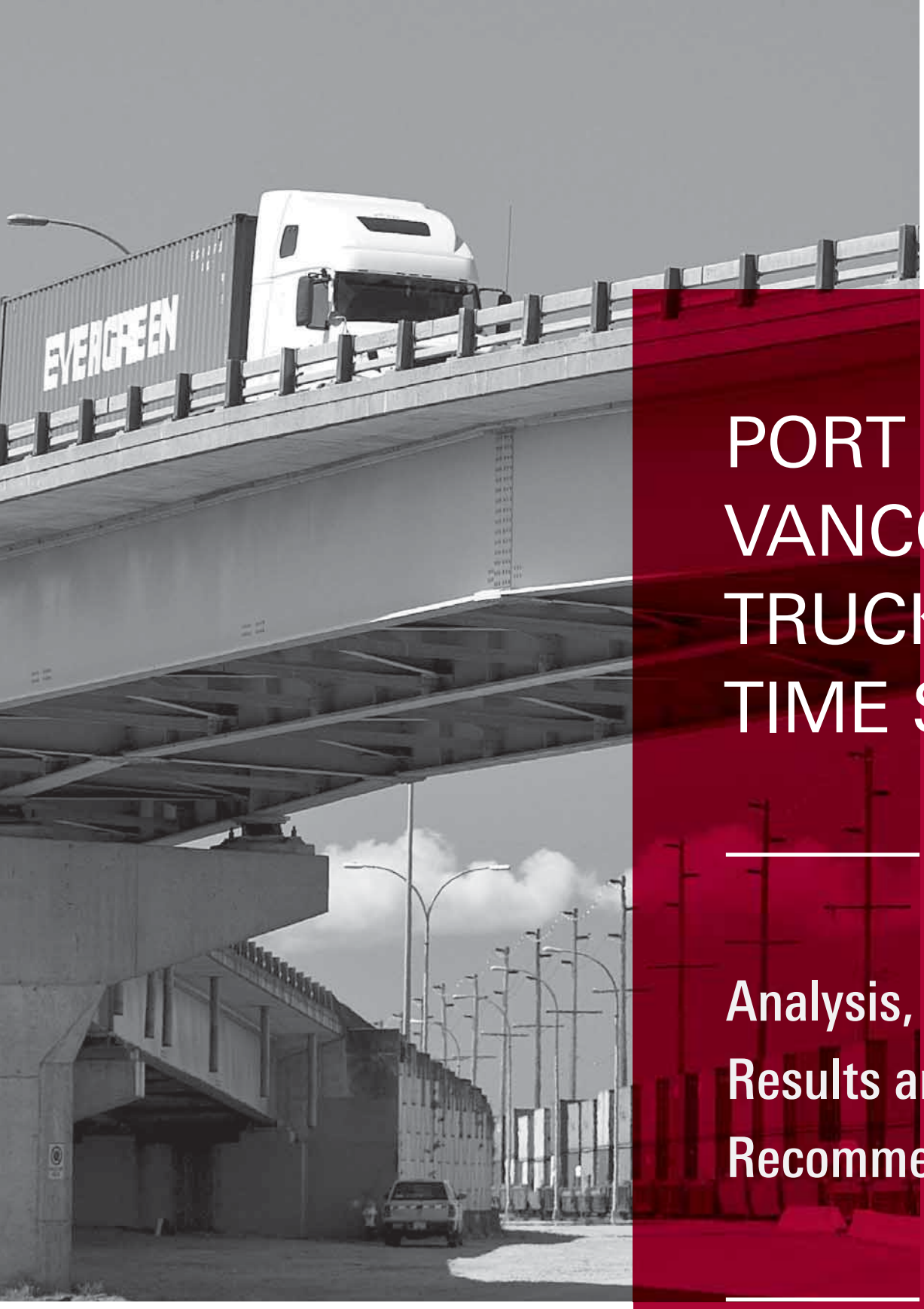

PORT METRO VANCOUVER TRUCK TURN TIME STUDY

Analysis, Results and Recommendations

ASIA PACIFIC GATEWAY
SKILLS TABLE

FINAL REPORT

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PORT METRO VANCOUVER TRUCK TURN TIME STUDY: ANALYSIS, RESULTS AND RECOMMENDATIONS

FINAL REPORT

Prepared by The Tioga Group, Inc. for the Asia Pacific Gateway Skills Table,
B.C. Trucking Association and Port Metro Vancouver

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EXECUTIVE SUMMARY

The Asia Pacific Gateway Skills Table (APGST) engaged The Tioga Group, Inc. to analyze long truck turn times at Vancouver's marine container terminals. The study was completed with the cooperation of Port Metro Vancouver (PMV) and the British Columbia Trucking Association (BCTA) using global positioning system (GPS) data collected by PMV as well as supplementary data sources.

Truck turn time is a critical factor in Gateway cost, capacity, and competitiveness as well as driver earnings and labour stability. PMV handled about 1.6 million containers in 2012, of which about 54% were trucked to and from the marine terminals.

DEFINING "TRUCK TURN TIME"

Truck turn time refers to the amount of time drayage trucks spend at marine terminals. In this report, the time a truck spends inside the terminal is referred to as "dwell time" or "terminal time." The time a truck spends in a staging area is referred to as the "staging time" or "wait time." The sum of the two times is the "turn time".

The study looked at average turn times, the distribution of turn times, and the frequency and causes of long turn times. For this study, "long" turn times were defined as those taking more than 60 minutes.

Although roadway time is not included in the definition of "turn time" for the purposes of this study, it can occasionally account for a significant waiting period that may be reduced/mitigated. As a result, roadway times were separately analyzed and the resulting findings and recommendations were included in this study.

1) The study began in October 2012 with data for the previous four months (June to September 2012). The study team found that the August–September data were more complete, and focused on that time period. Based on the available comparisons of GPS data and terminal records, the study team believes this percentage to be reasonably representative of all truck trips.
2) Note that inclusion of trips with multiple transactions may inflate these percentages somewhat. The prevalence of trips with multiple transactions is not documented in available data.

KEY FINDINGS

Average turn time in the PMV GPS data ranged from 36 minutes at Centerm to 64 minutes at Vanterm, with a three-terminal average of 56 minutes. These times are roughly competitive with known turn times at the largest and busiest North American ports. Nonetheless, overall turn times (including staging and terminal times) greater than 60 minutes for a single transaction exceed trucker and customer expectations, and signal an opportunity for improvement.

Overall, about **37%** of the trips by GPS-equipped trucks to Centerm, Vanterm, and Deltaport in August–September of 2012[1] resulted in turn times longer than 60 minutes (including both terminal and staging time). The table below shows the percentages for staging times over 30 minutes which leave too little time for the terminal transaction, terminal times over 60 minutes, and combined turn times over 60 minutes by terminal[2].

Long Truck Turn Times

Category	DPW-Centerm	Vanterm	Deltaport
Staging 30+ min	16%	30%	n/a
Terminal 60+ min	8%	18%	17%*
Turn Time 60+ min	20%	45%	43%

** Allowing 15 minutes for staging*

Causes of Long Turn Times

The analysis suggests several factors that may be responsible for the long turn times:

- → **"Broken" transactions** (e.g., documentation problems, unpaid fees, equipment issues, customs holds) appear to account for 5–10% of truck trips. (These are different from "slow" transactions, which are typically due to terminal congestion, restricted terminal functions, coffee or meal breaks, or the diversion of resources to a vessel. "Slow" transactions are successful, but take longer than necessary or expected. "Broken" transactions are process exceptions.)
- → When a terminal handles **multiple and/or late vessels**, it may slow terminal truck processing. At Centerm, for example, this study found that late vessels are associated with heavier terminal workloads and *usually* with longer average truck turn times.
- → **Lunch breaks** close the terminals from 12:00–12:30 p.m. and slow truck processing before and after, increasing staging and terminal times. The study found that terminal times longer than 60 minutes are concentrated at specific times of the day at all three major terminals studied. In each location, the largest shares of long in-terminal times is incurred by trucks that enter between 11:00 a.m. and 12:00 noon.
- → **Long queues before morning start-up** can also slow terminal processing. The data show a relatively high incidence of terminal times longer than 60 minutes in the early mornings, generally attributed to slow start-up of terminal operations. Truckers who show up very early for appointments incur long staging times, partly by choice. Longer working days spell greater earnings potential for drivers and companies; drivers want to be productive from 7:00 to 9:00 a.m. A number of drivers and trucking firms are therefore making a conscious trade-off, choosing to cope with high early-morning turn time in order to get an earlier start.

- → **Rail switching blockages** add to roadway times, in turn impacting truck turn times. As with vessel handling, the need to bring in extra rail transfer gangs to deal with high rail volumes or late rail movements reportedly tends to increase conflicts with truck handling in the terminal footprint. (Rail blockages are analyzed separately from terminal turn times.)
- → During **peak arrival periods** and gate closures or slow-downs, queues and staging times grow. Between peaks, the lines and waiting times shrink. The time a truck spends in staging outside the terminal gates depends on the pattern of truck arrivals and the rate at which the gates process arriving trucks.
- → The available data suggest that **terminal gate capacity** may be acting as a bottleneck and increasing turn times, but the implications are not definitive. Gate capacity constraints can increase staging and overall turn times *if* the gates become a bottleneck between the staging area and the container yard (i.e., if the terminal itself could have processed trucks faster than the gates), which *may* be the case at Vanterm. If the container yard processing capacity is less than the gate processing capacity, however, increasing gate flow merely shifts congestion from outside to inside the gate. More detailed data collection would be required to establish a definitive linkage between gate capacity and staging or turn times.

RECOMMENDATIONS

The report provides detailed descriptions of a number of recommendations intended to mitigate long truck turn times. For each identified contributing factor, current initiatives are described and detailed recommendations follow. These recommendations are summarized here under the table below (see "Opportunities for Improvement").

The table below presents average truck turn times by category (terminal, staging, roadway, combined) and shows what percentage in each category are "long" turn times. It also lists possible solutions to some of the factors considered responsible for causing long turn times.

Category	Average	% Long Turn Times	Major Factors	Recommendations
Combined Turn Times	36–64 minutes	20–45%	Terminal Lunch Breaks	Adjust appointment allocation
				Transition to staggered breaks
			Slow Morning Processing	Full staffing
Terminal Times	27–39 minutes	8–18%	Multiple Vessels	Long-term capacity additions
				Transition to multiple shifts
			Late Vessels	Vessel performance incentives
				Vessel status messaging
			"Broken" Transactions	Track and analyze process exceptions
				Common Data Interface
Staging Times	15–27 minutes	16–30%	Long Morning Queues	Adjust appointment allocation
				Restrict early morning arrivals
			Early Appointment Arrivals	Compliance initiative (in place)
				Roadway entry screening (in place)
Roadway Times	23–34 minutes	<10%	Rail Switching Blockages	Scheduling
				Messaging
				Overpass (in progress)

Many of these long turn time factors can be traced to strong cargo growth at PMV and the limited near-term capacity of the terminals, while others are traceable to legacy labour practices and terminal information system limitations. Recommendations, presented in general order of near-term priority and impact, include measures to reduce the incidence of long turn times in the short run while long-term capacity and systems improvements are planned and implemented.

