/11/2004 4:40:00 PM
Ready at 11/12/2004 12:27:00 PM
Delivery order received on 11/12/2004 12:00:00 AM
Terminal: Portsmouth Marine Terminal

SUDU3658057
Status as of 11/16/2004 2:51:35 PM
EMPTY ON TERMINAL.
Arrived at 11/16/2004 8:57:00 AM
Terminal: Portsmouth Yard

VIT's Tracking HotSheet for Excel also allows users to track containers in real time using Microsoft Excel. A Container SmartTag for Office XP allows users to run container tracking and history reports from any Microsoft Office XP application.

Finally, VIT offers mobile-enabled tracking tools and web camera access via cell phone (Exhibit 172).

Exhibit 172: VIT Mobile-Enabled Tracking Tools



A key tool in managing and communicating the preferred routing and disposition of empty containers is the Empty Return Matrix (Exhibit 173). This matrix is available on-line, and is updated daily.

Exhibit 173: VIT Sample Empty Return Matrix, 1/24/08

1	2	3	4	5	6	7	8
Shipline Code	**Shipline Name**	**20 foot standard dry box**	**40 foot standard dry box**	**40 foot high cube dry box**	**45 Foot**	**REEFER**	**Any other size or type**
AI	Alianca (Hamburg Sud)	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT/NNMT
AP	American President Line (APL)	PCY/NCY	PCY/NCY	PCY/NCY	NIT	NIT/PMT	NIT
AL	Atlantic Container Line (ACL)	PCY/NCY	PCY/NCY	PCY/NCY	PMT	NIT	PMT
AN	Australian National Line (CMA-CGM)	PMT	NIT	NIT	PMT	PMT	PMT
CV	Chilean Line (CSAV)	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT	PMT/NNMT	PMT
CS	China Shipping Container Line	PMT	PMT	PMT	PMT	PMT	PMT
CA	CMA-CGM (America) Inc	PMT	NIT	NIT	PMT	PMT	PMT
CH	COSCO (China Ocean Shipping)	NIT	NIT	NIT	NIT	NIT	NIT
EM	Emirates	PMT	PMT	PMT	PMT	PMT	PMT
EV	Evergreen Marine	PCY	PCY	PCY	PMT	PMT	PMT
CO	Hamburg Sud Na	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT/NNMT
HJ	Hanjin Shipping Line	NIT	NIT	NIT	NIT	NIT	NIT
HP	Hapag Lloyd Container Line	NCY	NCY	NCY	NIT	NIT	NIT
HY	Hyundai America Shipping Agcy	NIT/PMT	NIT/PMT	NIT/PMT	NIT/PMT	NIT	PMT
KL	K-Line	NIT	NIT	NCY	NIT	NIT	NIT
GL	Libra (CSAV)	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT	PMT/NNMT	PMT
MA	Mac Andrews (CMA-CGM)	PMT	NIT	NIT	PMT	PMT	PMT
MS	Maersk Line Agency	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE
MC	Marfret Compagnie Maritime						
MR	Maruba Lines						
MD	Mediterranean Shipping (MSC)	PCY	PCY	PCY	PMT	PMT	PMT
MI	Mitsui OSK Lines (MOL)	NIT	NCY	NCY	NIT	NIT	NIT
PA	Montemar Maritima (CSAV)	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT	PMT/NNMT	PMT
NY	N.Y.K. Lines	NIT	NCY	NIT	NIT	NIT	NIT
NS	Natl Ship Co Of Saudi Arabia (NSCSA)	NNMT	NNMT	NNMT	NNMT	NNMT	NNMT
NL	Norasia Line (CSAV)	PMT/NNMT	PMT/NNMT	PMT/NNMT	PMT	PMT/NNMT	PMT
OS	OOCL USA	NCY	NCY	NCY	NIT	NIT	NIT
SA	Safmarine (Maersk)	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE
SC	Shipping Corp Of India	PMT	PMT	PMT	PMT	PMT	PMT
TW	Torm West African Lines (Maersk)	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE	INELIGIBLE
TR	Turkon Line	NNMT	NNMT	NNMT	NNMT	NNMT	NNMT
UA	United Arab Line	NIT	NIT	NIT			
MY	Yang Ming	NIT	NIT	NIT	NIT	NIT	NIT
MZ	Zim American Israeli Shipping	PMT	PMT	PMT	PMT	PMT	PMT

The draymen and dispatchers use the matrix as follows:

1. Find the owner of the empty container (shipping line) in column One (1) or Two (2).
2. Locate the container size height and type column.
3. When a marine terminal or empty yard code is at the intersection, return the empty to that location. For example, 45-foot boxes belonging to American President Line (AP) must be returned to NIT (Norfolk International Terminal) on that day.

4. When the intersection has more than one code the box can be returned to either location. For example if it has "PMT / PCY" it can be returned to either PMT or PCY.

5. When the intersection is blank the empty should be returned to the terminal where the load was picked up.

6. When the word "Ineligible", highlighted in RED, is at the intersection then the empty cannot be returned. The drayman must contact the shipping line for instructions.

7. Boxes directed to NCY or PCY will not be accepted at the marine terminal. They will be turned back at the marine terminal gate.

Virginia DrayFLEET Model

Primary inputs for the DrayFLEET model calibrated for the Port of Virginia (NIT, PMT, NNIT) are shown in Exhibit 174.

Exhibit 174: Virginia DrayFLEET Primary Inputs

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0d of 06/10/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	2,128,366	2,128,366
Average TEU per Container	1.74	1.74
Inbound Share	49%	49%
Inbound Empty Share	0%	0%
Outbound Empty Share	50%	50%
Rail Intermodal Share	27%	27%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	24	24
Rail Terminals		
Weighted Average Miles from Port	11	11
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	147	147
Weighted Average Crosstown Trip Miles	12	12
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Scenario	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	100%	100%
On-Dock Rail (% of rail on-dock)	89%	89%
Automated Gates (% of gate transactions)	100%	100%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	100%

Port	Virginia
Terminal(s)	NIT/PMT/NNIT
Scenario	Base Case
Date	6/16/2008

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	2,683,241	2,683,241	0	0.0%
Drayage Trip Legs per Container	2.2	2.2	0.0	0.0%
Total Drayage VMT	233,284,181	233,284,181	0	0.0%
Drayage VMT per Container	190.7	190.7	0.0	0.0%
Fleet Required (FTE Tractors)	3,494	3,494	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	2,491,249	2,491,249	0	0.0%
Creep Hours	894,677	894,677	0	0.0%
Transient Hours	1,727,351	1,727,351	0	0.0%
Cruise Hours	5,243,436	5,243,436	0	0.0%
Total Drayage Hours	10,356,714	10,356,714	0	0.0%
Drayage Hours per Container	8.5	8.5	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	167	167	0.00	0.0%
CO	968	968	0.00	0.0%
NOx	4,465	4,465	0.00	0.0%
PM_{10}	110	110	0.00	0.0%
$PM_{2.5}$	93	93	0.00	0.0%
CO_2	263,796	263,796	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	23,577,530	23,577,530	0.0	0.0%
Total Drayage Cost	$ 339,205,428	$ 339,205,428	$ -	0.0%
Drayage Cost per Container	$ 277	$ 277	$ -	0.0%

Virginia Inland Port

Norfolk Southern (NS) railroad provides an intermodal service between Norfolk International Terminal (NIT) and the Virginia Inland Port (VIP). VIP's operations are beyond the scope of DrayFLEET, but the rail trips to and from VIP account for any of the inter-terminal drays within the VPA complex at Norfolk.

The VIP terminal in Front Royal is pictured in Exhibit 175. The facility is a U.S. Customs-designated port of entry, and the full range of customs functions is available. The marine carriers are the customers of VIT. The cargo largely remains in bond and clears customs in Front Royal. Some of the cargo may move on a through marine bill of lading with final destinations in Northern Virginia, West Virginia, Western Maryland, Pennsylvania and Ohio. VIT has contracts with NS to provide a second morning train service scheduled six days per week in each direction. VPA markets this service to marine carriers as a part of its terminal service package.

In Norfolk, the cargo can originate at the on-dock rail terminal at NIT and at NS's Chesapeake, Virginia facility (Exhibit 146). Container Movements from VIP terminate at NIT. In addition, containers can be drayed between the marine terminal at Portsmouth to the NS terminal in Chesapeake. The difference between this "inland port" arrangement and typical rail intermodal service to and from a seaport is that in this case the port operator takes responsibility for the container as if VIP were part of the seaport itself.

Exhibit 175: Virginia Inland Port Aerial View

By having the VIP option, VPA has significantly more short-haul rail movements than other ports. These containers might have otherwise moved by truck to Norfolk or to a competing port. Because the VIP containers are taken to the on-dock terminal at NIT, those bound to or from PMT must be drayed between the terminals, a distance of about 10 miles. This activity is reflected in the inter-terminal portion of DrayFLEET.

Exhibit 176 illustrates and isolates the importance of on-dock rail by "backing out" the existing on-dock volume. The "on-dock" share has been reduced from 89% to zero, and total rail intermodal has been reduced from 27% to 13.5%.

Exhibit 176: Impacts of On-Dock Rail at Virginia

Rail Intermodal Share	27%	14%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	24	24
Rail Terminals		
Weighted Average Miles from Port	11	11
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	147	147
Weighted Average Crosstown Trip Miles	12	12
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Scenario	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	100%	100%
On-Dock Rail (% of rail on-dock)	89%	0%
Automated Gates (% of gate transactions)	100%	100%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	100%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	2,683,241	3,410,546	727,304	27.1%
Drayage Trip Legs per Container	2.2	2.8	0.6	27.1%
Total Drayage VMT	[illegible]	283,481,425	50,197,243	21.5%
Drayage VMT per Container	190.7	231.8	41.0	21.5%
Fleet Required (FTE Tractors)	3,494	4,290	796	22.8%
Annual Duty Cycle Totals				
Idle Hours	2,491,249	3,113,038	621,789	25.0%
Creep Hours	894,677	1,102,301	207,624	23.2%
Transient Hours	1,727,351	2,113,990	386,638	22.4%
Cruise Hours	5,243,436	6,385,461	1,142,024	21.8%
Total Drayage Hours	10,356,714	12,714,789	2,358,076	22.8%
Drayage Hours per Container	8.5	10.4	1.9	22.8%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	167	204	36.84	22.1%
CO	[illegible]	1,182	213.86	22.1%
NOx	4,465	5,447	981.57	22.0%
PM_{10}	110	134	24.20	22.0%
$PM_{2.5}$	93	113	20.39	22.0%
CO_2	263,796	322,144	58,348	22.1%
Fuel Use and Total Cost				
Fuel - Gallons	23,577,530	28,792,545	5,215,014.7	22.1%
Total Drayage Cost	$ 339,205,428	$ 416,688,813	$ 77,483,384	22.8%
Drayage Cost per Container	$ 277	$ 341	$ 63	22.8%

Annually, there would be:

- over 700,000 additional drayage trips covering over 50 million annual miles and taking over 2.3 million driver and tractor hours;
- an additional 37 tons of HC, 214 tons of CO, 982 tons of NOx, 24 tons of PM_{10}, and 20 tons of $PM_{2.5}$;
- 5.2 million more gallons of diesel fuel consumed generating more than 58,000 tons of CO_2; and
- a $77.4 million increase in total drayage cost.

Here again, balancing the emissions benefits and costs of the on-dock rail would require separate estimates of the emissions impacts of the rail movement.

Combined Initiatives Impacts

Exhibit 177 shows the combined estimated impact of the multiple initiatives discussed above. initiatives. In 2007, these initiatives saved:

- Nearly 600,000 drayage trip legs covering nearly 6 million miles
- Over 600,000 annual hours of driver and tractor time
- 29% to 30% of HC, NOx, CO, and particulate emissions
- Over 1 million gallons of fuel, and 11,000+ tons of CO_2
- Over $22 million in drayage costs.

Exhibit 177: Port of Virginia - Combined Initiatives Impacts - 5 Mile Scope

Rail Intermodal Share	27%	27%
Marine Terminals		
Average Inbound Gate Queue Minutes	15	15
Average Marine Terminal Min. per Transaction	24	24
Rail Terminals		
Weighted Average Miles from Port	11	11
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	12	12
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	100%	0%
On-Dock Rail (% of rail on-dock)	89%	0%
Automated Gates (% of gate transactions)	100%	0%
Extended Gate Hours (% off-peak, 50% max)	0%	0%
Container Info System (% used)	90%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	2,683,241	3,248,622	565,381	21.1%
Drayage Trip Legs per Container	2.2	2.7	0.5	21.1%
Total Drayage VMT	23,005,596	28,843,437	5,837,841	25.4%
Drayage VMT per Container	18.8	23.6	4.8	25.4%
Fleet Required (FTE Tractors)	770	986	217	28.1%
Annual Duty Cycle Totals				
Idle Hours	1,146,962	1,451,054	304,092	26.5%
Creep Hours	327,836	410,348	82,512	25.2%
Transient Hours	230,711	330,610	99,899	43.3%
Cruise Hours	576,519	731,952	155,434	27.0%
Total Drayage Hours	2,282,027	2,923,964	641,937	28.1%
Drayage Hours per Container	1.9	2.4	0.5	28.1%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	23	30	6.83	30.0%
CO	133	174	40.22	30.2%
NOx	572	739	167.08	29.2%
PM_{10}	14	18	4.04	29.0%
$PM_{2.5}$	12	15	3.41	29.0%
CO_2	36,311	47,695	11,385	31.4%
Fuel Use and Total Cost				
Fuel - Gallons	3,245,362	4,262,888	1,017,525.4	31.4%
Total Drayage Cost	$ 78,836,518	$ 101,490,898	$ 22,654,380	28.7%
Drayage Cost per Container	$ 64	$ 83	$ 19	28.7%

Barge Handling Impacts

The Virginia model allows for about 8% barge handling, which is not present in the other case studies. Movement by barge to/from the same marine terminal does not involve over-the-road drayage.

There are proposals for additional barge services to/from the Port of Virginia. Exhibit 178 illustrates the impacts of converting existing over-the-road drayage to barge.

Exhibit 178: Impact of Additional Barge Service

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	2,683,241	2,402,326	-280,915	-10.5%
Drayage Trip Legs per Container	2.2	2.0	-0.2	-10.5%
Total Drayage VMT	233,284,181	205,007,131	-28,277,050	-12.1%
Drayage VMT per Container	190.7	167.6	-23.1	-12.1%
Fleet Required (FTE Tractors)	3,494	3,079	-415	-11.9%
Annual Duty Cycle Totals				
Idle Hours	2,491,249	2,206,763	-284,486	-11.4%
Creep Hours	894,677	791,008	-103,669	-11.6%
Transient Hours	1,727,351	1,519,383	-207,968	-12.0%
Cruise Hours	5,243,436	4,608,312	-635,125	-12.1%
		25,466	-1,231,248	-11.9%
		7.5	-1.0	-11.9%
		rio	Change	% Change
HC	167	147	-20.12	-12.1%
CO	968	851	-116.67	-12.1%
NOx	4,465	3,926	-539.07	-12.1%
PM_{10}	110	97	-13.30	-12.1%
$PM_{2.5}$	93	82	-11.21	-12.1%
CO_2	263,796	232,003	-31,793	-12.1%
Fuel Use and Total Cost				
Fuel - Gallons	23,577,530	20,735,898	-2,841,632.2	-12.1%
Total Drayage Cost	$ 339,205,428	$ 299,094,511	$ (40,110,917)	-11.8%
Drayage Cost per Container	$ 277	$ 245	$ (33)	-11.8%

	Default	Scenario
Port Operations		
Barge/Transshipment Share	8%	16%
Inter-Terminal Dray Share	15%	15%

Doubling the existing barge share from 8% to 16% (on the Secondary Inputs sheet) would result in:

- 280,915 fewer drayage trip legs and 28.3 million fewer VMT;
- 1.2 million fewer driver and tractor hours;
- emissions reductions ranging from 11 fewer annual tons of $PM_{2.5}$ to 539 fewer tons of NOx;
- 31,793 fewer tons of CO_2 from 2.8 million fewer gallons of diesel fuel ; and
- a $50 million cost savings.

These savings would, of course, be offset by the emissions and cost of the barge operations, which would require a separate calculation.

Houston Case Study

Overview

The Port of Houston Authority (PHA) owns and operates the public facilities located on the Houston Ship Channel. There are 43 publicly owned and operated general cargo wharves and two liquid-cargo wharves available for public hire in the Houston Ship Channel. These facilities were designed for handling general cargo, containers, grain and other dry bulk materials, project and heavy-lift cargos and virtually any other kind of cargo. In addition to the facilities owned by the Port Authority there are more than 150 private industrial companies along the Ship Channel. Collectively more than 200 million tons of cargo moved through the Port of Houston in 2006. A 2007 study by Martin Associates found the ship channel-related business supported more than 785,000 jobs throughout Texas while generating approximately $118 billion of statewide economic impact.

Prior to 2007 the only container terminal on property owned by PHA was Barbours Cut Container Terminal. The new Bayport container terminal opened in 2007 (Exhibit 179, but there is little performance data to date. The full buildout of Bayport will include additional container berths and a new cruise ship terminal. The Port Authority expects Bayport to have quicker drayage turn times due to is superior infrastructure and gate automation.

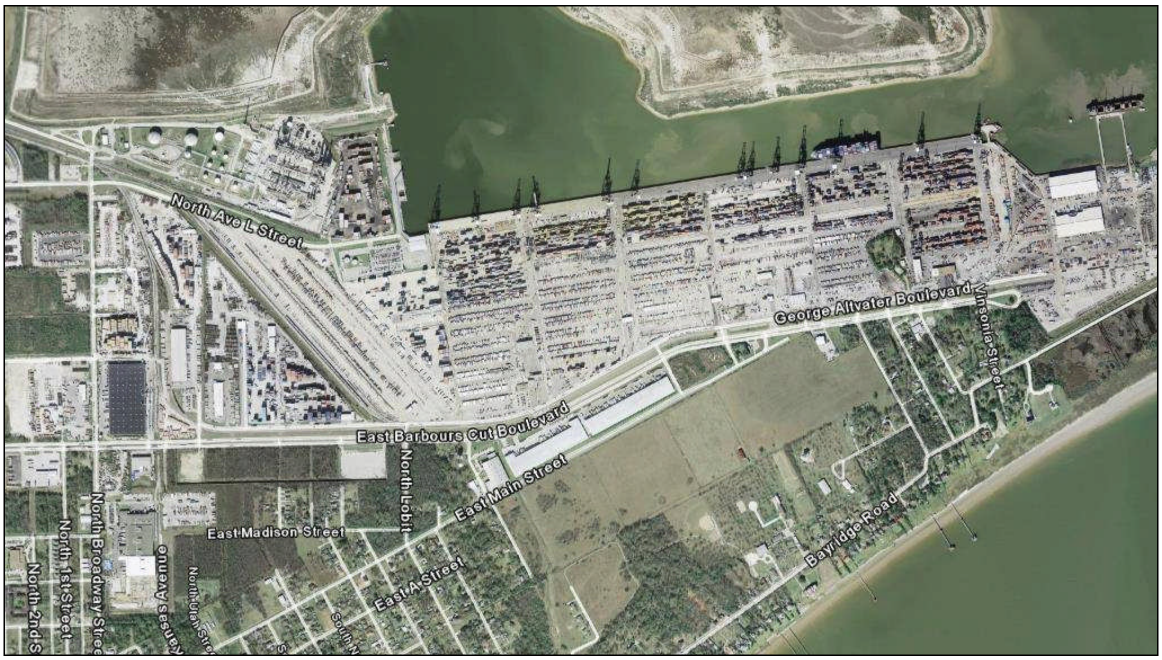
Exhibit 179: Bayport Container Terminal

The modeling effort in this project focused on Barbours Cut, as Bayport does not yet have performance or throughput data.

Barbours Cut

Barbours Cut (Exhibit 180 handled 1.61 million TEU in 2006, up slightly from 1.59 million in 2005. There are six berths providing 6,000 feet of continuous quay. Berths C1–C5 are common user facilities and C6 is dedicated to Maersk. There are two street gates into Barbours Cut, one for Maersk, and one that serves all the other lines that use the terminal. Access to both gates is via Barbours Cut Blvd. off the Texas Highway 146, the limited access highway 2.5 miles from the common user gate. The gate for the Maersk berth is approximately 1 mile closer to Highway 146.

Exhibit 180: Barbours Cut Terminal



Barbours Cut Blvd. has been a two lane road that serves not only Barbours Cut but also the container depots adjacent to the terminal, access to marine services support services companies, as well as, until the Bayport Cruse Ship terminal is open, cruse ship traffic. The road is a very high density two lane road that for most of 2007 has been in very bad repair. However, in late August 2007 an extensive rebuilding project has been underway to repair and improve flow by adding extra long turn lanes to better accommodate the high volume of truck traffic.

Container Flows

The last full year of container volume data for this case study was 2006, when all movements were in and out of Barbours Cut. There were 1.6 million TEU handled through the terminal with inbound and outbound equal. However unlike many other container ports in the US, loaded outbound (exports) exceeded inbound (imports).

Exhibit 181: 2006 Port of Houston Container Trade

	Inbound (Import)			Outbound (Export)			Total		
	Loaded	Empty	Total	Loaded	Empty	Total	Loaded	Empty	Total
TEU	651,379	151,801	803,180	712,500	90,680	803,180	1,363,879	242,481	1,606,360
Containers	399,404	93,079	492,483	436,881	55,602	492,483	836,285	148,681	984,966

The Port of Houston averages 1.631 TEU per container.

The movement of empty containers in both directions is due to seasonal needs, imbalances, and container size requirements.

Outbound (Export) Flows

The empty containers required for the outbound export loads are sourced from:

- street turns of import containers made empty in the Houston area – 15%
- pulls from container depots located near Barbours Cut – 65%
- pulls of empty containers from rail intermodal terminals – 10%
- reloads by import receivers – 10%

Loaded outbound containers are generally (75%) drayed directly to Barbours Cut. However, because of the steamship limitation on accepting containers no earlier than 7 days prior to sailing, draymen pull containers from exporters and hold the boxes at the drayage yard 25% of the time. This results in an additional drayage trip from the exporter to the drayage yard and then from the drayage yard to the port.

Once export containers are lifted from the chassis at the port, the chassis are split three ways:

- reused for subsequent import container handling – 66%
- dropped at on-dock chassis storage – 22%
- dropped at the container depot or held at the drayage yard – 11%

Inbound (Imports)

Loaded inbound containers are moved out of the port as follows:

- dray to off-dock intermodal terminal – 30%
- dray directly from port to consignee – 52%
- dray and hold at drayage yard prior to dray to consignee – 9%
- hostler move to on-dock rail – 8%
- directly from containership to barge – <1%

Once emptied at import consignees, empty containers are split as follows:

- importer reload for export – 10%
- street interchange from importer to exporter – 15%
- dray to empty container depot – 75%

Empty containers not reloaded or street turned are drayed to one of five empty container depots located within one mile of the port. Empty containers that are to be loaded on the outbound ships are drayed from the container depot to the terminal by hostlers on a dedicated port roadway. Maersk is the exception to this practice: empty containers are drayed directly to the Maersk on-dock empty storage yard.

Drayage Time and Distance Averages

The following are average activity times.

- Queue for In-Gate – 40 min.
- Time on Terminal – 45 min.
- Customs Clearance of Imports/Issues with clearance 25% – 120 min.
- Drop chassis at container depot due to lack of space on-dock – 90 min.
- Rail Intermodal Terminal – 40 min.

One drayage tractor can make 3.5 round trips per day on average (seven container, empty chassis, or bobtail moves per day).

Barbours Cut DrayFLEET Model

Based on these terminal and operations features the study team developed a default DrayFLEET model for Barbours Cut. Exhibit 182 shows the primary input and outputs.