Opportunities for Improvement

#1—Among the various recommendations, high priority should be given **to reducing the impact of broken transactions** related to process exceptions. Progress on that issue will require process exceptions to be documented (via trouble tickets or equivalents), root causes to be analyzed, and corresponding action plans to be created. The southern California ports have such a program in place. The PMV Drayage Common Data Interface (CDI) initiative[3] is expected to facilitate better transaction planning and reduce process exceptions.

#2—Delays caused by the arrival of multiple vessels can be at least partially addressed by **long-term capacity additions** now being planned, as these will increase the terminals' ability to cope with multiple and late vessels without delaying trucks. A **near-term transition to two-shift terminal operations for truck processing will also help, as will vessel performance improvements** resulting from current PMV initiatives. The **proposed CDI** will be able to help stakeholders cope with vessel and terminal issues by improving communication on operating conditions and vessel status.

#3—The impact of lunch breaks can best be mitigated by a **negotiated shift to staggered breaks** (the norm at most North American ports) in the long term; in the near term, this could be done by **adjusting appointment availability in the affected periods. Refining the appointment system** might also reduce morning start-up queuing. If staffing shortfalls are a regular feature of the morning start-up, additional efforts to maintain full staffing would help.

#4—There are fewer opportunities for near-term staging time improvements. Part of the staging time is attributable to driver choices, particularly in the mornings. **Adjusting the appointment system** and **more tightly controlling early arrivals** (now in progress) should lead to some improvement.

#5—Short-term reductions in roadway times might be achieved through **better rail activity scheduling** and **CDI messaging functions**. Overpasses on the South Shore roadway (now in progress) and on the Deltaport causeway (planned) will provide long-term relief.

3) The PMV Common Data Interface (CDI) initiative seeks to improve the coordination of the drayage (trucking) operations and terminal interface by developing a Common Data Interface. The implementation of a Drayage CDI System would enhance stakeholder visibility and accountability and improve operational efficiencies. See www.portmetrovancouver.com.

INTRODUCTION

PURPOSE AND SCOPE

The amount of time container drayage trucks spend at marine terminals, known as "turn time," is a key factor in drayage costs, truck and driver productivity, port-area traffic congestion, and air quality near ports. At the Port of Vancouver there have been past instances of labour unrest and instability, due in part to long terminal turn times that reduce driver productivity and earnings. Truck turn times also affect the cost and reliability of imports and exports through the Vancouver Gateway, and are thus a factor in gateway competiveness.

Port Metro Vancouver (PMV) has initiated a pilot project to collect data on turn times and other metrics from global positioning system (GPS) equipped drayage trucks. The Asia Pacific Gateway Skills Table, in partnership with B.C. Trucking Association and Port Metro Vancouver, engaged the Tioga Group to conduct an in-depth analysis of these and other data with the **specific goal of identifying and understanding long turn times, defined for this purpose as over 60 minutes.**

DEFINITION OF TURN TIME

Turn time can be defined differently by different parties to the transaction.

- Marine terminals typically equate "turn time" with the time spent within their gates and recorded in their operating systems. In this report—and in the PMV GPS data—this metric is referred to as "terminal time."
- Truck drivers and drayage firms typically equate "turn time" with the time spent queuing outside the terminal gates—referred to here as "staging time"—plus the terminal time.
- The PMV GPS data also include time spent on the South Shore roads leading to Centerm and Vanterm and on the causeway leading to Deltaport. The published PMV data compilations[4] include roadway time in the turn time total.

This study adopts the truck turn time definition, which is both terminal and staging time, as the most useful metric for the time required to complete container terminal transactions. This metric also captures the broadest cost, congestion, and emissions implications of truck time at container terminals.

4) www.portmetrovancouver.com/en/users/landoperations/trucking/container-truck-efficiency-pilot-program

DATA-DRIVEN APPROACH

Every effort was made to base the turn time analysis on objective data. June–September 2012 GPS data provided by Port Metro Vancouver were the primary source for the study. PMV has defined 11 geozones in three categories: marine terminals, staging areas and roadways. The times when trucks enter and exit these geozones are recorded in the data and form the basis for analysis. Selected data were also provided by other organizations:

- Canadian Tire provided data collected through GPS tags on their chassis fleet.
- Harbour Link Container Services provided data collected through their PDA-based truck location system.
- BCTA provided GPS data collected by Transport Canada.
- DP World (DPW)–Centerm provided data on their truck transactions, as well as on vessel berth occupancy, longshore gangs working, and vessel unloading/loading throughput.
- PMV also provided data on gate volumes, railway road blockage and vessel arrival times.

These additional data were used to supplement the base PMV GPS data, and provided valuable insights. In general, the study team found broad agreement between the various data sets on the magnitude and pattern of terminal and queuing times. Detailed information on all the data sources used in this study can be found in Appendix A of the supplementary Appendices.

The PMV GPS data are gathered from 300 trucks operated by firms that volunteered their cooperation. The planned expansion of the PMV program to the 700 newest trucks, for a total of 1,000 units, should improve the reliability of the data.

The available data did not allow the study team to analyze every turn time issue. It was not possible to differentiate single transaction turn times from double transactions, speed gate moves from normal moves, or more complex refrigerated or hazardous cargoes from ordinary dry van shipments. The available data from Centerm did, however, allow the study team to analyze transaction type (import, export, empty) which yielded information on faster turn times for exports[5].

As Exhibit 1 indicates, the analysis generally validated the GPS-based data and turn time averages compiled by Port Metro Vancouver (PMV). The PMV published averages for August 19–September 15, 2012 align closely with the averages derived by the study team from the June to September data provided by the Port. The key difference is in the combined turn time (terminal plus staging time), which PMV publishes as a sum of the category averages but which was compiled move-by-move for this study.

Exhibit 1: Study and PMV Turn Time Data

PMV Published Averages* vs. Study Findings

Category	DPW-Centerm		Vanterm		Deltaport	
	PMV Avg.	Study Avg.	PMV Avg.	Study Avg.	PMV Avg.	Study Avg.
Staging	14	15	24	27	n/a	n/a
Terminal	27	27	38	39	n/a	n/a
Turn Time	41	36	62	64	62	63

** August 19–September 15 2012 Dayshift*

STAKEHOLDER CONTACTS

While the analysis was primarily data-driven, contact with selected drayage firms, marine terminals, PMV personnel and other stakeholders provided the study team with a better understanding of what the data mean and how truck turn times are affected by operational factors.

5) See Appendix A (Exhibit 11) in the Appendices for detailed analysis.

TURN TIME FINDINGS

The analysis in this section covers the combined turn time, terminal time only, and staging time only. Roadway times are not part of the basic turn time definition, and are therefore analyzed separately.

The consultant team analyzed the data to locate:

- Combined terminal and staging turn times over 60 minutes;
- Terminal times over 60 minutes (leaving no time for staging); and
- Staging times over 30 minutes (leaving insufficient time for normal terminal time).

COMBINED TURN TIMES: TERMINAL AND STAGING

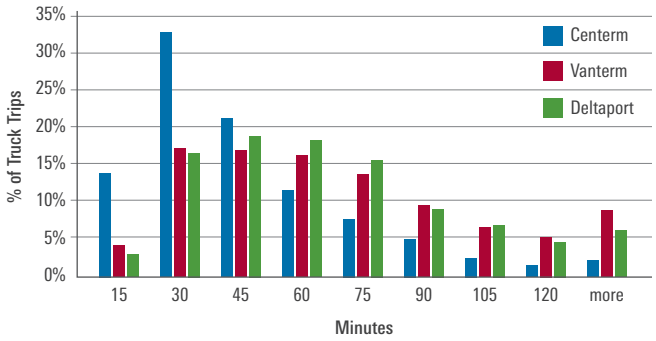
In this report, the time a truck spends inside the terminal is referred to as "dwell time" or "terminal time." The time the truck spends in a staging area is referred to as the "staging time" or "wait time." The sum of the two times is known as the "turn time."

Average turn time in the PMV GPS data ranged from 36 minutes at Centerm to 64 minutes at Vanterm, with a three-terminal average of 56 minutes.

These times are roughly competitive with known turn times at the largest and busiest North American ports, e.g., Los Angeles–Long Beach and New York–New Jersey. A 2011 turn time study at Los Angeles–Long Beach (LA/LB) found the median turn time there to be 51 minutes, with 42% taking an hour or longer.

Exhibit 2 shows the distribution of overall sample turn times at the three terminals.

Exhibit 2: Overall Truck Turn Times by Terminal



The distribution pattern is also typical of terminal time distributions found at other major ports: most trips are completed within a reasonable time span, but some take much longer and form a long "tail" to the distribution. The transactions in the "tail" of the distribution account for what stakeholders view as excess delays, and are often attributable to terminal closures or process exceptions.

Truck turn times of longer than 60 minutes exceed expectations for a "normal" trip by many port stakeholders. Exhibit 3 shows the percentages for staging times over 30 minutes (which leave too little time for the terminal transaction), terminal times over 60 minutes, and a combined turn time of over 60 minutes by terminal. The percentages of turn times longer than 60 minutes ranged from 20% at Centerm to 45% at Vanterm.

Exhibit 3: Turn Time Summary Table

Category	DPW-Centerm	Vanterm	Deltaport
Staging 30+ min	16%	30%	n/a
Terminal 60+ min	8%	18%	17%*
Turn Time 60+ min	20%	45%	43%

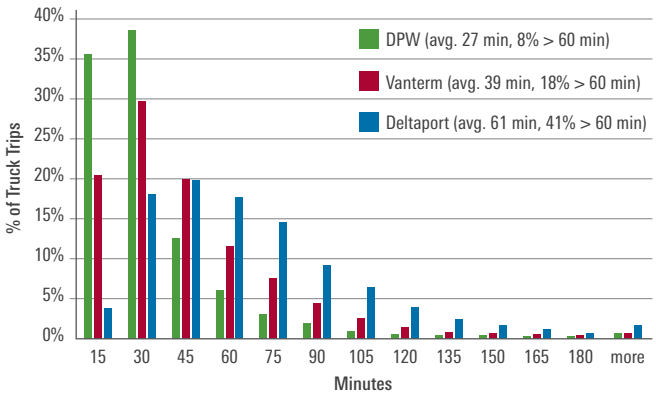
** Allowing 15 minutes for staging*

Overall, about 37% of trips by GPS-equipped trucks to Centerm, Vanterm, and Deltaport in August–September of 2012 resulted in turn times (terminal time plus staging time) of over 60 minutes. These data include trips with multiple transactions, which likely increase the apparent frequency of long turn times. Based on available comparisons of GPS data and terminal records, the study team believes this percentage to be reasonably representative of all truck trips.