Exhibit 182: Barbours Cut DrayFLEET Model Primary Inputs

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0E of 06/25/2008

Port	Houston
Terminal(s)	Barbours Cut
Scenario	Base Case
Date	6/25/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2006	2006
Annual TEU	1,020,002	1,020,002
Average TEU per Container	1.61	1.61
Inbound Share	49%	49%
Inbound Empty Share	37%	37%
Outbound Empty Share	4%	4%
Rail Intermodal Share	21%	21%
Marine Terminals		
Average Inbound Gate Queue Minutes	20	20
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	25	25
Average Inbound Gate Queue Minutes	25	25
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	0%	0%
Container Shippers/Receivers		
Weighted Average Miles from Port	38	38
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 15.25	$ 15.25
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Scenario	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	90%	90%
On-Dock Rail (% of rail on-dock)	20%	20%
Automated Gates (% of gate transactions)	100%	100%
Extended Gate Hours (% off-peak, 50% max)	100%	100%
Container Info System (% used)	70%	70%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	100%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	1,942,493	1,942,493	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	0.0	0.0%
Total Drayage VMT	45,988,094	45,988,094	0	0.0%
Drayage VMT per Container	72.6	72.6	0.0	0.0%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	1,148,904	1,148,904	0	0.0%
Creep Hours	441,322	441,322	0	0.0%
Transient Hours	406,848	406,848	0	0.0%
Cruise Hours	1,134,690	1,134,690	0	0.0%
Total Drayage Hours	3,131,764	3,131,764	0	0.0%
Drayage Hours per Container	4.9	4.9	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	39	39	0.00	0.0%
CO	238	238	0.00	0.0%
NOx	871	871	0.00	0.0%
PM_{10}	32	32	0.00	0.0%
$PM_{2.5}$	27	27	0.00	0.0%
CO_2	101,373	101,373	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	9,060,468	9,060,468	0.0	0.0%
Total Drayage Cost	$ 124,569,558	$ 124,569,558	$ -	0.0%
Drayage Cost per Container	$ 197	$ 197	$ -	0.0%

The model version shown above accounts for the container volume moving through the common-user portion of Barbours Cut. Particular effort was required to model the unique system of on-dock chassis and container storage using the separate gate.

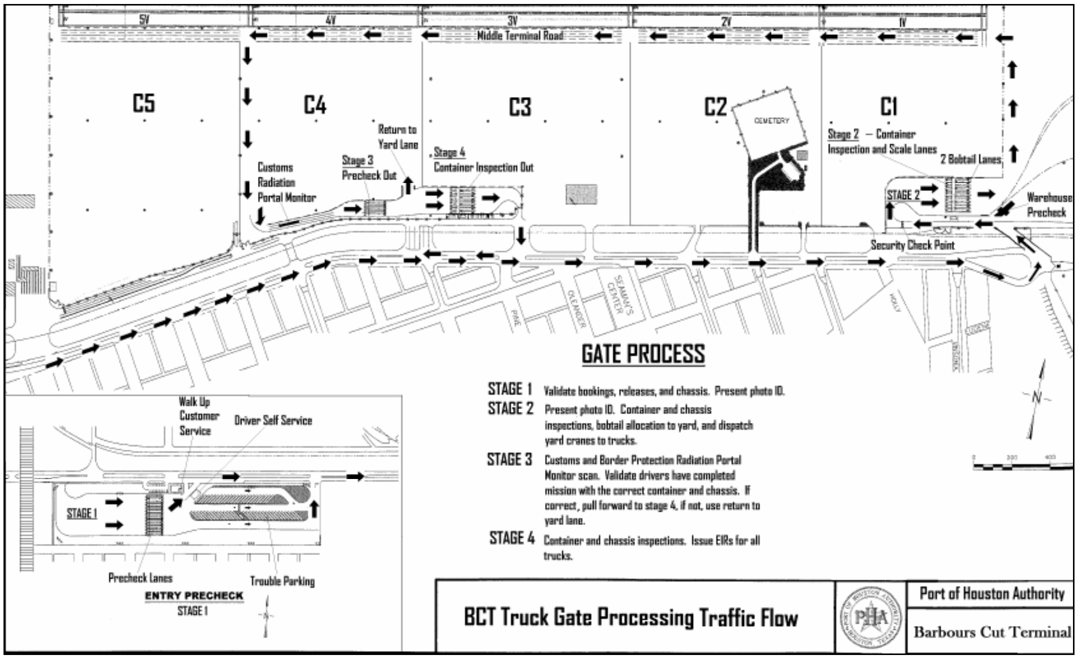
Neutral Chassis Pools

There are two neutral chassis pools to support drayage operations at the common user terminal. Maersk has its own pool. Flexi-Van and Xtra are the two chassis pool managers. Storage on empty chassis to support live loading activity on the terminal is limited to 600. This limited storage space results in extra drayage movements when the drayman no longer needs the chassis and there is no space to drop it on-dock. The drayman must find space at one of the five near-dock empty container depots or take it to the drayman’s terminal for storage. Lack of on-dock chassis storage space is a daily occurrence according to the draymen interviewed.

Automated Gate

In addition to the roadway improvements in late 2007, a new common user automated gate has been put into operation as of mid-November 2007 (Exhibit 183).

Exhibit 183: Barbours Cut Automated Gate (Opened November 2007)



Units wishing to enter the common user terminal – loaded or empty containers, bare chassis, or bobtail tractors – will exit Barbours Cut Blvd. to the right and proceed to Stage I processing for the new automated gate. If all is in order for entry, the driver will be instructed to proceed to Stage II. If there is an issue that will delay processing, the unit will be directed to a holding area adjacent to, but not blocking, the Stage I gate until the problem can be resolved. At Stage II, instructions will be issued directing the drayage unit movement on the terminal. Generally the instructions will be single activity instruction:

- Loaded Container - proceed to a specific spot for a live container lift off the chassis and to drop the chassis at the on-dock neutral chassis pool if not needed by the drayman for the next activity and proceed to the out-gate for processing
- Empty Chassis – proceed to container live load spot to wait for loading and then to out gate processing
- Bobtail – proceed to the natural chassis pool to pull a chassis and proceed to the container live load spot to wait for loading and then to out-gate for processing.

Once the driver has completed the work to be done on the terminal, the unit proceeds to Stage III for validation that the driver has correctly completed all the work as assigned. This is also where the U. S. Customs Clearance is confirmed and Border Protection Radiation Portal Monitor Scan is accomplished on import containers leaving the terminal. If there is a problem the drayman is directed to the return-to-yard lane to resolve the problem. Once clear of Stage III the unit pulls forward to Stage IV, the outgate, for final container and chassis inspection.

Exhibit 184 shows the estimated impacts of a queuing time reduction from a historical average of about 40 minutes to a new benchmark of 20 minutes.

Exhibit 184: Impacts of Queuing Time Reduction

Rail Intermodal Share	21%	21%
Marine Terminals		
Average Inbound Gate Queue Minutes	20	40
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	25	25
Average Inbound Gate Queue Minutes	25	25
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	0%	0%
Container Shippers/Receivers		
Weighted Average Miles from Port	38	38
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 15.25	$ 15.25
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	90%	90%
On-Dock Rail (% of rail on-dock)	20%	20%
Automated Gates (% of gate transactions)	100%	100%
Extended Gate Hours (% off-peak, 50% max)	100%	100%
Container Info System (% used)	70%	70%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	100%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	1,942,493	1,942,493	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	0.0	0.0%
Total Drayage VMT	45,988,094	46,276,744	288,650	0.6%
Drayage VMT per Container	72.6	73.0	0.5	0.6%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	1,148,904	1,148,904	0	0.0%
Creep Hours	441,322	601,683	160,361	36.3%
Transient Hours	406,848	406,848	0	0.0%
Cruise Hours	1,134,690	1,134,690	0	0.0%
Total Drayage Hours	3,131,764	3,292,125	160,361	5.1%
Drayage Hours per Container	4.9	5.2	0.3	5.1%

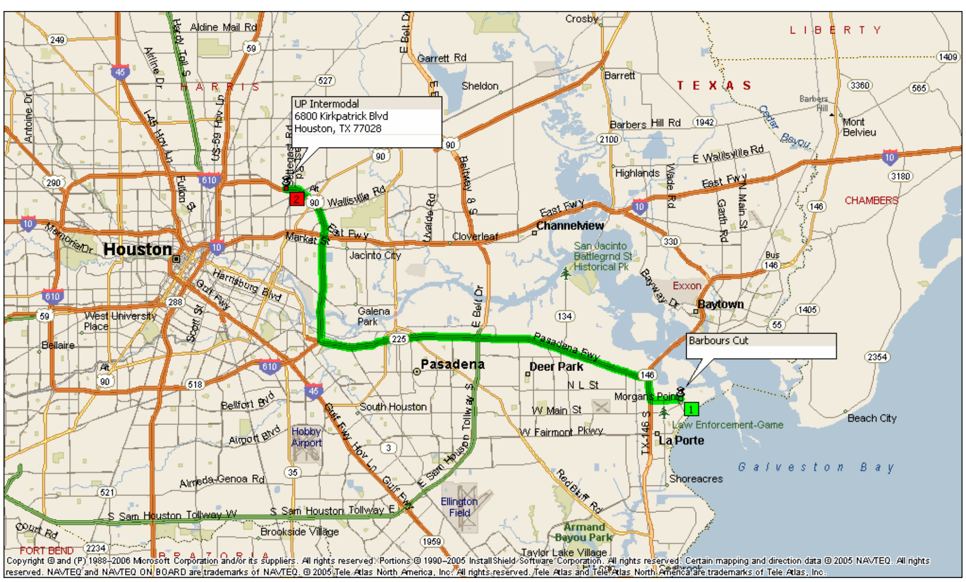
Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	39	40	0.77	1.9%
CO	238	243	4.86	2.0%
NOx	871	883	12.11	1.4%
PM_{10}	32	32	0.40	1.3%
$PM_{2.5}$	27	28	0.35	1.3%
CO_2	101,373	102,709	1,336	1.3%
Fuel Use and Total Cost				
Fuel - Gallons	9,060,468	9,179,881	119,412.4	1.3%
Total Drayage Cost	$ 124,569,558	$ 128,735,330	$ 4,165,772	3.3%
Drayage Cost per Container	$ 197	$ 203	$ 7	3.3%

The reduction saved an estimated 160,000+ annual driver and tractor hours and over 119,000 annual gallons of fuel, with commensurate emissions reductions of 1.3% to 2.0% and a $4.2 million annual cost savings. These impacts are not as dramatic as the LALB example due to the smaller volume being handled at Houston.

Barbours Cut Rail Intermodal

As shown in Exhibit 182, about 20% of the rail intermodal volume at Barbours Cut is reportedly handled on-dock, with the bulk of the rail intermodal handled at the Union Pacific terminal about 25 miles away (Exhibit 185).

Exhibit 185: Drayage Distance to Off-Dock Rail



An increase in the share of intermodal rail handled on-dock from 20% to 40% would have the impacts shown in Exhibit 186.

Exhibit 186: Impacts of Greater Houston On-Dock Rail

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0E of 06/25/2008

Port	Houston
Terminal(s)	Barbours Cut
Scenario	Base Case
Date	6/25/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2006	2006
Annual TEU	1,020,002	1,020,002
Average TEU per Container	1.61	1.61
Inbound Share	49%	49%
Inbound Empty Share	37%	37%
Outbound Empty Share	4%	4%
Rail Intermodal Share	21%	21%
Marine Terminals		
Average Inbound Gate Queue Minutes	20	20
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	25	25
Average Inbound Gate Queue Minutes	25	25
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	0%	0%
Container Shippers/Receivers		
Weighted Average Miles from Port	38	38
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 15.25	$ 15.25
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Scenario	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	90%	90%
On-Dock Rail (% of rail on-dock)	20%	40%
Automated Gates (% of gate transactions)	100%	100%
Extended Gate Hours (% off-peak, 50% max)	100%	100%
Container Info System (% used)	70%	70%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	100%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	1,942,493	1,887,186	-55,308	-2.8%
Drayage Trip Legs per Container	3.1	3.0	-0.1	-2.8%
Total Drayage VMT	45,988,094	45,149,705	-838,389	-1.8%
Drayage VMT per Container	72.6	71.3	-1.3	-1.8%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	1,148,904	1,113,393	-35,511	-3.1%
Creep Hours	441,322	425,027	-16,295	-3.7%
Transient Hours	406,848	395,766	-11,081	-2.7%
Cruise Hours	1,134,690	1,109,266	-25,424	-2.2%
Total Drayage Hours	3,131,764	3,043,453	-88,311	-2.8%
Drayage Hours per Container	4.9	4.8	-0.1	-2.8%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	39	39	-0.98	-2.5%
CO	238	232	-5.94	-2.5%
NOx	871	850	-21.04	-2.4%
PM_{10}	32	31	-0.76	-2.4%
$PM_{2.5}$	27	27	-0.66	-2.4%
CO_2	101,373	98,909	-2,463	-2.4%
Fuel Use and Total Cost				
Fuel - Gallons	9,060,468	8,840,292	-220,175.9	-2.4%
Total Drayage Cost	$ 124,569,558	$ 121,020,622	$ (3,548,937)	-2.8%
Drayage Cost per Container	$ 197	$ 191	$ (6)	-2.8%

Because of the elimination of a 25-mile trip for each container affected, doubling the on-dock share would annually eliminate an estimated:

- 55,308 trip legs and 838,389 VMT;
- 88,311 driver and tractor hours;
- emissions, including 21.0 tons of NO_x and 5.9 tons of CO;
- 220,176 gallons of diesel fuel burned, generating 2,463 tons of CO_2; and
- \$3.5 million in drayage costs.