TERMINAL TIME

The average in-terminal times at Centerm, Vanterm, and Deltaport (Exhibit 4) appear to be in the range of 25–40 minutes, which is again competitive with major North American ports (the 2011 LA/LB study found a 31-minute median).

Exhibit 4: Terminal Dwell Times: PMV GPS Data



Note: Vanterm and Deltaport dwell times include double transactions, DPW data does not.

However, a significant portion of truck trips result in terminal times longer than 60 minutes, which puts them over the threshold for this study. As Exhibit 4 shows, the frequency of terminal times over 60 minutes ranges from about 8% at Centerm to 18% at Vanterm. At Deltaport, the reported frequency is 41%. However, the Deltaport geozone combines terminal and staging areas. If a rule-of-thumb 15-minute allowance is made for staging, an equivalent Deltaport threshold of 75 minutes yields a 17% frequency —comparable to Vanterm. These long terminal times suggest either slow or "broken" transactions.

→ **Slow** transactions are typically due to terminal congestion, restricted terminal functions, coffee or meal breaks, or the diversion of resources to handle a vessel. In these instances, the transaction is successful, but takes longer than necessary or expected.

→ **Broken** transactions are typically attributable to process exceptions such as documentation problems, unpaid fees, equipment issues, customs holds, or other regulatory delays. In these cases, the transaction is interrupted and delayed while the problem is resolved, or may not be completed at all.

Vessel-induced delays and lunch breaks may account for roughly one-third of terminal times over 60 minutes. For Centerm, the frequency of 60-minute (or longer) terminal times drops to 4–5% when the terminal is not handling vessels or is not closed for lunch, versus an average of 8%. For Vanterm, the frequency drops to a minimum of 11–13% versus an average of 18%.

The rest of the long terminal times are more likely attributable to broken transactions rather than slow handling or congestion.

The study team analyzed several terminal time issues for which either data were not available for detailed analysis or the issue did not appear to impact turn time significantly. These issues included:

1) Double versus single transactions

The study team was unable to establish the range of expected times for double transactions during a single truck visit. These reportedly average about 19% of visits at Centerm and 33% at Vanterm and Deltaport, but those shares are not verifiable from the available data. At Centerm, when a truck with multiple appointments is processed, the appointments are all processed at the in-gate by the Checker so they will all have about the same start time even though the truck can only be physically serviced for one appointment at a time. A truck visit may have up to 4 transactions (2 drop off and 2 pickup). Double transactions increase drayage efficiency, but can be expected to take longer in the terminal than do single transactions.

2) Arrival time in appointment window[6] [7]

The specific time at which a truck arrives in its two-hour appointment window appears to make only a small difference in turn time, although trucks that arrive earlier in their appointment windows tend to turn slightly faster than those that arrive later.

3) Volume of truck transactions[8]

The volume of truck transactions by itself does not appear to have a significant impact on terminal times. The reservation system thus appears to be effective in preventing in-terminal truck congestion, although truck volume and peaking can have an impact on staging time (outside the terminal).

4) Speed gates[9]

Speed gates are understood by all parties to result in faster terminal times, and should bring down the average terminal times where they are heavily used. However, the study team was unable to obtain data on speed gates separately from other transactions to conduct a more detailed analysis. The limited data available do suggest that increased use of speed gates at Vanterm (TSI) helped reduce and stabilize terminal times compared to previous months, with fewer speed gate transactions. However, the greater use of speed gates by itself seems to have had relatively little impact on overall average terminal time. It appears, then, that speed gates are helpful in reducing or at least stabilizing terminal times, but that their use must be part of an overall strategy in order to be most effective.

6) See Appendix B in the Appendices for detailed analysis.
7) It is noted that Port Metro Vancouver (PMV) meters the flow of traffic on the South Shore Corridor by managing the time in which a truck may enter the roadway in advance of their designated appointment window.
8) See Appendix C in the Appendices for detailed analysis.
9) See Appendix D in the Appendices for detailed analysis.

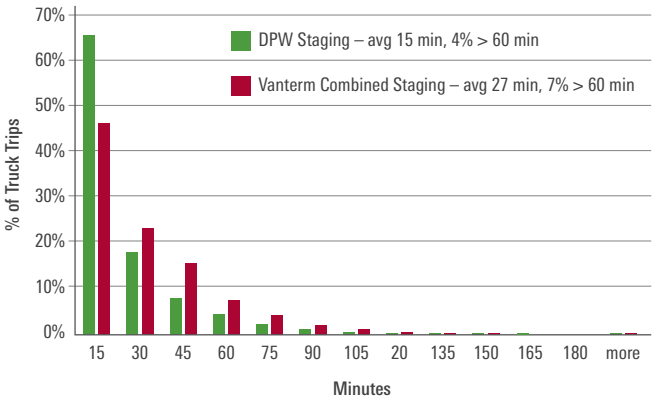
STAGING TIME

Staging time—the time truckers spend in line outside the entry gates—averages about 15 minutes at Centerm[10] and 27 minutes at Vanterm according to the GPS data. Exhibit 5 shows the distribution of staging times. About 16% of the staging times at Centerm were over 30 minutes. For the combined staging and pre-staging times at Vanterm, about 30% were over 30 minutes. By comparison, the LA/LB study found a 20-minute median staging time at those ports. There are no separate PMV GPS data for staging at Deltaport.

As noted earlier, the average in-terminal times at Centerm, Vanterm, and Deltaport appear to be in the range of 25–40 minutes. A staging time of over 30 minutes outside the gates therefore makes it unlikely that the entire turn time can be less than 60 minutes. Staging times of over 30 minutes suggest congestion, processing delays, or early truck arrival for appointments or gate openings.

Part of the staging time is attributable to driver choices—particularly the mornings. Adjustments to the appointment system and tighter control over early arrivals (part of which is now in place) should mitigate staging times somewhat.

Exhibit 5: Centerm and Vanterm Staging Times: PMV GPS Data



10) There is a gap in the geozone coverage between the Clark–Heatley roadway zone and the Centerm staging zone in which trucks spend an average of about four minutes that should be added to the Centerm staging time. Also, some of the terminal geozone is actually in the staging area, which understates staging time but overstates terminal time by a small margin.

FACTORS IN LONG TURN TIMES

The study team identified several factors that tend to increase turn time:

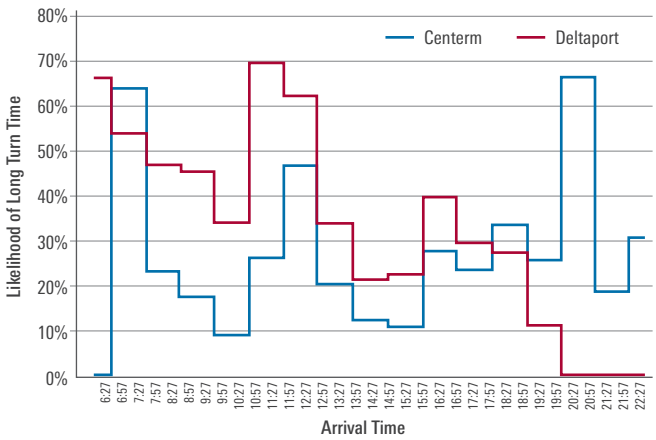
1. Broken transactions
2. Vessel activity at the terminals
3. Morning and lunch breaks
4. Rail activity at the terminals
5. Peaking
6. Gate capacity

These factors are discussed in greater detail below. Some factors affected *both* terminal time and staging time, driving up turn time in combination. There were other factors that affected either terminal time only or staging time only. (As mentioned, roadway times are not part of the basic turn time definition, and are therefore analyzed separately.)

1. BROKEN TRANSACTIONS

Broken transactions and accompanying long turn times appear to affect 5 to 10% of truck trips. As shown in Exhibit 6, at Centerm the likelihood of a long turn time reaches a minimum of 8% when no other factors, such as peaking or labour schedules, are affecting turn times. The likelihood of long turn times at Deltaport likewise drops to a minimum of 11%. (Vanterm numbers are not comparable due to the terminal operating system conditions during the study period.)

Exhibit 6: Long Turn Time Likelihood at Centerm and Deltaport



The 8% minimum at Centerm appears comparable to the 5% trouble ticket frequency reported for the Ports of LA/LB, NY/NJ, and Houston in Tioga's drayage productivity study for the U.S. Transportation Research Board,[11] since there would ordinarily be a few long turn times attributable to other causes. The 11% rate at Deltaport may reflect a broken transaction frequency of around 10%. These observations suggest to the study team that 5 to 10% of the long turn times can be attributed to process exceptions or *broken* transactions.

Current gate process documentation practices at PMV terminals limit the extent to which the causes of broken transactions can be identified. Current reported practice for process exceptions is to bring the trucker into the terminal to park in a designated area while the issue is resolved. A limited number of truck trips were traced in detail using GPS records to confirm that at least some of the long terminal times included substantial time in these trouble booth parking areas. This observation reinforces the appearance of broken transactions instead of slow terminal handling.

If the issue involves customer-carrier, trucker-carrier, or customer-trucker communications in which the terminal

11) 2011 report for the National Cooperative Freight Research Program (NCFRP), Report 11.

itself is not directly involved, the issue is not documented in the terminal operating system (TOS)—in other words, no "trouble ticket" is issued or recorded, and there are no data on these process exceptions. Trouble tickets or equivalent documentation may be created for instances in which the terminal itself is involved, e.g., difficulty locating a container, storage charges, etc.

Although the team could not obtain data on these issues, discussions with Metro Vancouver stakeholder contacts and observations at comparable terminal operations elsewhere suggest there are several kinds of process exceptions that could result in broken transactions and long terminal times, such as:

- Import containers that have customs holds, have not been cleared for entry, or have holds for other reasons.
- Import containers on which fees (i.e., storage charges) are unpaid.
- Export containers or loads that do not match booking details.
- Export containers that arrive before the earliest receiving date (ERD) or after vessel cut-offs.
- Export containers with lading or seal problems.
- Incomplete HAZMAT documentation.
- Export loads with incomplete or inaccurate documentation.
- Export containers with damage.

2. VESSEL ACTIVITY AT THE TERMINALS

The association of long truck terminal times and vessel activity is clear. This association has been mentioned in every stakeholder contact.

As shown in Exhibit 7, the probability of a 60-minute or longer terminal time at Centerm (for which these data were available) rises when vessels are worked by the terminals (i.e., loading and unloading). The 4% probability for 60+ minute turn time when no vessels are present may indicate process exceptions—"broken" transactions—independent of terminal activity. The average rises to 6% when one vessel is being handled, but more than doubles to 13% when two vessels are being worked.

Exhibit 7: Marine Terminal Delays and Number of Vessels *(Centerm: Odds of 60+ Minute Terminal Time)*

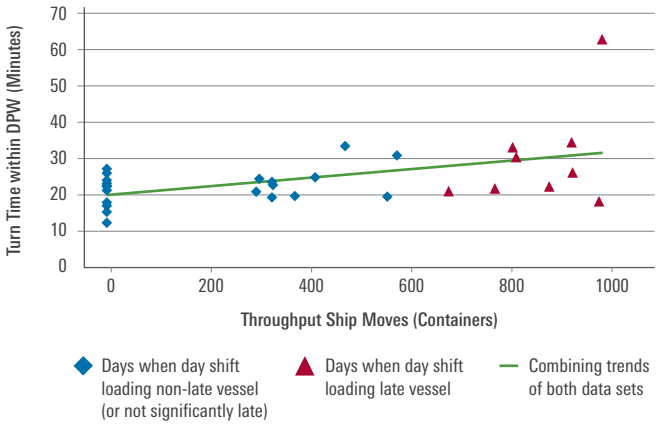
4%	6%	13%
by 0 Vessels	by 1 Vessel	by 2 Vessels

The available vessel handling data only covered Centerm, but the impact of multiple vessel arrivals is understood by stakeholders to affect all terminals, including Vanterm and Deltaport. Data provided to the study team indicate that the three major PMV terminals were handling vessels at all berths (two at Centerm or Vanterm, three at Deltaport) on about 22% of the days in the database. Analysis of available terminal data suggests that handling vessels at all berths adds about nine minutes to average truck terminal time.

It is very common for vessels to be late. In 2012, 39% of the vessels at Centerm, 44% at Vanterm and 54% at Deltaport were more than eight hours late. Depending on the timing, vessels a few hours late may actually be worked a day late.

Exhibit 8 shows that, at least at Centerm, late vessels are associated with heavier terminal workloads (in terms of container moves off and on the vessel), and usually with longer average truck turn times. Sometimes, however, the terminal can cope with the extra volume: on four occasions in August 2012, Centerm was able to keep average truck terminal times close to 20 minutes while working a late vessel.

Exhibit 8: Centerm Ship Moves vs. Drayage Terminal Times, August 2012



There are several ways in which vessel activity could be contributing to longer truck turn times and greater probability of turn times over 60 minutes.

- Centerm, Vanterm, and Deltaport are all operating at very high dayshift volumes, near or over their inherent capacity. Intensive container yard activity in support of vessel throughput is likely to delay trucking activity in the same confined yard space.
- Activity in support of vessel unloading or loading sometimes leads terminal managers to close down portions of the container yard (e.g. specific rows or blocks) to truck handling to simplify operations or insure safety. When portions of the yard are closed, affected truckers may have long in-terminal dwell times.
- Terminal resources such as lift machinery and personnel may be shifted from functions and locations that handle trucks to those that support the vessel, thereby slowing truck turn times.

Ordinarily, the highest operating priority for terminal managers is handling the vessel and turning it on schedule. Ocean carriers are the only direct customers of the terminal operators, and are known to pressure the terminals to minimize vessel turn time at all costs. The impact of later vessels is more severe as terminal operators are pressured to turn around the vessel even more quickly.

Ideally, marine container terminals would have sufficient space, lift capacity, and labour supply to provide consistent truck turn rounds while working a vessel at each berth. In reality, the PMV terminals have limited footprints and are operating at high throughput volumes, leaving little reserve capacity.

→ **1)** Based on Tioga's March 2012 estimates, Centerm occupies about 77 acres of which 38 acres are container yard (CY). The two deep berths give Centerm the ability to handle very large vessels. Yet 38 acres for two berths gives Centerm only 19 acres of backland per berth, a very tight footprint.

→ **2)** Vanterm is about the same overall size at 76 acres with 34 acres of container yard. Vanterm also has two deep berths, but only 17 acres of CY backland for each.

→ **3)** Deltaport has a much larger total footprint at about 228 acres with 142 acres of container yard. With three berths, the average is 47 acres of CY per berth.

→ **4)** Fraser Surrey Docks has about 87 acres of which 48 are usable as CY, but handles only a small part of the PMV total.

In 2012 PMV handled 2.7 million TEUs with about 95% of it at the three main terminals. Centerm, Vanterm, and Deltaport are therefore operating at average annual throughputs of over 7,000 TEUs per gross acre and 12,600 TEUs per CY acre. These averages place the PMV terminal utilization very high by North American standards.

Such high space utilization, however, implies very little slack to cope with late vessels, cargo surges, and other factors that push the terminal workload above an already high average. With loading and unloading the vessel being the terminals' highest priority, truck turn times can be expected to suffer. A detailed analysis of the impact of vessel activities on truck turn times is available in Appendix E of the supplementary Appendices.

3. MORNING AND LUNCH BREAK IMPACTS

The dynamics of truck and terminal interactions at morning gate openings and lunchtime breaks lead to a higher percentage of combined staging and terminal times over 60 minutes. As Exhibit 9 to 11 show, terminal times over 60 minutes are concentrated at specific times of the day at all three terminals. At all three major terminals, the largest share of long in-terminal times are incurred by trucks that enter between 11:00 a.m. and 12:00 p.m. Some of these trucks remain in the terminal through the 12:00–12:30 p.m. lunch break. The other concentration of long terminal times occurs when trucks enter right after the gates open at 7:00 a.m. (7:30 a.m. at Centerm).

Exhibit 9: Long Centerm Terminal Times by Time of Day

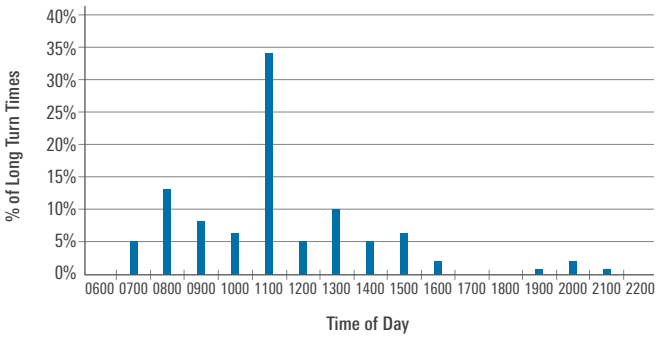


Exhibit 10: Long Vanterm Terminal Times by Time of Day

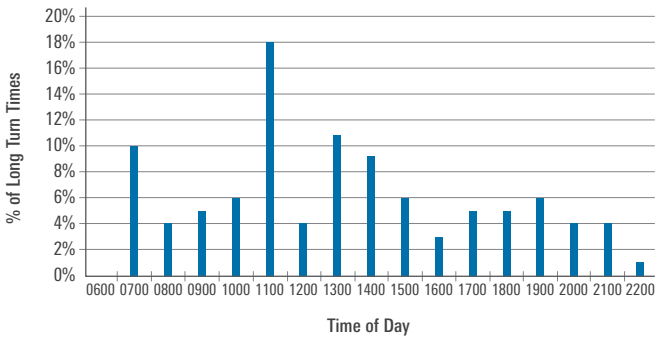


Exhibit 11: Long Deltaport Times by Time of Day

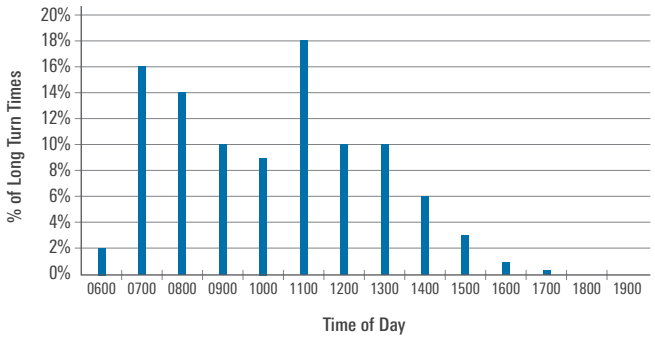
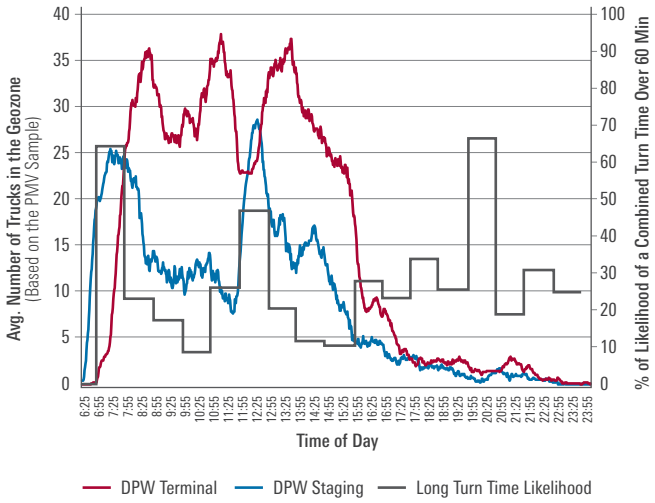


Exhibit 12 shows the relationship between the number of trucks in staging, the number of trucks in the terminal, and the likelihood of long turn times at Centerm. These PMV GPS data have been roughly normalized to estimate the actual number of GPS and non-GPS trucks involved.

Exhibit 12: Centerm Occupancy & Long Turn Times

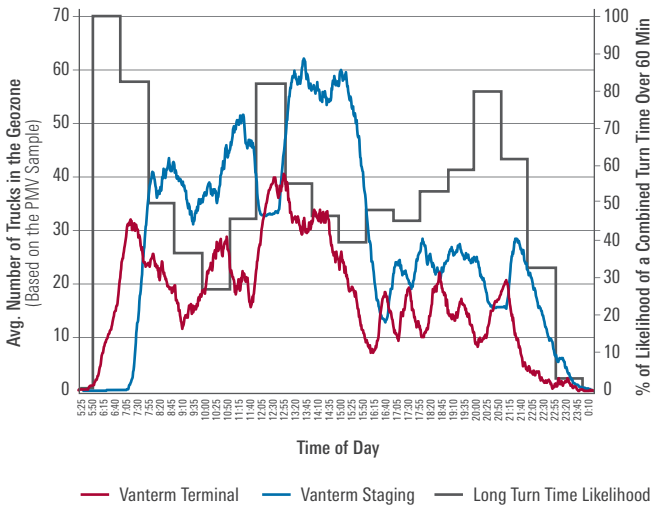


As the blue line shows, the queue in Centerm staging builds up starting at about 6:30 a.m. As these first trucks are processed, the staging queue drops. The queue builds again until the gates reopen and the backlog is reduced. The staging queue rises slightly at the 2:00 p.m. coffee break. The number of trucks in the terminal (red line) rises to an average of about 36 after the gates open, then declines as that first wave of trucks is processed. The number peaks again at about 37 trucks around 11:00 a.m. An average of about 23 trucks remains unprocessed in the terminal over lunch. The on-terminal backlog rises to about 37 trucks again as the staging queue is processed.