Combined Impact of Port Initiatives

Exhibit 187 illustrates the combined impact of the multiple initiatives undertaken at the Port of Houston, restricting scope to five miles from the Port[15]. "Backing out" the automated gates, container informational system, and neutral chassis pools while reinstating the former 40-minute queue time suggests that the combined impact of the initiatives was to:

- reduce VMT by over 2 million miles;
- reduce annual drayage hours (tractor and driver) by over 1.2 million;

[15] As with LALB, this modeling step "moves" the rail terminals closer to the port.

- reduce emissions by 22.0% to 33.4%, including over 90 tons of NOx and almost 10,000 tons of CO2;
- reduce fuel consumption by about 888,000 gallons; and
- reduce total drayage cost by almost $32 million.

Exhibit 187: Port of Houston - Combined Impact of Initiatives – Five Mile Limit

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs

DrayFLEET Version 1.0E of 06/25/2008

Port	Houston
Terminal(s)	Barbours Cut
Scenario	Base Case - Five Mile Limit
Date	7/23/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2006	2006
Annual TEU	1,020,002	1,020,002
Average TEU per Container	1.61	1.61
Inbound Share	49%	49%
Inbound Empty Share	37%	37%
Outbound Empty Share	4%	4%
Rail Intermodal Share	21%	21%
Marine Terminals		
Average Inbound Gate Queue Minutes	20	40
Average Marine Terminal Min. per Transaction	30	30
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	25	25
Average Rail Yard Min. per Transaction	30	30
Container Depots		
Weighted Average Miles from Port	2	2
Share of Empties Stored at Depots	0%	0%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 15.25	$ 15.25
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	90%	90%
On-Dock Rail (% of rail on-dock)	20%	20%
Automated Gates (% of gate transactions)	100%	0%
Extended Gate Hours (% off-peak, 50% max)	100%	0%
Container Info System (% used)	70%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	100%	0%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	1,942,493	1,942,493	0	0.0%
Drayage Trip Legs per Container	3.1	3.1	[illegible]	0.0%
Total Drayage VMT	17,933,015	19,966,416	2,033,401	11.3%
Drayage VMT per Container	28.3	31.5	3.2	11.3%
Fleet Required (FTE Tractors)	1,224	1,224	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	945,734	1,052,731	106,997	11.3%
Creep Hours	355,652	1,484,895	1,129,243	317.5%
Transient Hours	180,651	180,701	50	0.0%
Cruise Hours	429,349	429,349	0	0.0%
Total Drayage Hours	1,911,386	[illegible]	1,236,290	64.7%
Drayage Hours per Container	3.0	5.0	2.0	64.7%

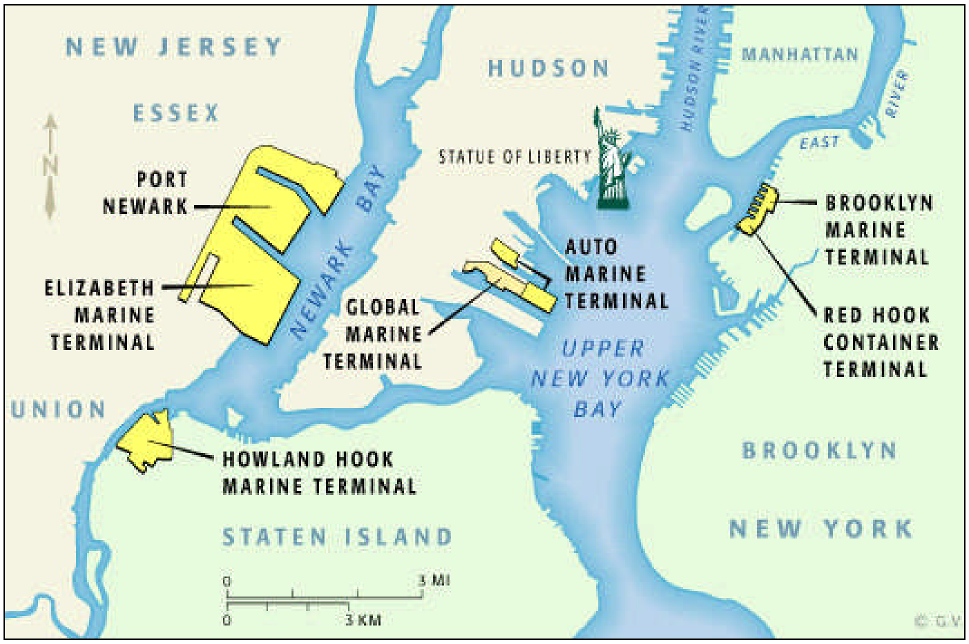
Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	18	24	5.72	32.1%
CO	108	144	36.12	33.4%
NOx	375	465	90.06	24.0%
PM_{10}	14	16	2.98	22.1%
$PM_{2.5}$	12	14	[illegible]	22.0%
CO_2	[illegible]	53,023	9,936	23.1%
Fuel Use and Total Cost				
Fuel - Gallons	3,850,986	4,739,055	888,068.8	23.1%
Total Drayage Cost	$ 73,078,496	$ 105,044,827	$ 31,966,331	43.7%
Drayage Cost per Container	$ 115	$ 166	$ 50	43.7%

New York-New Jersey Case Study

New York-New Jersey Overview

The primary agency managing ports in the New York metropolitan area is the Port Authority of New York and New Jersey. The Port Authority (PA) is a bi-state agency which serves as a landlord for several marine terminals (Exhibit 188).

Exhibit 188: PANYNJ Marine Terminals



As illustrated in the map, Global Marine terminal is privately owned, but is identified by the Port Authority as an integral element of the system. Characteristics of the five most important container facilities in the New York metropolitan area are listed in Exhibit 189.

Exhibit 189: Primary PANYNJ Container Terminals

Terminal	Location	Stevedore	Acreage
Maher	Port Elizabeth, NJ	Maher	445
Maersk/Sealand	Port Elizabeth, NJ	APM	350
PNCT	Port Newark, NJ	Ports America	175
Howland Hook	Staten Island, NY	NYCT	187
Global	Jersey City, NJ	GTCS	100

Maher Terminals has been a major innovator and provided much of the information for this case study. Maher was sold to a new owner in 2007, but continues to operate under the Maher name. *This case study focuses on terminal operations through 2007.*

New York is the largest port on the Atlantic Coast by a wide margin. The five busiest east coast ports are listed in Exhibit 190, below. The table also shows that, aside from Savannah, New

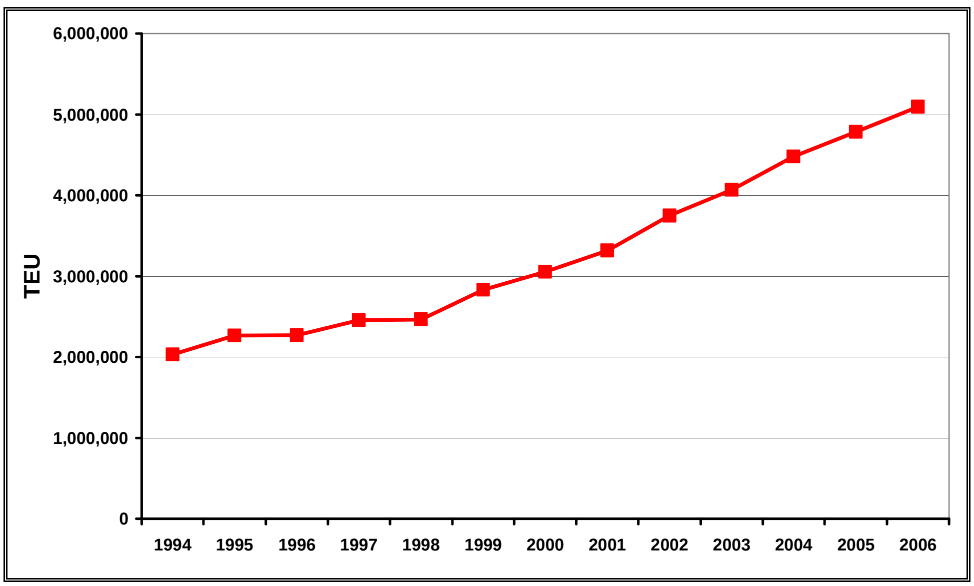
York has been the fastest growing port on the east coast in terms of absolute volume and second fastest in terms of growth rate. This rapid growth is a significant factor in the number of terminal management initiatives undertaken at NYNJ.

Exhibit 190: East Coast Port Volumes[16]

Port	2006 TEU	Growth 1994-2006	Growth 1994-2006
New York	5,092,806	3,058,927	150%
Savannah	2,160,113	1,597,902	284%
Hampton Roads	2,046,285	1,152,219	129%
Charleston	1,968,474	1,070,994	119%
Montreal	1,288,910	560,111	77%

A twelve year graph of New York container volume (Exhibit 191) shows the steady increase in volume over the period, averaging more that 7.5% per year.

Exhibit 191: NYNJ Port Volume



This trend is continuing. While 2007 was a generally slow year for most ports, through nine months of 2007 PANYNJ volume was up 5.5%.

Unlike many ports in the United States, most of the cargo that uses the port of New York is consumed locally and most drayage is a local exercise. Based on PA studies, the estimated distribution is as follows.

- 15% of the cargo is handled by rail, most using on-dock rail facilities and the rest using nearby rail intermodal terminals.

[16] Source: American Association of Port Authorities, http://aapa.files.cms-plus.com/PDFs/2006%5FNorth%5FAmerican%5FContainer%5FTraffic.pdf

- 60% of the cargo moves to the four surrounding New Jersey counties; much of this is transloaded for delivery in New York and other northeastern cities.
- 4% moves to locations within 260 miles to nearby destinations in NY, CT, PA, MA, and RI.
- 15% moves to U.S. locations beyond 260 miles such as Pittsburgh, Cleveland, and Buffalo.
- 3% moves to Canadian locations such as Montreal and Toronto.

The large share of local consumption means that the landside access modal share associated with motor carriers is unusually large.

Drayage Conditions

While drayage conditions associated with highway congestion in the region have generally worsened over time, there has been a significant improvement in speed with which trucks are processed through regional marine terminals. A 1994 study[17] performed by Tioga's principals for the PA found that marine container terminal turn time in the PA's main terminals varied between two and three hours, and was the worst among competitive east coast terminals. This finding was corroborated by a separate 1994 study performed for New Jersey Transportation Planning Authority, which illustrated anecdotally the myriad of marine terminal procedural problems facing drivers. These problems limited ordinary productivity to less than two local turns per day.[18]

Currently, drivers typically move through PA terminals in less than an hour. APM Terminals even posts current turn time information on its website. Exhibit 192, below, reflects Thanksgiving week of 2007, which would typically result in increased congestion.[19],[20] Instead, the moving average line (black) is well under 60 minutes. This is a remarkable accomplishment in the face of volume increases and the increasing demands associated with Homeland Security procedures.