The black line on the chart shows the impact on turn time. About 67% the trucks that enter staging before the gates open have long (60 minutes or more) turn times. About 46% of the trucks that arrive around the lunch break have long turn times.

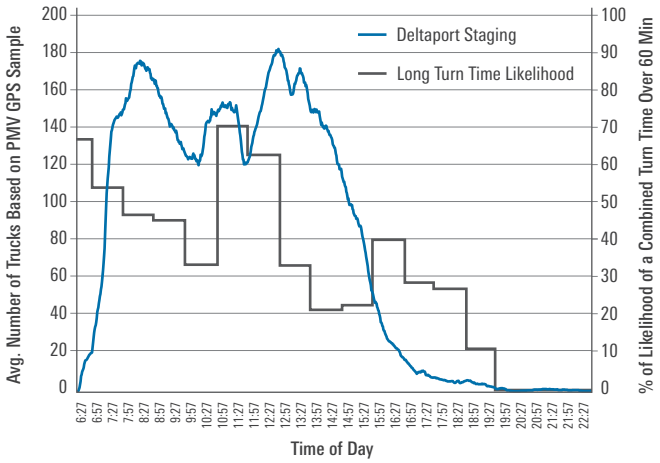
Vanterm has a roughly similar pattern (Exhibit 13). There is also a high probability of long turn times during the evening shift "lunch" break. This result is more significant at Vanterm because Vanterm frequently schedules night shifts.

Exhibit 13: Vanterm Occupancy & Long Turn Times



The analysis for Deltaport (Exhibit 14) is different because the staging and terminal data are combined. However, the basic pattern is again similar, with a high likelihood of long turn times in the early morning and at lunch. The evening "lunch" does not result in long turn times as frequently at Deltaport as it does at Vanterm.

Exhibit 14: Deltaport Occupancy & Long Turn Times



The prevalence of long terminal and turn times when the gates first open raises questions about trucker and terminal operating practices. It is common at container ports for drivers to queue up early, before the gates are scheduled to open, to be processed and on their way, as early as possible. In effect, the drivers are trading off a longer wait in the queue for a longer working day. The longer working day increases their earnings potential—and the trucking company's earning potential as well. If the driver waited for the 9 to 11 a.m. "sweet spot," where queues and terminal time are at a minimum, the turn time would be quicker but the hours between 7 and 9 a.m. would have been non-productive. For this reason, a portion of the high early-morning turn time can be chalked up to a conscious trade-off decision made by drivers and trucking firms (a factor that is not under terminal control).

The second half of the issue is early morning processing time within the terminal. As exhibits 12 through 14 show, there is a relatively high incidence of terminal times longer than 60 minutes in the early mornings. In the absence of specific on-site observations, these long terminal times are generally attributed to slow start-up of terminal operations. Effectively, the terminal itself is not fully functional when the gates open. This slow start-up could be attributed to the fact that some terminal personnel are not yet in place and ready to work; because not all necessary systems are yet up and running; or because lift equipment is not yet positioned where needed.

A detailed analysis of the impact of morning and lunch breaks on truck turn times is available in Appendix F of the supplementary Appendices.

4. RAIL ACTIVITY AT THE TERMINALS

All three major terminals have on-dock rail facilities (Exhibit 15 through Exhibit 17). The typical pattern is for one group of rail cars to be spotted in time for the morning terminal shift, and that group switched out for another group of rail cars in mid- to late afternoon. While the rail loading and unloading areas are physically separate from the main areas that handle trucks, the rail containers are moved to and from the same stacks. Safety considerations often require all activity to stop in the vicinity of moving rail cars. Moreover, the switching movements tend to block exit roads at Vanterm and Centerm. Rail loading and unloading may also take priority over truck handling. The need to handle rail containers within the same tight terminal footprint as trucks will thus tend to increase truck terminal time. The data available for this project did not support a detailed analysis of this factor.

As with vessel handling, the need to bring in extra rail transfer gangs to deal with high rail volumes or late rail movements reportedly tends to increase conflicts with truck handling in the terminal footprint.

Exhibit 15: DPW–Centerm Rail Transfer Area

Exhibit 16: Vanterm Rail Transfer Area

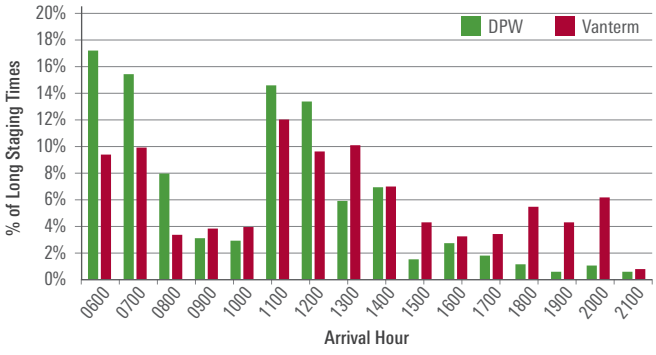
Exhibit 17: Deltaport Rail Transfer Area

5. PEAKING

The time a truck spends in staging outside the terminal gates depends on the pattern of truck arrivals and the rate at which the gates process arriving trucks. During peak arrival periods and gate closures or slow-downs, the queues and staging times grow. Between peaks, the lines and waiting times shrink.

As Exhibit 18 illustrates, long staging times at Centerm and Vanterm are more common in the morning and around lunch time, consistent with the earlier discussion of morning start-up and lunch breaks. Some of these staging times reflect trade-offs being made by truck drivers who arrive before the gates open (trading off longer staging times for an earlier start to the day), or arrive when gates are closed for lunch in order to get in as soon as possible when they reopen.

Exhibit 18: DPW–Vanterm Staging Time Distribution by Time of Day



The pattern shown in the graph is also determined in part by the natural peaking of daily truck activity. Drivers start their first trips early in the morning and return to the terminal late in the morning or early in the afternoon for additional trips. The mid-morning and mid-afternoon lulls at the terminals occur when the trucks are on the road or at customer locations.

6. GATE CAPACITY

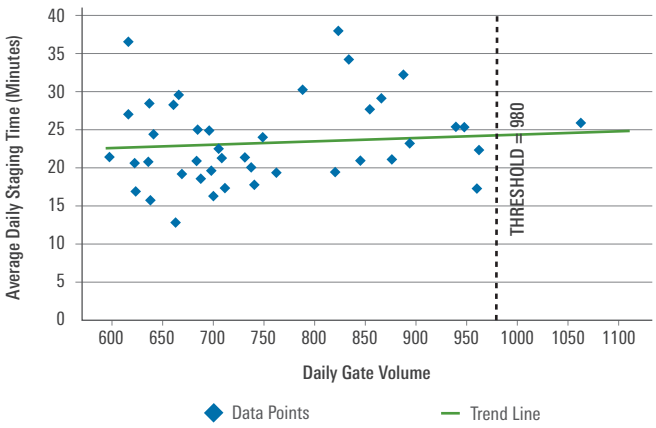
The available data suggest that terminal gate capacity may be acting as a bottleneck and increasing turn times, but the implications are not definitive. Terminal gate capacity limits can increase turn times if the gates become a bottleneck between the staging area and the container yard. Under those circumstances, trucks incur extra staging time. If the container yard processing capacity is less than the gate processing capacity, however, increasing gate flow merely shifts congestion from outside the gate to inside the gate. It is generally preferable to keep any congestion outside the gate for operational and safety reasons, so the Vancouver terminals report that they sometimes slow down gate processing to allow in-terminal congestion to clear.

The generally longer staging times at Vanterm (averaging around 23 minutes on weekdays, versus about 15 minutes at Centerm on the same days) could be due in part to the number of entry gates: six at Vanterm versus 12 at Centerm. (There are no separate staging time data for Deltaport.) Processing time at terminal gates typically averages around three to five minutes[12] per truck, so each gate is capable of processing 12–20 trucks per hour.

As illustrated in Exhibit 19, Vanterm data show average daily staging times trending slightly upward as volume increases. Vanterm's nominal daily threshold is 980 trucks. In the 8.5 hours of operations between 7:00 a.m. and 4:00 p.m. (allowing for the lunch break), the six Vanterm entry gates would be able to process between 612 and 1,020 trucks, with the upper end of that range likely becoming a strain on gate capacity.

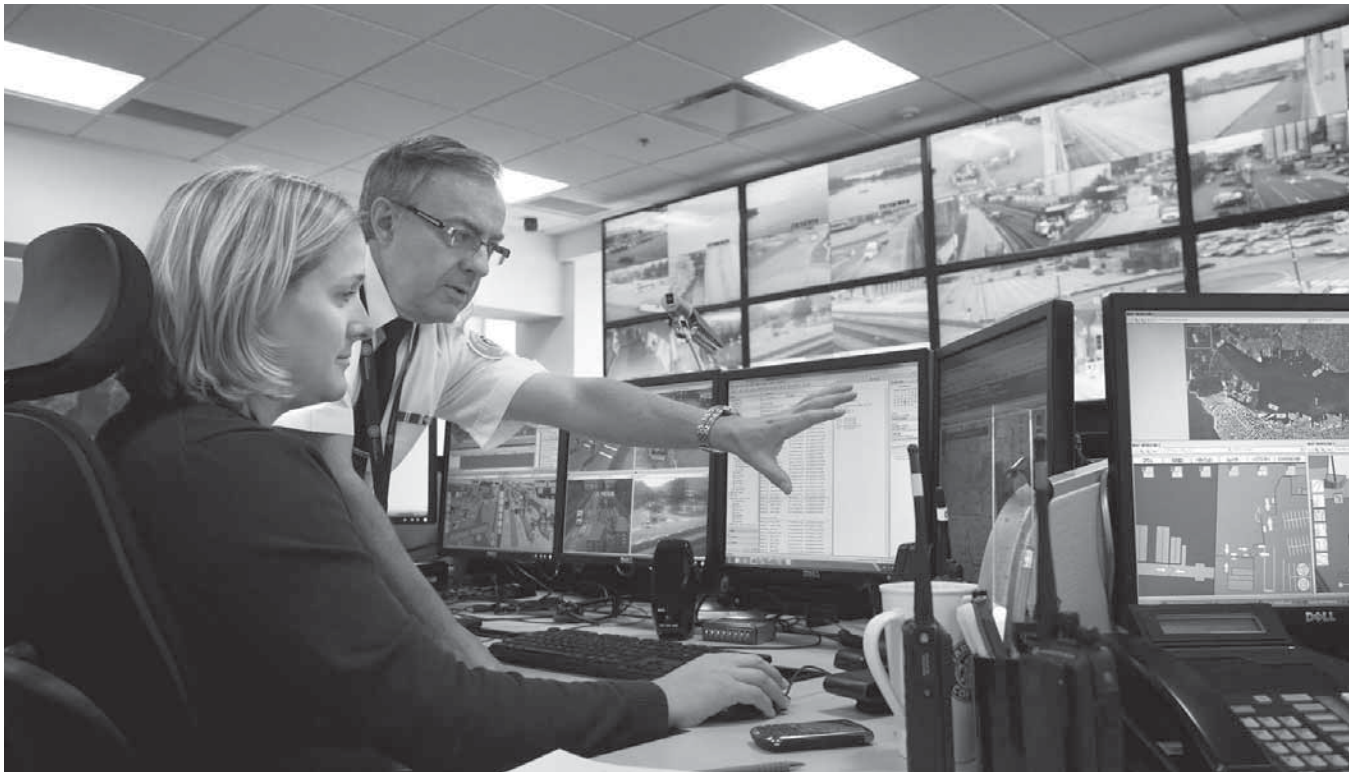
12) Based on data from Centerm and analysis at other ports (outside Metro Vancouver).

Exhibit 19: Vanterm Staging Times and Day Gate Volumes *(Avg. Daily Staging Time vs. Day Gate Volume, July–Sep 2012)*



Centerm's 12 entry gates could process 1,224–2,040 trucks in the same 8.5 hours; its nominal threshold is lower, at 900 trucks per day. A comparable analysis shows no upward trend in Centerm's daily average staging time as truck volume rises.

As noted above, however, these data do not directly show the effect of gate numbers or processing rates, so further, more detailed data collection would be required to establish a definitive linkage between gate capacity and staging or turn times.



ROADWAY TIME FINDINGS

The analysis of roadway travel times focussed on the South Shore road and terminal complex. The issues there are more complex—and the impacts more significant—than on the Deltaport approach road.[13]

The South Shore roadway is divided into three geozones:

- The *Commissioner–Victoria geozone* stretches from the intersection of Commissioner and McGill past the port complex entry gate (opposite the foot of N. Renfrew Street, also called the McGill gate) to the foot of Victoria Drive (now blocked off). This geozone covers about two kilometres (1.23 miles). It includes access to the Columbia and Marco container storage depots as well as the staging areas being developed by PMV along Commissioner Street. This road segment is crossed by active railway tracks in two places.
- The *Victoria–Clark geozone* starts at the foot of Victoria Street and follows Stewart Street to the intersection of Centennial Road and Clark. Clark was formerly the main entrance and exit route for Centerm and Vanterm, but is now an exit only for trucks. The Victoria–Clark geozone is crossed by multiple active railway tracks leading to industrial customers on the north side of Stewart Street. This section of roadway is about 0.76 kilometres (.47 miles).
- The *third roadway zone, Clark–Heatley,* extends along Centennial Road from Clark to Heatley, about 1.0 kilometre or 0.64 miles. This geozone covers the entrances to Vanterm and Centerm and, like the Victoria-Clark segment, is crossed by multiple railway tracks.

Trucks are allowed to enter the system only from the east end, through the gate on Commissioner Street. They can exit at Clark or at Commissioner.

Over 90% of the transit times on each South Shore roadway segment are less than 10 minutes; most transit times are less than five minutes.

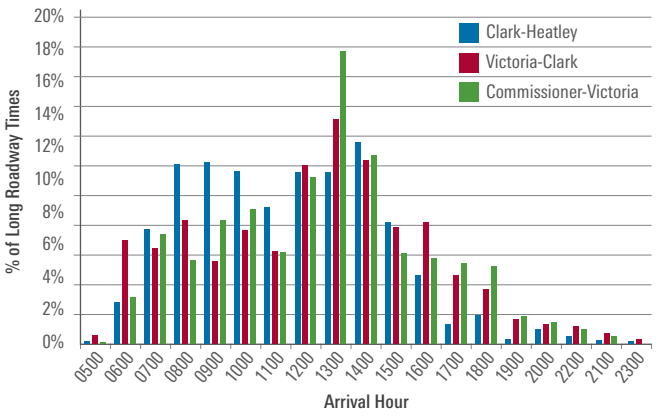
The Deltaport roadway geozone includes the causeway. Most trips take less than 15 minutes. The average inbound trip takes 14 minutes while the outbound average is three minutes. The difference implies an average delay, stop or queue times of 11 minutes inbound before the truck reaches the Deltaport staging/terminal geozone.

SOUTH SHORE ROADWAY TIME FACTORS

Although the exact causes cannot be ascertained from the data, there appear to be multiple factors in longer transit times on the South Shore roadway complex. When longer transit times do occur, as shown in Exhibit 20, they tend to be in mid-afternoon, most likely due to:

- Roadway blockages due to railway switching, reportedly more common in the afternoons; or
- Truck parking and staging along the roadways, which tends to increase during the lunch break and persist for some time thereafter.

Exhibit 20: Long Roadway Times by Time of Day
(Distribution of 10+ Minute Transit Times by Hour of Day)



13) See Appendix H, "Deltaport Roadway Times Analysis," in the Appendices.

Some of the "delays" may also reflect drivers who stop at roadside to communicate with their dispatchers, eat lunch, rest, or for other purposes.

The most frequent delays are for inbound trips on the Commissioner–Victoria segment, with 29% of the inbound trips taking longer than five minutes (an average speed of less than 24 kilometres per hour). The more frequent inbound delays are consistent with:

- Waits for appointment windows. The Commissioner gate began to enforce appointment windows after these data were collected, which should help to mitigate this problem.
- Non-terminal trips. About 20% of the trucks that enter the Commissioner gate stay on the Commissioner–Victoria segment, presumably to access the two container depots located there.

Outbound, Victoria–Clark (8%) and Clark–Heatley (8%) are more likely to have long outbound times (over 10 minutes) than Commissioner–Victoria. Most truck drivers exit the South Shore area on Clark, so congestion may be one factor in the longer outbound times.[14]

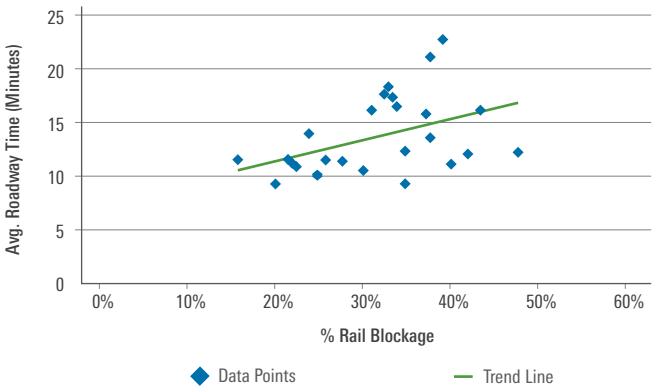
ROADWAY RAIL BLOCKAGES

The relationship between South Shore roadway times and rail blockages is complex.

The study team compared PMV data on the percentage of the day when railcars block the roadway to the percentage of trips taking more than 10 minutes. The Commissioner–Victoria segment showed the strongest relationship, with the likelihood of a long transit increasing more rapidly as rail blockage increased. The two other segments (Victoria–Clark and Clark–Heatley) also showed an increased likelihood of long transit times with increased rail blockage, as expected, but the impact appeared to be lower.[15]

There is a clear relationship between the percentage of time during which the roadway is blocked and the average length of the transit time (Exhibit 21). The average blockage time is about 30% of the dayshift hours, which appears to raise the weighted average transit time to Vanterm by about three minutes and to Centerm by about seven minutes.

Exhibit 21: South Shore Roadway Transit Time as a Function of Rail Blockage



14) Detailed analysis of the South Shore roadway times is available in Appendix G of the supplementary Appendices.

15) Detailed analysis of roadway rail blockages is available in Appendix I of the supplementary Appendices.

RECOMMENDATIONS

The sections below summarize the major turn time issues, current stakeholder initiatives to address those issues, and recommendations for further steps, in general order of near-term priority. It is clear from the analysis that many of the factors in average turn times and in the prevalence of long turn times are structural. Vancouver trade patterns, terminal capacities, and operating conditions create challenges for truckers and terminals alike. Accordingly, the recommendations below include long-term improvements that PMV and other stakeholders are already pursuing, as well as short-term mitigation steps that should reduce delays within existing capacity.

BROKEN TRANSACTION IMPROVEMENTS

Issue: Broken transactions appear to be the mostly prevalent of the turn time problems, the most amenable to near-term improvements, and therefore the highest priority for attention. Process exceptions, broken transactions, and their turn time impacts are all preventable in principle. While no system will ever achieve perfection, it is likely that the incidence of broken transactions and resulting long terminal times can be reduced. The key steps would be to document the nature of the problems and their incidence, and formulate action plans specific to each problem type. Many—perhaps most—of these problems involve Beneficial Cargo Owner (BCO)–carrier relationships and communications, and cannot be solved by marine terminals or truckers acting alone.

Current initiatives: The PMV Common Data Interface (CDI) initiative,[16] if successful, would provide one means of reducing the number of broken transactions by making critical information (such as customs clearance and fee payment status) available on a timely and consistent basis.

Recommendation: Ideally, the most immediate solution for trucking companies would be to reassign their trucker to another transaction—a method commonly seen at other ports. For example, in the U.S. port meetings held during Tioga's Transportation Research Board (TRB) drayage study, drayage company managers noted that drivers typically wait no more than about 30 minutes to resolve a problem transaction. If they are not successful, they may abandon that transaction (for a later date) and shift their attention to another transaction after talking to their dispatcher. However, the appointment system at PMV terminals may not permit this. Since the system ties appointments to specific import containers, reassigning the truck may not be an option.

16) The PMV Common Data Interface (CDI) initiative seeks to improve the coordination of the drayage (trucking) operations and terminal interface by developing a Common Data Interface. The implementation of a Drayage CDI System would enhance stakeholder visibility and accountability and improve operational efficiencies. See www.portmetrovancouver.com.