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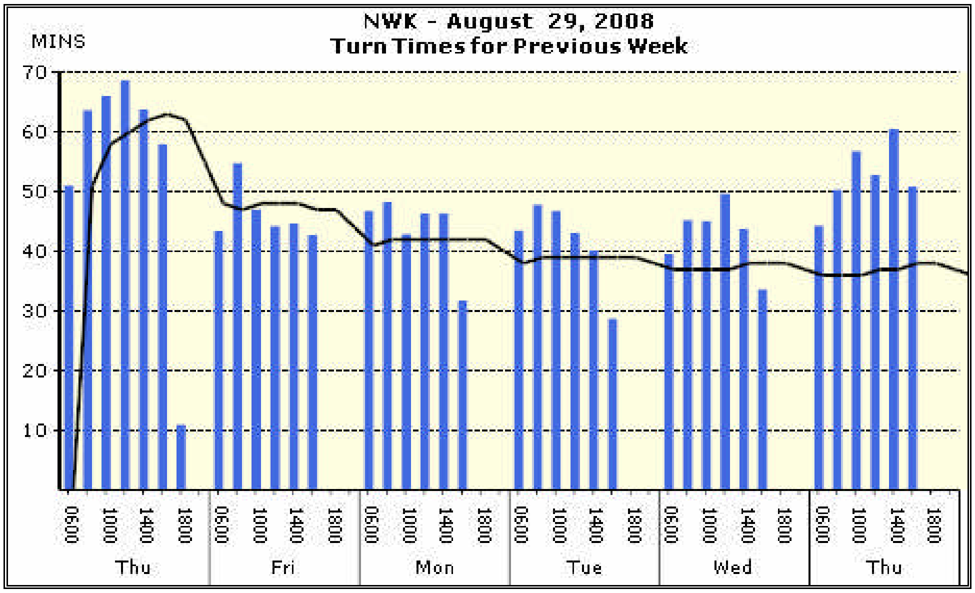
[17] "Drayage Services Improvement Study." This 1994 study was performed by Tioga's principals while engaged by Mercer Management Consulting.

[18] "Intermodal Coordination Study: A Survey and Consultant Recommendations on Containerized Transportation in Northern New Jersey." Prepared by the Foundation of the NJ Alliance for Action, August 1994.

[19] http://dataservices.namapmterminals.com/apmt/turntime.aspx?Loc=nwk

[20] http://dataservices.namapmterminals.com/apmt/turntime.aspx?Loc=nwk

Exhibit 192: APM Driver Turn Time for the Week of November 27, 2007



Between 1994 and 2006 container volume more than doubled and terminal turn time was cut in half. It is difficult, however, to attribute gains contributed by each feature with precision since the features are functionally interrelated.

Of the increase of 3 million TEU during the period about 17% can be attributed to increased facility size and 5% can be attributed to the increase in the volume moving by rail. Some additional percentage can be attributed to the internal remodeling of existing terminals. Clearly the gain in management methods and procedures is much more important.

DrayFLEET Model Configuration (subject to revision)

Tioga conducted an internet search to update port statistics and model inputs which are readily available from both port and stevedore websites. Historical data is available from several drayage studies that have been accomplished by the PA and other agencies over the past several years.

Data from all these sources was used to calibrate the DrayFLEET model for the port of NYNJ. Exhibit 193 shows the primary inputs used to reflect operations in 2007.

Exhibit 193: NYNJ Primary Inputs and Outputs

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs — DrayFLEET Version 1.0d of 06/10/2008

Port	New York - New Jersey
Terminal(s)	All
Scenario	Base Case
Date	6/16/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	5,299,105	5,299,105
Average TEU per Container	1.71	1.71
Inbound Share	50%	50%
Inbound Empty Share	1%	1%
Outbound Empty Share	44%	44%
Rail Intermodal Share	15%	15%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	19
Rail Terminals		
Weighted Average Miles from Port	14	14
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	45	45
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Scenario	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	80%	80%
On-Dock Rail (% of rail on-dock)	80%	80%
Automated Gates (% of gate transactions)	90%	90%
Extended Gate Hours (% off-peak, 50% max)	20%	20%
Container Info System (% used)	90%	90%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	80%	80%

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	8,469,920	8,469,920	0	0.0%
Drayage Trip Legs per Container	2.7	2.7	0.0	0.0%
Total Drayage VMT	274,696,007	274,696,007	0	0.0%
Drayage VMT per Container	88.6	88.6	0.0	0.0%
Fleet Required (FTE Tractors)	4,971	4,971	0	0.0%
Annual Duty Cycle Totals				
Idle Hours	4,458,614	4,458,614	0	0.0%
Creep Hours	1,848,985	1,848,985	0	0.0%
Transient Hours	2,155,504	2,155,504	0	0.0%
Cruise Hours	6,269,823	6,269,823	0	0.0%
Total Drayage Hours	14,732,926	14,732,926	0	0.0%
Drayage Hours per Container	4.8	4.8	0.0	0.0%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	251	251	0.00	0.0%
CO	1,454	1,454	0.00	0.0%
NOx	6,010	6,010	0.00	0.0%
PM_{10}	204	204	0.00	0.0%
$PM_{2.5}$	177	177	0.00	0.0%
CO_2	337,555	337,555	0	0.0%
Fuel Use and Total Cost				
Fuel - Gallons	30,169,896	30,169,896	0.0	0.0%
Total Drayage Cost	$ 489,629,685	$ 489,629,685	$ -	0.0%
Drayage Cost per Container	$ 158	$ 158	$ -	0.0%

Exhibit 193 also shows the corresponding primary outputs. The DrayFLEET model estimates that a total of 4,971 FTE tractors would be needed to travel 274.7 million miles over 14.7 million hours to make the 8.5 million trip legs required to handle 5.3 million TEU in 2007 .

Once calibrated to the Port this way, the DrayFLEET model can be used to estimate the impact of operational changes on activity, emissions, and cost. Examples are provided below.

Drayage Initiatives and Impacts

Institutional Prerequisite

Faced with the need to handle ever-increasing demand while improving in-terminal drayage times to levels that would be competitive with other east coast ports, there developed a very strong level of cooperation within the port community in New York. This is an intangible benefit, but is very important in creating a climate in which the PA, stevedores, and truckers can collaborate to mutual advantage. The NJ Motor Truck Association and Bi-State Harbor Carriers have forged a strong alliance with the PA and with the stevedores, particularly Maher. The alliance works both on local operational issues and political issues at local, state, and national level.

This collaboration has resulted in a number of individual initiatives by terminal operators which in the aggregate produced a dramatic improvement in motor carrier productivity and a reduction in drayage idling. While it is difficult to assess the precise impact of so many interrelated initiatives implemented simultaneously, in the aggregate more than an hour of driver time per turn has been gained by these efforts over the past 12 years.

Co-op Chassis Pools

Maher was one of the early innovators in the establishment of a co-op neutral chassis pool in 1995. In a co-op neutral chassis pool each steamship line participant contributes their chassis to the pool and then is able to use any chassis in the pool as needed to meet ordinary and extraordinary demands. The benefits of the pool included a 25% reduction in the number of chassis required to serve the collective demand and improved quality and consistency of chassis maintenance practices. The reduction in chassis numbers results from the elimination of the extra chassis maintained as a reserve by each ocean carrier and from the better condition of the fleet, as well as the benefits of a pool serving trade lanes that have different seasonal peaks.

From a motor carrier's perspective the improved chassis quality results in less breakdown time and equipment violations while on the road as well as less marine terminal time required to find and/or make a chassis serviceable. In a co-op pool situation the draymen can often keep a chassis for multiple trips, thereby reducing the number of unpaid moves to exchange chassis. In the past these steps were required for each load. Use of pool chassis not only eliminates gate transactions, it simplifies and speeds gate processes. Finally, a chassis system that has higher quality chassis and is easier to use makes the driver's task more straightforward and less frustrating. The result is a significant increase in productivity.

In the Port of New York, in 1994 it was easily a two-hour process to drop off one line's chassis and pick up one from another company. This was in part because of the poor maintenance condition of the chassis. This process was not always required, but it was common. The poor maintenance condition of the chassis fleet had the further impact of adding as much as an hour on the outgate roadability inspection process. Maher's neutral chassis pool significantly addressed these concerns.

Container Terminal Information System

Each terminal has an information system that maintains container status and availability information. In each case the information is available in a number of different communications formats including via the internet. All the terminals except Maher participate in the eModal system. The practical value of accurate information is that it permits motor carrier dispatchers to plan work efficiently and to avoid "dry runs" – moves made with the goal of picking up a container that is not available for some unforeseen reason. The information system and associated operating discipline has had the further benefit of reducing visits truckers make to the "trouble window" for exceptional or difficult movements.

The information system, port ID Card, and gate automation all have combined to reduce the gate process time from an estimated 5-10 min average to a current 3-5 min average. That likely reduced the outside-the-gate standing time by about 30 minutes.

Automated Gates

All the PA marine terminals have been continuously improving gate technology. In particular, Maher was a leader in the implementation of Optical Character Recognition (OCR) technology at marine terminal gates and now declares that it is on its third generation of automated gate. Each generation of gate system improved throughput by eliminating, automating, and speeding business processes. When a minute is taken off the process time, the effect is multiplied as the total impact is that minute plus a minute of queue time for each truck in line. If there are ten trucks in line, then the average turn time is reduced by more than 10 minutes by that one-minute processing improvement.

This observation points to the match of the physical capacity of the gate, including technological features, with the need for increased throughput as the critical factor in the speed and capacity of marine terminal gates. Demand in this case includes both the throughput needs as well the menu of functions, including security functions, required to be performed at the gate.

Port ID Card

NYNJ was one of the first ports to implement a uniform truck driver identification card, called SEALINK®. The uniform ID was one of the building blocks that is used to simplify business processes at marine gates and reduce the time taken to process trucks. A SEALINK® card is presently required for every transaction a driver makes at a PA marine container terminal. Like gate automation, the card reduces both processing time and queue time.

Extended Gate Hours

Maher extended gate hours to 6:00 am–10:00 pm without penalty charges and has been almost as successful as PierPASS at increasing gate capacity. The late gate does nothing to change the actual process of the gate transaction, but it does spread the existing demand over a greater time period thereby reducing the number of trucks in the queue and the resulting wait time. Extending gate hours costs the marine terminal operating dollars. From Maher's point of view, however, the ability to achieve more throughput per acre justifies the cost. Maher reported that existing night time bans on truck movements in local communities is the major barrier to the growth of this program. Other terminals hours are as follows:

- Global 6:00 am–6:00 pm
- APM 6:00 am–4:30 pm
- NYCT 6:00 am–4:00 pm, closed 12:00 noon–1:00 pm
- PNCT 6:00 am–4:00 pm

Concurrently the gate periods were gradually expanded from 8:00 am–4:00 pm in the past, with an hour off for lunch, to a minimum of 6:00 am–4:00 pm without closing for lunch, an increase in practical capacity of 29%. Generously expanded gate hours can account for another third of the growth.

Extended gate hours at Maher terminals were reportedly eliminated in 2008 as a cost-control measure.

Staggered Lunch Breaks

ILA work rules now permit staggered shifts over the lunch hour. In the past it was possible for truckers to get caught in the terminal and be forced to sit idle for an hour while the gates closed for lunch. Only the NYCT facility continues to maintain this practice.

Gate Web Cameras

Gate Web Cameras (Exhibit 194) help level the demand for gate services over the available time by giving motor carrier dispatchers and drivers real time information regarding gate congestion. This information can be used to plan work more efficiently and reduce average turn time by spreading the work load to ensure the gates are consistently busy. APM, Global, and PNCT currently use Gate Web Cameras. Tioga Group staff were able to use the web cameras to check terminal operations and conditions in the course of the study.

Exhibit 194: Global Marine Terminal Web Camera

Investment in Terminal and Gate Capacity

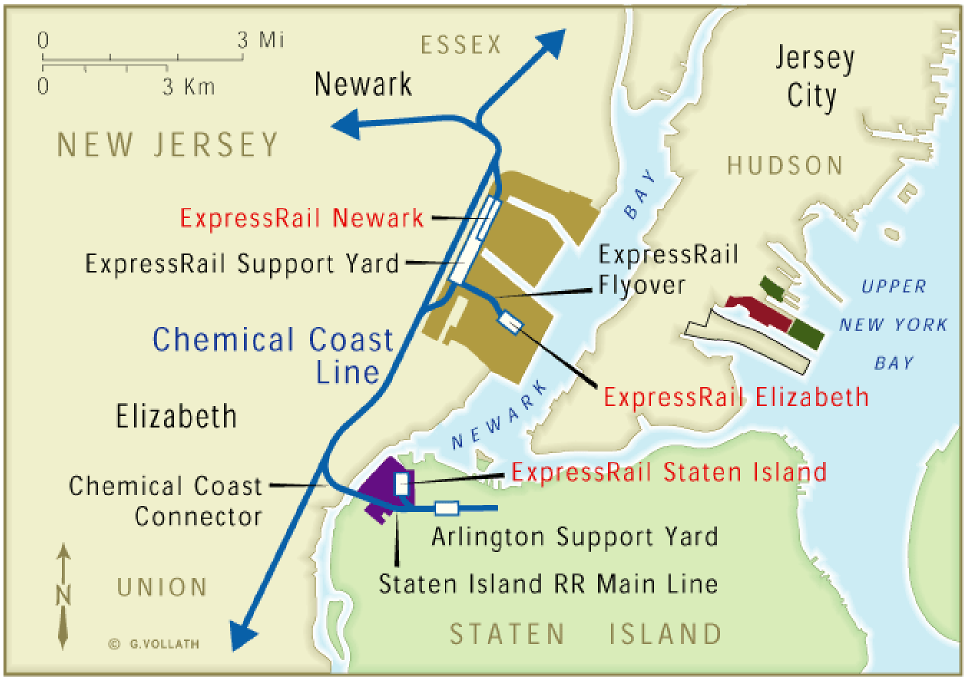
Another way to reduce trucker turn times is to increase terminal capacity. At NYNJ, Howland Hook Marine Terminal was reopened in 1996 after a period of dormancy. The terminal's 187 acres added approximately 17% to marine container facilities; an additional 124 acres were acquired for future development in 2001. Thirty-nine of those acres have been developed as an on-dock rail facility. The practical impact is that the workload is spread over more gates and a greater area, producing shorter lines and associated wait time.

During this period, Maher's two separate terminal operations were consolidated into a single more efficient 445-acre terminal, and the APM terminal was expanded from 266 to 350 acres. Concurrently the ExpressRail Elizabeth on-dock rail terminal was relocated and expanded from 32 to 70 acres.

On-Dock Rail

The PA's first on-dock rail terminal, ExpressRail, began operation in 1991. ExpressRail is now a system of three on-dock rail terminals which handled 358,043 lifts in 2007. The system is pictured in Exhibit 195, below.

Exhibit 195: ExpressRail On Dock Rail Terminal System



The three terminals in the system include:

- ExpressRail Elizabeth is a 70-acre facility adjacent to both Maher and APM terminals. It became operational in 2004.
- ExpressRail Staten Island is a 39-acre facility adjacent to NYCT on Staten Island. The facility became operational in 2007 and was a key commercial factor in the reactivation of the Staten Island Railway by New York Economic Development Corporation and the Port Authority.
- At present PNCT is being served by a small interim rail facility. ExpressRail Newark, is planned to be much larger and offer direct access to Port Newark Container Terminal.

The cargo shipped using on-dock rail terminals typically avoids all the marine gate processes and queues as well as the dray to the customer or off-dock facility.

Combined Impact of Terminal Initiatives

The combined impact of these multiple terminal initiatives has been substantial.

Exhibit 196: Combined NYNJ Terminal Initiatives Impact - Five Mile Limit

SmartWay DrayFLEET Version 1.0 Primary Inputs & Outputs DrayFLEET Version 1.0d of 06/10/2008

Primary Inputs	Default	Scenario
Port		
Calendar Year	2007	2007
Annual TEU	5,299,105	5,299,105
Average TEU per Container	1.71	1.71
Inbound Share	50%	50%
Inbound Empty Share	1%	1%
Outbound Empty Share	44%	44%
Rail Intermodal Share	15%	15%
Marine Terminals		
Average Inbound Gate Queue Minutes	11	11
Average Marine Terminal Min. per Transaction	19	60
Rail Terminals		
Weighted Average Miles from Port	5	5
Average Inbound Gate Queue Minutes	5	5
Average Rail Yard Min. per Transaction	15	15
Container Depots		
Weighted Average Miles from Port	4	4
Share of Empties Stored at Depots	5%	5%
Container Shippers/Receivers		
Weighted Average Miles from Port	5	5
Weighted Average Crosstown Trip Miles	10	10
Cost Factors		
Average Drayage Labor Cost per Hour	$ 12.00	$ 12.00
Average Diesel Fuel Price per Gallon	$ 4.00	$ 4.00

Initiative Inputs	Default	Scenario
Port/Terminal Initiatives		
Stacked Terminal (% stacked)	80%	0%
On-Dock Rail (% of rail on-dock)	80%	0%
Automated Gates (% of gate transactions)	90%	0%
Extended Gate Hours (% off-peak, 50% max)	20%	0%
Container Info System (% used)	90%	0%
Virtual Container Yard (% available)	0%	0%
Neutral Chassis Pool (% used)	80%	0%

Port	New York - New Jersey
Terminal(s)	All
Scenario	Base Case
	Five-Mile Limit
Date	7/23/2008

Activity Outputs	Default	Scenario	Change	% Change
Annual Activity				
Number of Drayage Trip Legs	8,469,920	9,174,216	704,295	8.3%
Drayage Trip Legs per Container	2.7	3.0	0.2	8.3%
Total Drayage VMT	70,049,637	77,054,647	7,005,010	10.0%
Drayage VMT per Container	22.6	24.9	2.3	10.0%
Fleet Required (FTE Tractors)	2,314	3,731	1,417	61.2%
Annual Duty Cycle Totals				
Idle Hours	3,147,653	6,400,242	3,252,589	103.3%
Creep Hours	1,296,196	1,987,109	690,913	53.3%
Transient Hours	695,967	820,577	124,610	17.9%
Cruise Hours	1,718,603	1,850,191	131,589	7.7%
Total Drayage Hours	6,858,419	11,058,120	4,199,700	61.2%
Drayage Hours per Container	2.2	3.6	1.4	61.2%

Emissions Outputs	Default	Scenario	Change	% Change
Pollutant (annual tons)				
HC	82	103	21.17	25.9%
CO	479	607	127.94	26.7%
NOx	1,870	2,264	394.43	21.1%
PM_{10}	63	75	12.47	19.9%
$PM_{2.5}$	54	65	10.81	19.9%
CO_2	111,494	142,708	31,214	28.0%
Fuel Use and Total Cost				
Fuel - Gallons	9,965,092	12,754,918	2,789,826.7	28.0%
Total Drayage Cost	$ 234,250,746	$ 334,563,283	$ 100,312,537	42.8%
Drayage Cost per Container	$ 76	$ 108	$ 32	42.8%

As Exhibit 196 suggests, the combined 2007 port-area[21] impact of the various initiatives described above, including a reduction in average terminal transaction time from roughly 60 minutes to a 2007 average of 19 minutes, was to:

- eliminate over 700,000 drayage trip legs, covering over 9 million VMT;
- reduce total driver and tractor hours by 4.2 million;
- reduce emissions by 19.9% to 26.7%, including nearly 400 tons of NOx;
- reduce fuel consumption by almost 2.8 million gallons; and
- reduce drayage cost by over $100 million.

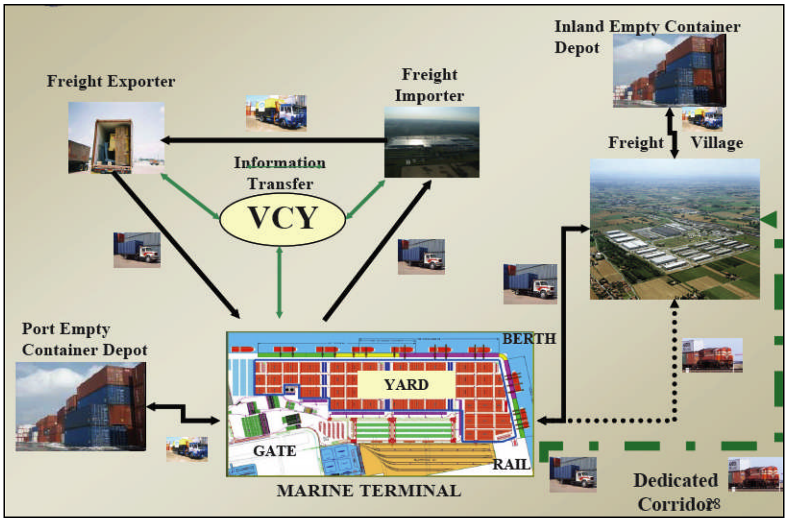
The absolute magnitude of these impacts is testament to the huge volume of drayage activity in major ports and the power of cumulative incremental improvements.

VCY

PANYNJ has sponsored the development of a Virtual Container yard (VCY) for the regional port community (Exhibit 197). The system is being developed by eModal, the same organization involved in the LALB VCY effort. The system is expected to be complete in June 2008.

[21]Restricting the drayage distance to five miles effectively "moves" the off-dock rail terminals closer to the port.

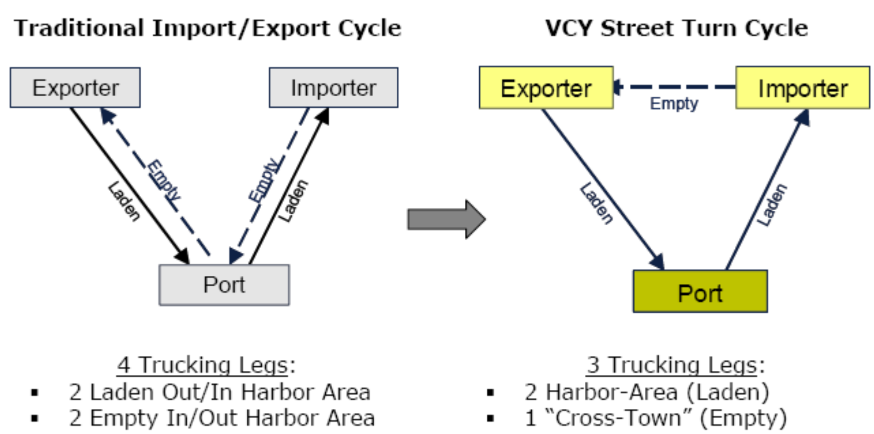
Exhibit 197: Role of PANYNJ Virtual Container Yard



Source: The Partnership to Maximize Port Industry Performance At The Port of NY & NJ: How Can Advanced Research Methods Assist Stakeholder Efforts?, Boile, Theofanis, and James, October 2007

As illustrated in Exhibit 198, the objective is to encourage reuse of empty containers, thus reducing drayage trips. As the system has not yet been fully implemented it is too early to expect any usage or benefits data.

Exhibit 198: Reducing Drayage Trips



Appendix: Literature Review

Overview

The study team undertook an initial review of the available literature on marine terminal management strategies to reduce truck VMT and/or emissions. The management strategies and related initiatives under investigation include several in use or under consideration at U.S. ports.

- **Extended gate hours** tend to reduce peak period congestion and idling/queuing time.[22] Extended gate hours may also reduce the need for drayage firms to park and store containers overnight.
- **Appointment systems** tend to reduce terminal congestion and waiting time, and may also reduce non-productive trips when containers are not ready to move.
- **Virtual container yards** are expected to increase opportunities for reusing empty containers and reduce empty movements.
- **Information Systems** let truckers obtain status information on containers at marine terminals and facilitate the development and implementation of VCYs and appointment systems.
- **Chassis pools** reduce the time required to locate a serviceable chassis, reduce the need for chassis "flips" in rail yards, and reduce delays for chassis repairs.[23]

Much of the literature focuses on the Southern California ports. The numerous studies commissioned and completed by the Metrans[24] program at the University of Southern California account for much of the Southern California literature.

Extended Gate Hours

An early report in the Metrans efforts (Mallon and Magaddino, 2001)[25] applied economic break-even analysis to extended gate hours. The authors suggest introduction of a "community based appointment and scheduling system to coordinate truck dispatch with gate transactions." The authors define "throughput velocity" as the number of twenty-foot equivalent units (TEU) per acre per month multiplied by the average dwell time. This definition has the curious effect of yielding higher "velocities" for containers with longer dwell times (i.e. that sit still longer). The study makes the common assertion that extended gate hours are only feasible with a commitment to extended shipping and receiving hours by regional customers. This assertion may be

[22] *A Glance at Clean Freight Strategies: Gate Accessibility for Drayage,* U.S. EPA SmartWay Program, 2006

[23] *A Glance at Clean Freight Strategies: Common Chassis Pools for Drayage,* U.S. EPA SmartWay Program, 2006

[24] The Metrans website at http://www.metrans.org/ has extensive information on their research program and access to most of the published work.

[25] Mallon, L and Magaddino, J., "An Integrated Approach to Managing Local Container Traffic Growth in the Long Beach-Los Angeles Port Complex, Phase II," Metrans, 2001.

unnecessarily limiting. In Southern California, at least, there are major concentrations of distribution centers 60-90 minutes away. Normal shipping hours of 8:00 am to 5:00 pm for these more distant customers would generate numerous truck trips during extended gate hours. To reach an import customer 90 minutes way at 8:00 am, a drayman would have to be in line at the marine terminal by 6:00 am to leave with a container by 6:30 am. If a shipper 90 minutes from the port releases an export container at 5:00 pm, the drayman will not reach the marine terminal until 6:30 pm and will probably not be done until 7:00 pm at the earliest. Extended gate hours are thus necessary for regional customers to use their full 8:00–5:00 shipping day.