Addressing the impact of broken transactions would require a four-step program:

→ **1.** PMV should establish GPS geozones covering the trouble window waiting areas at the three major terminals to determine the extent of this problem. Data on the number of trucks that park in these areas for significant periods would suggest the frequency of broken transactions, the delay incurred, and the potential benefits of solutions.

→ **2.** Vancouver container terminals should develop methods for documenting process exceptions. Preliminary information indicates that the Navis systems currently in use at DPW–Centerm, Deltaport and Vanterm can be used to issue and record "trouble tickets" for process exceptions, as is the practice at many U.S. port terminals. While this procedure would require a small amount of extra work for terminal operators, it would make it easier to identify and reduce the most common process exceptions. Adopting consistent trouble ticket coding by DPW, TSI and FSD would make it even easier to identify the most common problems.

→ **3.** PMV, the terminal operators and Vancouver area truckers should then collectively review the data collected to analyze the extent and nature of the broken transaction problem, locate root causes, and identify action steps.

→ **4.** An action program should then be devised to target the most serious types of broken transactions. The southern California trouble ticket reduction program may have features that are applicable to PMV terminals. Information can be found on the PierPASS website.[17]

This process should, in turn, reduce the number of trucks idling in the parking areas for terminal trouble windows and reduce the need for terminal staff to deal with preventable problems. As noted above, the current level of broken transactions at Vancouver terminals appears to be in the range of 5–10%.

VESSEL HANDLING IMPROVEMENTS

Issue: The adverse impact of multiple and late vessel calls on truck terminal times is a long-term problem for PMV and the terminal operators. The three major PMV terminals are among the most intensively used in North America, and have limited opportunities to expand their footprint. Within that footprint, vessel operations take priority over truck operations. Trucks are delayed when all berths are occupied and the terminal capacity is stretched to its limit.

These delays are part of the larger impacts of limited terminal capacity on gateway operations, and share the high priority of that overall gateway issue. Reducing the delays requires reducing the exposure of truck operations to late vessels and capacity shortfalls; reducing the frequency of late vessels; or increasing terminal capacity to accommodate both truck and vessel operations without delays.

Current initiatives: In the near term, the proposed transition to regular night gate operations five days a week at the three major terminals should ease the impact of vessel activity somewhat by allowing operators to spread the truck volume over multiple shifts and reduce truck exposure to vessel-induced delays. At the December 2012 Container Drayage Leadership Team (CDLT) meeting, the TSI representative suggested a 60/40 split of truck activity between day and night gates as a goal. Terminals typically work three shifts as needed to handle vessels already, so spreading the truck volume across at least two shifts in this manner should reduce truck drivers' vulnerability to vessel-induced terminal congestion on the single day shift.

17) http://pierpass.org/2013/01/10/marine-terminal-operators-at-the-ports-of-los-angeles-and-long-beach-launch-initiative-to-speed-cargo-moves-by-reducing-trouble-tickets.

PMV has begun a performance initiative to encourage vessels to adhere to schedules. Other measures under consideration include incentives for better vessel schedule adherence. This is also one area in which BCOs dissatisfied with vessel performance can have a significant influence, since they can "vote with their feet" and shift cargo to more reliable carriers. Vessel performance is not under PMV stakeholders' control, and terminal capacity is a long-term problem.

Recommendation: In the near term, the current suggestion to expand the use of night gates to spread volume over two shifts will help to reduce vessel-induced congestion on the day shift.

The long-term solution is to expand terminal capacity, but new berths or terminals have a long development timeline. The container shipping industry as a whole suffered financially during the recent recession, and has not fully recovered yet. For some participants, access to capital for capacity improvements was restricted while financial returns were sub-par. When and if capital becomes more available, Vancouver terminals may be able to make internal capacity improvements to ease the strain of handling multiple vessels. PMV is in the planning stages for new terminal capacity at Deltaport in 2015, and TSI has conceptual plans for additional capacity at Vanterm[18].

18) Global Terminals Inc (TSI), Asia-Pacific Gateway Growth: Implications for the Trucking Industry Presentation, May 2012.

LUNCH BREAK IMPROVEMENTS

Issue: There are two factors in the impact of lunch breaks.

- Lunch break closures. The 12:00–12:30 p.m. lunch break closure is part of the contractual agreement between terminal operators and longshore labour. A change from a common break to a staggered break would involve contract negotiations.
- Pre- and post-lunch slowdowns. The other impact of the lunch break is the slower processing from 11:45 a.m. to 12:00 p.m. and 12:30–12:45 p.m.

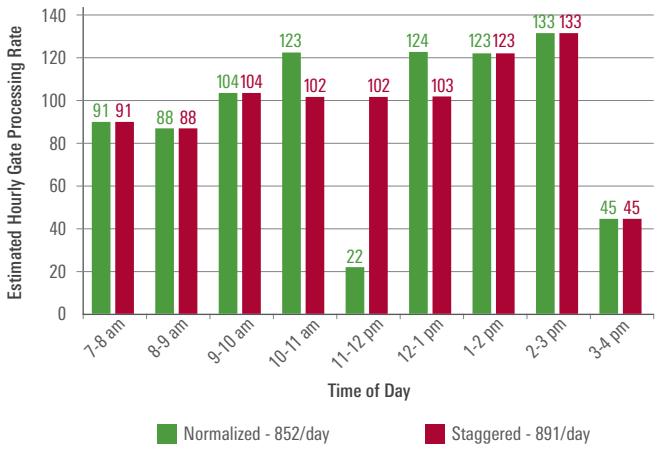
The same issues affect the evening shift "lunch break," and by some stakeholder accounts, the impacts on truck turn time are more dramatic then. Near-term steps to reduce the impact of lunch closures and slow-downs are a fairly high priority, while the long-term transition to staggered gates and terminal beaks are a long-term concern.

Current initiatives: Since the data was collected for this study, some terminal appointment times have reportedly been shifted from the noon window to the 11:30 a.m. and 12:30 p.m. windows in an effort to reduce the impact of the lunch closure. This measure will likely reduce the number of trucks caught in the terminals over the break if the terminals are able to process the 11:30 a.m. appointments before the lunch closure. But for the trucks with 12:30 p.m. appointments, there may only be a material difference to turn times if the trucks make the conscious decision to wait in the line-up over the lunch closure.

Recommendation: Staggered lunch breaks are the norm at most North American ports, and PMV's competitive position would be improved by moving in that direction. Staggered lunch breaks keep the gates open (although perhaps not as many gates), and keep the container yard processing trucks (although perhaps more slowly).

A preliminary analysis (Exhibit 22) suggests that terminals may be able to increase dayshift truck throughput by 4–5% by staggering lunch breaks. If this increase could be achieved at all three major terminals, the current dayshift threshold total of 3,345 trucks could be raised by 134–167.

Exhibit 22: Estimated Hourly Vanterm Day Shift Truck Processing Rates



Although outside the scope of this study, common versus staggered lunch breaks can also interrupt vessel handling and reduce terminals' ability to turn vessels on schedule. The lunch break issue is thus a factor in terms of the larger considerations of gateway productivity and competitiveness.

While the added costs of longer turn times are born by drayage companies and their customers, the direct cost of labour to keep the gates open will be borne by the terminal operators. PMV and the terminal operators will need to compare the productivity gains achievable through staggered lunch breaks with the contractual labour concessions required to make the change.

MORNING STAGING AND PROCESSING TIME

Issue: The morning slow-down is a lower priority than the lunch break problems, as its impacts are lower and part of the problem is inherent in driver choices. There are often long staging queues before the gates open, and morning terminal processing times are initially high. Some of the early morning staging time is the inevitable result of drivers wanting to start their working days as early as possible. Preventing drivers from joining the terminal queue early would like have the effect of inducing those drivers to idle elsewhere, such as along the South Shore roadway or outside the Commissioner gate, with no true savings in costs or emissions.

The 7:00–8:00 a.m. period is overtime for local terminal labour union members, so staffing this period is an additional expense for terminal operators. It is possible that full staffing may not always be available for this period; stakeholder opinions differed on this question.

The appointment system currently has two-hour windows, so a driver can arrive as early as one hour before the appointment time and still be served. The staging queue at a 7:00 a.m. gate opening can therefore include drivers with appointments at 7:30 and 8:00 a.m. as well as drivers with 7:00 a.m. appointments.

Recommendation: It may be possible for the Commissioner roadway entry gate to hold drivers with 7:30 or 8:00 a.m. appointments until 7:15 a.m. or later to allow the 7:00 a.m. drivers to be served first. This measure might reduce the initial rush of trucks into the container yard and allow for a smoother start-up. If early morning staffing consistency is indeed a problem, either the staffing problem should be addressed or early morning appointment slots should be adjusted downward to create a realistic match.

ROADWAY RAIL BLOCKAGES

Issue: The numerous at-grade rail crossings on the South Shore roadway periodically halt truck traffic, particularly in the afternoon. Blockages are not predictable at present, so truck dispatchers and drivers cannot plan to avoid them or minimize their impacts.

On the Deltaport roadway, rail movements sometimes block the truck exit routes, with attendant delays.

Roadway blockages are a high priority, and are mostly being addressed by PMV's South Shore and Deltaport causeway overpass projects. Near-term mitigations, as noted below, may produce some useful gains while the long-term solutions are being implemented.

Current initiatives: The impact of rail blockages and other disruptions on the western roadway segments should be greatly reduced when PMV's overpass project[19]—now under construction—is completed. However, this project will not eliminate all the grade crossings. In addition to the switching of container cars to and from Vanterm and Centerm, the roadway is blocked by switching to the grain terminals and other industrial customers along the South Shore complex.

The proposed overpass on the Deltaport causeway should also minimize truck-rail interference.

19) Part of PMV's South Shore Corridor Project; see http://southshorecorridorproject.com/.

Recommendation: In the near term, advance notice of rail switching movements, even if only by 15–30 minutes, would enable truck drivers to take alternate routes where available or change their planned trips. Once trucks are queued up at a blocked grade crossing, it is very difficult for them to leave the line. There is only one entrance point for the South Shore roadway right now, but there is a choice of exit points (Clark St. or the Commissioner Gate). Mechanisms for announcing rail switching moves could include changeable message signs along the South Shore roadway and at the Commissioner Entrance gate; social media, such as Twitter; and dedicated texting systems.

In the long run, developing a fixed schedule for switching moves on grade crossings not eliminated by the overpass project would enable all parties to plan better, even if the schedule could not be kept with precision.

STAGING TIME IMPROVEMENTS

Issue: Staging times are more difficult to mitigate, and are a lower priority since they are driven by the natural peaking inherent in containerized shipping and are affected by individual driver decisions and strategies. Gate capacity could be a bottleneck in some cases.