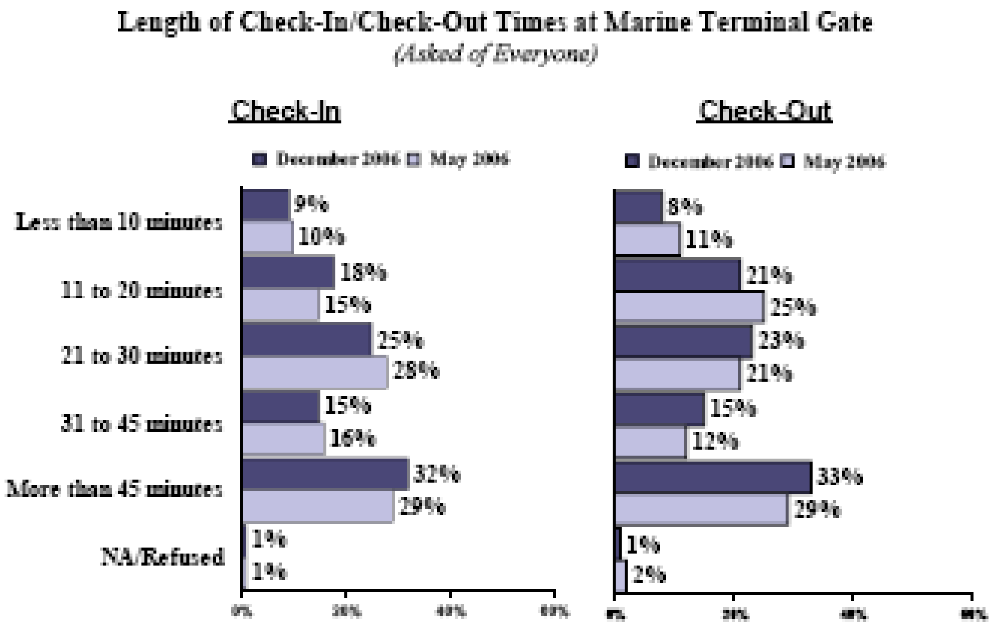
The report also contains potentially useful data on the manning costs of marine terminal gates. Since these data likely reflect year 2000 labor costs, however, they would probably need to be updated.

The Southern California PierPASS system of extended gate hours and its OffPeak truck traffic diversion initiative is well documented and has been the subject of company-sponsored drayage industry surveys.[26] The PierPASS OffPeak program imposes a fee of $50 per TEU ($50 for a 20-ft. container, $100 for a 40-ft. container) for gate arrivals during "peak" daytime hours and waives the fee in off-peak hours. About 40% to 45% of the eligible loaded drayage trips at the Ports of Los Angeles and Long Beach have shifted to off-peak hours. In the first year of operation since July 2005, about 2.5 million truck trips were diverted to off-peak hours. Annual diversions for 2006 were expected to be 2.8 to 3.0 million trips.

Drayage driver surveys taken on behalf of the PierPASS program, most recently in late 2006, reveal mixed acceptance of PierPASS and the OffPeak incentive system. Of those drivers familiar with OffPeak in December 2006, 61% had an overall positive opinion and 29% had a negative opinion (10% were neutral). The survey found that 67% of the drivers experienced reduced traffic congestion and that 45% were able to complete more trips per shift. Half of those familiar with OffPeak reported less congestion on the I-110 and I-710 freeways serving the ports. Two surveys were combined to produce the check-in/check-out time charts in Exhibit 199.

[26] PierPASS Los Angeles/Long Beach Harbor Truckers Follow-up Survey, Fairbank, Maislin, Maullin & Associates, November-December 2006.

Exhibit 199: Check-in/Check-out Results from PierPass Survey



Although not showing dramatic changes, these survey data may be valuable in assessing the separate and combined impacts of the multiple terminal management initiatives being pursued in Southern California.

Appointment Systems

The Transportation Development Centre of Transport Canada commissioned a very extensive study of truck appointment systems and other efforts to reduce greenhouse gas emissions from container trucks at North American ports[27]. The authors conducted a literature review, a largely unsuccessful telephone and fax survey, and in-depth interviews with a few major Canadian and U.S. ports. The study focused on appointment systems, finding that the implementation, usage, and benefits of such systems varied widely.

- Early Southern California appointment systems implemented due to the Lowenthal Bill[28] (as opposed to those that were subsequently incorporated into eModal and VoyagerTrack) were under-used and delivered few benefits. Information systems such as eModal are heavily used, and the PierPASS program has successfully shifted truck trips to off-peak hours.

- The STS terminal in Oakland has a successful appointment system[29].

[27] Roche Ltée & Levelton Consultants, Ltd. "Terminal Appointment System Study," Transport Canada, 2006.

[28] California Assembly Bill 2650. Complete text at http://www.leginfo.ca.gov/pub/01-02/bill/asm/ab_2601-2650/ab_2650_bill_20020930_chaptered.pdf

[29] The STS terminal uses VoyagerTrack.

- The Vancouver terminal appointment systems (unnamed) have achieved progress despite implementation problems.

Reading between the lines in this study, it could be concluded that appointment systems with commitment from terminal operators tend to succeed (Oakland, Vancouver), while appointment systems reluctantly implemented due to outside pressure (Southern California) tend to fail. The report stops short of providing detailed information on the appointment systems that did or did not succeed. It does, however, offer extensive information on the use of gate and information technologies (optical character recognition, closed-circuit television, etc.) terminal operating systems (NAVIS, COSMOS) and yard equipment control technology (GPS, RFID), to reduce the time spent by trucks in gate queues and container yard operations. Significantly, the report concludes in passing that truck idling time is the critical factor because truck travel time is a function of terminal size and design rather than of terminal management. Finally, this report includes a valuable discussion of truck idling emissions factors and modeling approaches.

A 2006 Metrans study[30] concurred in the generally negative assessment of the initial appointment systems at the Southern California ports. Those systems were implemented in 2002 in grudging response to the Lowenthal Bill, which allowed terminals to either implement an appointment system or extend gate hours to avoid paying heavy fines for gate queues. The Metrans report found that the early appointment systems had little impact on gate queues. Use of the systems varied widely as a function of terminal operating practices. The variability of appointment system use across terminals is a key finding of the Metrans report. Of the 14 container terminals at LA and Long Beach, 10 offered appointment systems and 4 did not. Three different appointment systems were offered, and system implementation varied even between terminals on the same system. These systems were eventually phased out and replaced by VoyagerTrack and eModal, described below.

Another in the series of papers on modeling terminal transactions examined the use of "time windows" (appointments) in a theoretical framework[31]. The approach assumed that container terminals run optimization algorithms to general "wide" time windows for container pickup, and that trucking companies would then run their own algorithms to narrow the time windows. The paper also assumes that the customer (i.e. the import distribution center) does not assign delivery windows, although in practice most do use delivery appointments. This paper also describes "Terminal Simulation" software developed by the authors. Further investigation will be required to determine the potential utility of this simulation software in analyzing alternative terminal management strategies.

Still another in the series of modeling papers by Ioannou, et al[32] address the limitations of standard algorithms (the "Multi-Traveling Salesman Problem with Time Windows," or M–

[30]A. Guiliano, S. Hayden, P. Dell'aguila, T. O'Brien, "Evaluation of the Terminal Gate Appointment System at the Los Angeles/Long Beach Ports", Metrans Project 04-06, 2006. (Draft Final Report).

[31] Ioannou, P., Chassiakos, A., Jula, H., and Valencia, G., "Cooperative Time Window Generation for Cargo Delivery/Pickup with Applications to Container Terminals," Metrans Project 03-18, 2006.

[32] Ioannou, P., Chassiakos, A., Jula, H., and Unglaub, R., "Dynamic Optimization of Cargo Movement by Trucks in Metropolitan Areas with Adjacent Ports," Metrans, 2002.

TSPTW) by developing two alternative methods. The first is a hybrid dynamic programming/genetic algorithm method. The second is a heuristic insertion method. The later method was preferred for the dynamic environment of port drayage and offers potential efficiencies in calculations.

Virtual Container Yards

A 2002 study by the Tioga Group[33] on behalf of Southern California planning agencies and ports encompassed several aspects of the potential for reuse of empty import containers or rationalization of their movement. The Tioga study distinguished two types of potential rationalization:

- "street turns" – reuse of an empty import container for an export load without an intervening empty move to the marine terminal.
- "depot direct off-hires" – moving an empty leasing company container directly to an off-dock depot without first taking it to the marine terminal.

Identifying the "depot direct" rationalization opportunity significantly increased the potential reduction in VMT in the Tioga study.

The Tioga study describes the internet-based information systems operating in 2002: eModal, VoyagerTrack, InterBox, and SynchroNet. None of these systems functioned as a Virtual Container Yard, although all included features that could contribute to a VCY solution. Analysis in this study included a listing of VCY information requirements (Exhibit 200).

Exhibit 200: VCY Information Requirements

Info Source	*Container Info*	*Chassis Info*
Ocean Carrier	**Box Serial No.**	**Chassis Serial No.**
	Box Type & Specs	**Chassis Type**
	Reuse Limits	**Reuse Limits**
	Return Location	**Return Location**
	Free Time/Per Diem	**Free Time/Per Diem**
Trucker	**Location**	**Location**
	Time/Date Available	**Time/Date Available**

The Tioga study noted that the key purposes of a VCY are to:

- post needed information about containers (status, location, etc.)

[33] Empty Ocean Container Logistics Study, the Tioga Group, Inc., 2002. Prepared for the Southern California Association of Governments, the Gateway Cities Council of Governments, and the Port of Long Beach.

- facilitate communication between parties (motor carriers, ocean carriers, leasing companies, chassis pool operators);
- permit equipment interchange and other processes to take place without moving the container to the harbor; and
- assist the parties to make optimal decisions regarding container logistics (return, reuse, interchange, etc.) rationalize moves, and plan ahead.

The Tioga study makes the critical observation that a VCY would not be a dispatching system, since trucking firms would retain their own dispatching functions. Instead, the VCY would provide truck dispatchers with usable information and a means to make better dispatching decisions. Finally, the Tioga study provides extensive coverage of the institutional factors that impinge on the potential of virtual container yards and related systems, notable among these institutional factors are:

- ocean carrier free time and per diem provisions;
- inspections, and liability for damage on interchanged containers;
- ocean carrier incentives for empty return versus export loading; and
- the legal framework of the Uniform Intermodal Interchange Agreement (UIIA) that governs most container and chassis interchanges.

A subsequent study of Southern California empty container logistics[34] (LeDam Hanh, 2003) may have been somewhat hampered by unfamiliarity with some aspects of the container shipping business (e.g. an assertion that, "for the most part, containers are still owned by carriers," when in fact about half are leased) and by a tendency to dismiss institutional problems such as damage liability on the basis of a successful but anecdotal example. The report may also have confused the function of a VCY in posting the availability of empty containers (posted by truckers) with sharing information on the availability of export loads (which is strictly proprietary). The study touches briefly on the potential role of chassis pools but devotes more attention to collapsible containers, an oft-proposed but never implemented concept.

Ioannou et al[35] focused on the empty container interchange problem, in this case through a simulation of substituting one type of container with another type. The simulation includes substitution between containers owned by different ocean carriers (steamship lines). This is not a form of substitution in current practice, but it would increase the potential for reuse.

[34] LeDam Hanh, P., "The Logistics of Empty Cargo Containers in the Southern California Region: Are Current International Logistics Practices a Barrier to Rationalizing the Regional Movement of Empty Containers?," Metrans, 2003.

[35] Ioannou, P., Chassiakos, A., Jula, H., Chang, H., and Valencia, G., "Development of Methods for Handling Empty Containers with Applications in the Los Angeles/Long Beach Port Areas", Metrans Project 04-05, 2006.

Most recently, Janakiraman, S., et al,[36] developed a stochastic, simulation-based model of VMT changes resulting from implementation of a VCY at the Port of NY/NJ. The authors ran multiple simulations covering a range of container volumes and interchange nodes, and three different VCY collaboration scenarios.

- No collaboration between ocean carriers.
- Collaboration between ocean carriers on container sharing within groups.
- Universal collaboration.

With the largest volumes, the most modes, and full collaboration, the authors estimated total VMT reductions of nearly 20%. In common with other modeling efforts, this paper and the model it presents rely on assumptions.

- Truckers are not exclusive to one or a group of ocean carriers. This is generally the case in practice and should not affect the validity of the outcomes.
- All containers are owned by the ocean carriers. Ocean carriers, in fact, own about half the containers. They do, however, control leased containers for extended periods, so this assumption may not cause problems.
- Import and export sites have the same geographic distribution from the port. This assumption would rarely be borne out in practice, and may prove to be a limiting factor on the success of VCYs.
- The ratio of import to export sites is 0.42[37].

The paper does not examine the sensitivity of the model results to variations. This model is apparently focused on the role of a VCY in container sharing between ocean carriers, and uses the foreign destination of the export movement as a significant dependent variable. This is a different objective than reducing empty inland movements or reducing VMT, and is the objectives of other systems (Synchronet, IAS) rather than VCYs. The street turns facilitated by VCYs would include:

- reuse of a given container for another customer of the same ocean carrier and trucker, and
- reuse of a given container by a different trucker to serve another customer of the same ocean carrier.

The paper shows the frequency of interchange rising from zero in the non-VCY base case to 15.4% in the full collaboration case with 100 nodes and 15,000 containers. The basis for this percentage of interchanges is, however, unclear from the paper.

[36] Janatiraman, S., Theofaius, Boile, and Naniopoulos, A. "Virtual Container Yard: A Simulation-based Perspective," Transportation Research Board, January, 2007.

[37] Since this implies a strong surplus of export sites, the paper may have misstated this ratio.

Interbox and eModal together are trying to develop the only operating VCY in Southern California. Recent contacts with stakeholders indicate that the system is not yet fully functional and not yet delivering anticipated benefits.

Information Systems

There is extensive documentation of the major on-line port container information and appointment systems, eModal[38] and VoyagerTrack[39]. Both systems were developed in Southern California. Both have since been implemented in other West Coast ports and eModal has also been implemented on the East Coast. Both systems offer drayage firms the ability to check the status of containers on-line and to make appointments. eModal[40] has added more features, such as electronic settlement of fees, electronic delivery orders (eDO), and an identification and registry system for drayage drivers (Truckercheck). The documentation for these systems, however, is primarily informational rather than analytic. Performance metrics for the VoyagerTrack system were incorporated in DrayFLEET model features.

The Georgia Port Authority's WebAccess[41] is an interface for entering and accessing real-time container information and reports, using information managed by Navis' SPARCS and EXPRESS integrated terminal software. WebAccess connects to SPARCS, Navis' graphical planning and control system for yard, vessel, or equipment planning; and EXPRESS, Navis' comprehensive information system that manages and maintains all terminal business transactions in an Oracle database. Web Access, in combination with extended gates hours and other port and terminal initiatives, reportedly reduced average truck turn times at Savannah from 75 minutes in 2000 to 42 minutes in 2004[42]

The Freight Information Real-Time Support for Transport (FIRST)[43] was designed by the Port Authority of New York and New Jersey (PANYNJ) FIRST was intended to combine information from ocean carriers, marine terminals, railroads, and drayage companies for access through a common web portal (not unlike eModal or comparable systems at other ports). FIRST was expected to help rationalize truck trips, reduce VMT, ease congestion, and improve terminal efficiency. A 2002 review of freight transportation technologies[44] by the New York Metropolitan Transportation Council mentions FIRST, which was then just starting out.

The FIRST website was launched in late 2001. The FIRST website (http://www.firstnynj.com/) is active but provides no background information on the system. Customer acceptance was

[38] See http://www.emodal.com

[39] see http://www.voyagertrack.com/File/en/VTHome.html

[40] *A Glance at Clean Freight Strategies: EModal Port Community System for Drayage*, U.S. EPA SmartWay Program, 2006

[41] *Navis Launches WebAccess for Real-Time Container Information Exchange and Reporting Via the Internet*, Press release, January 22., 2002, and WebAccess website at http://webaccess.gaports.com/express/about.jsp

[42] *A Glance at Clean Freight Strategies: Terminal Appointment Systems for Drayage*, U.S. EPA SmartWay Program, 2006

[43] Freight Information Real-Time Support for Transport Evaluation Final Report, SAIC, for U.S. DOT, 2003.

[44] Review of Technologies Used in Freight Transportation in the New York Metropolitan Region, New York Metropolitan Transportation Council, October 2002

lackluster. By March of 2003, only 1% of the known port motor carriers were registered with FIRST.

- Drayage firms found the information available via FIRST to be limited, and not always accurate or timely.
- Ocean carriers saw no benefits from FIRST, and some stopped providing data.
- Terminal operators and ocean carriers began providing their own websites, supplanting FIRST.

The evaluation team found that FIRST was underused due to both internal and external factors and that the expected benefits did not materialize. The ongoing value of this evaluation is in its analysis of reasons for success and failure, its comparisons with other systems, and its efforts to model FIRST's potential benefits. The evaluation team compared FIRST with the Pacific Gateway Portal (at the Port of Vancouver) and eModal (originally at Los Angeles and Long Beach). The key distinctions included:

- careful upfront planning by a comprehensive stakeholder group
- incorporation of a functional appointment system
- features that deliver concrete benefits to users.

The simulation model yielded estimates of significant emission benefits, but under the assumption that all trucks had appointments.

Chassis Pools

Maher terminals in New Jersey has been operating a cooperative chassis pool for several years. Among the benefits commonly cited is a 25% reduction in the on-terminal chassis fleet despite a growing cargo volume. The workings of the chassis pool are described in various presentations and press releases.

The Ocean Carrier Equipment Management Association (OCEMA) has been developing neutral chassis pools at rail intermodal terminals. Union Pacific and CSXI have done likewise. Here too, the publicly available information is descriptive and promotional.

The chassis pool implemented by Virginia Inland Terminal (VIT) and OCEAMA reportedly reduced the required chassis inventory by 23% (very similar to the Maher results) and increased asset utilization by 27%[45]. The system received the 2006 IANA Intermodal Achievement Award.

Multi-Strategy Studies

Fischer, et al[46], summarize the potential contribution of several truck trip reduction strategies to the goal of reducing VMT at the Ports of Long Beach and Los Angeles. The analysis used the

[45] Virginia Port Authority News Release, November 21, 2006

Quick Trip truck trip generation model developed as part of the Port's travel demand model. The trip reduction strategies assessed included:

- a Virtual Container Yard (VCY);
- extended marine terminal gate hours (including the PierPASS program);
- expanded on-dock rail transfer;
- rail shuttle trains; and
- expanded near-dock rail.

The VCY analysis used the results of the Tioga Study (2002), which postulated 5% and 10% container reuse percentages with a VCY compared to 2% without. (The Fischer Study did not include an independent reassessment of the VCY potential.) The Quick Trip analysis yielded an estimated 2005 VMT reduction of 0.7% for 5% reuse and 1.8% for 10% reuse. The authors note that additional cross-town trips required to interchange the containers would offset the reduction in trips to and from the Port. Emissions reductions were proportional to the VMT reductions.

Extended gate hours were found to have no VMT reductions, as expected, since the point of extended gate hours was to reduce congestion in peak periods rather than to reduce trips. The authors note, correctly, that reducing congestion and the time trucks spend idling or creeping in traffic would reduce emissions, but that reduction is not captured in the Quick Trip model.

A 2005 study of multiple innovative transportation strategies by the LBJ School of Public Affairs[47] discussed the initiatives being pursued by Maher Terminals at the Port of New York/New Jersey, including:

- automated gate systems
- extended hours
- chassis pooling
- on-dock rail

The report is largely descriptive, as the initiatives discussed had only a short track record to date. As of the study date, Maher expected to raise the share of on-dock rail from 11% to 25%; expand the share of containers handled in extended gate hours above 10%; and increase overall terminal throughput capacity.

The modeling efforts tend to be theoretical rather than pragmatic in orientation. A manageable modeling approach commonly requires a series of simplifying assumptions to cope with complex realities. Some of these efforts may suffer from lack of familiarity with industry practices. The

[46] Fischer, M., Hicks, G., Cartwright, K. "Performance Measure Evaluation of Port Truck Trip Reduction Strategies." Date _______.

[47] Innovative Strategies to Raise Efficiencies along Transportation Corridors and at Multimodal Hubs, Lyndon B. Johnson School of Public Affairs, Policy Research Project Report 147, 2005

major value in these studies is the accumulated knowledge on various modeling approaches and methodologies.

A Canadian Federal-Provincial Task Force completed a study of container movements at British Columbia Ports in October 2005[48]. The study covered best practices at North American ports, including extended gate hours, information systems, virtual container yards, and appointment systems. The task force findings included the following.

- "The implementation of extended gate hours at container terminals has emerged as the single most effective method for reducing delays accessing the terminals." The system at the Port of Montreal and PierPASS were cited as best practices.

- "Common user information systems can speed processing of gate and terminal transactions by integrating necessary information for all participants." The Port of Montreal and eModal were cited as examples.

- "From our research, it appears that few terminals in North America currently rely on a reservation [appointment] system as a key element in optimizing their efficiency." The Evergreen terminal in Los Angeles (which uses VoyagerTrack) was cited as an example of a successful system.

Findings

The available literature on terminal management strategies and related approaches to reducing drayage VMT and emissions can generally be described as promising but not conclusive.

Most of the modeling literature focuses on either rationalization through exchange and reuse via VCYs, or on appointment systems. Both approaches are seen as yielding significant VMT and/or emissions reductions. The amount of the estimated reductions is heavily influenced by the modeling assumptions. The major value of these papers is in their contribution to the repertoire of modeling techniques and applications to drayage. The modeling efforts do not, in general, attempt or claim to estimate the results achievable at any specific marine terminal or port.

The forward-looking studies (Tioga and Fisher, et al) are helpful in establishing the potential application of terminal management strategies and related initiatives and outlining the relationship between the volume of containers affected (e.g. the percentage of containers reloaded achieved by a virtual container yard) and the beneficial outcomes (e.g. reduction in truck VMT and emissions). These studies stop short of discussing the details of management strategies or estimating the volume of container transactions that would be affected. The forward-looking studies do attempt to estimate the results possible from VCYs and other

[48] Final Report of the Task Force on the Transportation and Industrial relations Issues Related to the Movement of Containers at British Columbia Lower Mainland Ports, Canadian Ministry of Transport, et al, October 2005.

initiatives. In both cases the potential for VMT reductions is promising, especially in the hypersensitive Southern California context where reductions in port-related emissions promise to be costly and hard to achieve. The degree to which the Tioga and Fischer findings can be generalized to other ports is a central focus of the present study.

The surveys of current practices typically describe the status of relevant programs at selected ports and the results achieved (or anticipated) to date. These surveys do not typically delve into the details of the successful or unsuccessful programs, and therefore require some follow-up efforts in the present study. They do, however, assist in establishing the context for case studies and provide a range of potential benchmarks for successful programs. The general observations are that appointment systems and information-sharing systems achieve the best results when they are developed from within, by, and for the affected parties. Systems imposed from without were less likely to have large on-going benefits.

Clearly, the literature reflects an emerging body of knowledge. Implementations of promising terminal management strategies are as yet few and recent so there is little empirical data on which to base or calibrate a model. The forward looking and modeling studies are uniformly encouraging, and should lead to additional demonstration projects or system implementations. The results from pilot projections should, in turn, support improved models.

The abstractions necessary to model virtual container yards and container exchanges reveal the true complexity of the actual port drayage context. That context is shaped by institutional practices, local import/export balances, and even geography. The simplifying assumptions necessary in modeling exercises raise some questions regarding sensitivity. Where possible, varying the assumptions to explore the sensitivity of the outcomes would have been instructive. In other cases, the assumptions are necessary to make the model workable and must be accepted in that context.

The team also reviewed a number of PowerPoint presentations, website descriptions, brochures and other materials on the status and benefits of virtual container yards, port community information systems, empty container management systems, etc. Commercial system descriptions and promotional literature are, as expected, sales-oriented rather than aimed at delivering technical information. The more promotional or descriptive presentations tend to contain little in the way of hard data or system information. Some incorporate good summaries of system features or useful graphics. The PowerPoint presentations and website/brochure literature are updated more often than one-time studies or white papers, and care is necessary to make sure that the information is the latest available.