The study team was told, but could not verify, that one factor in long queuing times was the presence of trucks arriving well before their appointment window. Prior to October 1, 2012, the Commissioner entry gate did not check whether or not trucks were within their appointment windows before allowing them on the terminal access roads. The smaller number of gates at Vanterm may also contribute to longer staging times there.

At the core of the staging problem is the unevenness and unpredictability of a driver's daily routine. If a driver finishes the first daily task by 10:30 a.m. and does not have a subsequent terminal appointment until 11:00 a.m., there

is seldom any productive option except to join the terminal queue. A more precise appointment system may not be workable, because it can be likely that the first task of the day takes longer than expected—in which case the driver will have difficulty returning to the terminal in time for the second appointment.

Current initiatives: Any problem with early appointment arrivals should be reduced via the new policy of checking the appointment window at the Commissioner gate before allowing entry to the roadway. Terminals have also reportedly begun to turn away trucks that arrive at the gates outside of their appointment windows, which should reduce the impact on drivers that return early for second appointments without leaving and re-entering the Commissioner gate.

In the long term, TSI has conceptual plans for Vanterm that include a new gate complex, which may speed processing and reduce queuing. The proposed transition to multi-shift operations should also reduce dayshift staging times. Expanding gate hours to include regular evening gates will spread the business over more hours and reduce queuing.

Recommendation: Ultimately, terminals cannot directly control staging times because they cannot control when drivers arrive. The major staging time reduction tools available to marine terminals are the gate hours and processing rates.

PMV terminals have implemented some gate processing improvements, including the automated exit gates at Centerm. Further improvements will likely be possible with radio frequency identification (RFID), dedicated short-range communications (DSRC), optical character recognition (OCR), and smart phone technologies that enable the automated identification of trucks, drivers and containers entering the gate. These technologies will increase the rate at which each gate can process trucks, and should reduce errors. As capital becomes available for such upgrades, they should be evaluated for implementation at Vancouver terminals. At Vanterm, an upgrade of the terminal operating system in spring 2013 will likely facilitate additional gate processing upgrades.

The appointment system appears to be successful in avoiding truck congestion *within* the terminals. Further refinements to the length, spacing and allocation of appointment windows could help to reduce queues and staging times. As noted above in reference to morning start-up delays, the current system allows drivers with later appointments to be in line in front of drivers with nearer appointments (as suggested above for morning start-up delays). Drivers can now arrive and join the queue as much as an hour before their appointment time, which can still add to the queue but is an improvement over the previous system.

APPENDICES

Data Supporting the Port Metro Vancouver Truck Turn Time Study

Prepared by
The Tioga Group, Inc.

For
Asia Pacific Gateway Skills Table
B.C. Trucking Association
Port Metro Vancouver

INTRODUCTION TO THE PORT METRO VANCOUVER TRUCK TURN TIME STUDY

The Asia Pacific Gateway Skills Table (APGST) engaged The Tioga Group, Inc. to analyze long truck turn times at Vancouver marine container terminals. The study was completed with the cooperation of Port Metro Vancouver (PMV) and the British Columbia Trucking Association (BCTA) using global positioning system (GPS) data collected by PMV and supplementary data sources.

Truck turn time is a critical factor in Gateway cost, capacity and competitiveness as well as in driver earnings and labour stability. PMV handled about 1.6 million containers in 2012, of which about 54% were trucked to and from the marine terminals.

The study looked at average turn times, the distribution of turn times, and the frequency and causes of long turn times. **For this study, long turn times were defined as those longer than 60 minutes.** Average staging and terminal times at PMV terminals are roughly competitive with turn times at the largest and busiest North American ports. However, overall turn times (including staging and terminal times) in excess of 60 minutes exceed trucker and customer expectations and signal an opportunity for improvement.

ABOUT THESE APPENDICES

The nine appendices (A–H) contained in this report show and further explain the data that supplement and support the primary project final report, entitled Port Metro Vancouver Truck Turn Time Study.

The primary report summarizes the key analysis and its results, and concludes with recommendations to reduce truck turn times at the Metro Vancouver Gateway. These appendices present, in greater detail, the data and analysis that underpin the primary report's results and recommendations.

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STUDY METHODOLOGY & APPROACH

Truck drayage has been established as a major source of emissions and congestion in port areas. Reducing unnecessary and unproductive time spent by drayage trucks in port terminals could materially reduce both emissions and congestion. Moreover, excess truck time at terminals raises the costs of both drayage and terminal operations, delays import and export shipments, reduces shipment reliability, and cuts effective port capacity. All stakeholders can gain from minimizing truck turn times at port terminals.

The Port of Metro Vancouver (PMV), the B.C. Trucking Association and the Asia Pacific Gateway Skills Table (APGST) were interested in initiating a project to document, analyze and develop recommendations to reduce the frequency of marine terminal truck turn times longer than one hour. Ordinarily, turn times of this duration imply a breakdown in processing or other delays that increase cost, congestion and emissions. Such instances are usually "outliers," beyond the normal distribution of acceptable terminal and truck performance.

APGST retained The Tioga Group, Inc. to perform the analysis. Tioga's background in port drayage analysis includes the recent *Truck Drayage Productivity Guide* (developed under the U.S. National Cooperative Freight Research Program), the development of the U.S. Environmental Protection Agency's SmartWay DrayFLEET drayage emissions and cost model, and other related studies.

This project sought to locate, understand and quantify bottlenecks and other sources of delay in port container drayage, and then to describe best practices and potential solutions. The issue of quantifiable data is key, as past discussions of drayage issues have often leaned heavily on surveys, opinions and perceptions rather than on hard data. Tioga approached the problem by first locating the available data—chiefly global positioning system (GPS) truck movement data collected by PMV. These data were supplemented by additional sources (as described in the next section, Data Sources).

Tioga then used the data to locate instances of truck turn times over one hour, and then to determine the pattern of such occurrences by time of day, day of week, etc. Tioga also prepared distributions and averages of turn times to aid in analyzing the issues.

From these initial observations, Tioga was able to discern patterns and relate them to potential contributing factors, including:

- → Vessel activity at terminals
- → Process exceptions and transaction delays
- → Truck arrival peaking
- → Gate processing rates
- → Morning start-ups and lunch breaks
- → Street blockage by rail operations

The study established linkages between some of these factors and the prevalence of long turn times. The team then documented these delays and linkages and related them to potential improvements and remedies.

DATA SOURCES

The purpose and focus of this study was to use objective data, where available, to analyse truck turn times for drayage activities at Metro Vancouver terminals. Where possible, multiple data sources were used to analyze terminal turn times and queuing.

The June–September 2012 GPS data provided by Port Metro Vancouver served as the primary data source for the study. PMV has defined distinct 11 "geozones" (specific geographical areas) in three categories: marine terminals, staging areas and roadways. The times when trucks enter and exit these geozones are recorded in the data, and form the basis for analysis. Selected data were also provided by other organizations:

- Canadian Tire provided data collected through GPS tags on their chassis fleet.
- Harbour Link Container Services provided data collected through its PDA-based truck location system.
- BCTA provided GPS data collected by Transport Canada.
- DP World (DPW)–Centerm provided data on its truck transactions, as well as on vessel berth occupancy, longshore gangs working, and vessel unloading/loading throughput.
- PMV also provided data on gate volumes, railway road blockage, and vessel arrival times.

These additional data supplemented the base PMV GPS data and provided valuable insights. In general, the study team found broad agreement between the various data sets on the magnitude and pattern of terminal and queuing times. The differences tended to reflect:

- Detailed differences in data collection, such as variations in geozone definition; and
- Differences in movement coverage, such as data with speed gates versus data without speed gates.

Exhibit 1 summarizes the data sets provided by port stakeholders and used in this analysis.

Exhibit 1: Project Data Sets

#	Data Source	Period
	Primary Data Sources	
1	PMV GPS Data	June–September 2012
2	DPW – Centerm Terminal Data	June–September 2012
3	Harbour Link GPS Data	May–June 2013
	Supplementary Data Sources	
4	Canadian Tire – GPS Data on Chassis	June–August 2012
5	Transport Canada GPS Dwell Time Data	April 2012
6	PMV Vessel Performance	January–September 2012
7	PMV Terminal Daily Transaction Reports	June–October 2012
8	PMV Rail Crossing Data	August 15–September 30, 2012
9	Gate Camera Data	September 28, October 16 2012

The major source of data was the compilation of GPS geofence data for June–September 2012, provided by PMV. These data were the most widely applicable, and their use provides a conceptual link between the findings of this analysis and PMV's ongoing data program.

The study also made extensive use of PMV data on vessel schedules and arrivals and on terminal gate transactions. These data allowed Tioga to associate truck turn time distributions with other terminal activities that could contribute to delays. PMV data on rail switching blockages of the South Shore roadway were used in the same way.

The study team used transaction data and other information provided by DPW Centerm to analyze individual stages of the truck handling process and relate turn times to measures of vessel and terminal activity.

Data supplied by Harbour Link Container Services, as well as data from Canadian Tire and Transport Canada, were also used to cross-check the reasonableness of the PMV GPS data.

It is important to note that the data sets do not always directly measure the activities or factors at issue in this study. Accordingly, some of the study findings must be qualified by noting that they rely on inference and observations at comparable ports elsewhere as well as on the available metrics.

Exhibit 2: Port of Metro Vancouver Geozones, September 2012

1 — PMV GPS Data

The primary data source for the study was provided by Port Metro Vancouver (PMV) and was collected using GPS units installed on the trucks. The times when trucks enter and exit specified geographical regions (geozones) are recorded and compiled by port staff. Subtracting the exit time from the entry time produces a record of the time spent inside a particular geozone.

Geozones

Eleven geozones were analyzed in the following three categories (illustrated in Exhibit 2):

- → **Marine Terminals.** Centerm, Deltaport, Fraser Surrey Docks (FSD) and Vanterm fall into this category. For the marine terminal geozones, this time is known as the dwell time, or terminal time.
- → **Staging Areas.** Trucks wait in these areas before entering the terminal. The time spent in the staging area is known as the staging time, or wait time. The sum of the two times is known as the turn time.
- → **Roadways.** Clark–Heatley, Commissioner–Victoria, and Victoria–Clark are geozones that cover the roadway on the North Shore. The Deltaport roadway is the fourth roadway geozone.

Sample Size

There are about 270 trucks providing GPS data. These perform roughly 16.5 % of terminal transactions.

File Format

Data were provided in the form of a Microsoft Excel spreadsheet. The data columns were labeled as WebTech ID and Locator No. (which both identified the trucks), Geofence, Start Time and End Time, as documented in Exhibit 3.

Exhibit 3: Sample PMV GPS File Structure

WebTech-ID	Locator-No	GeoFence-Name	Start Time	End Time	Dwell	Day
3277729	7034633	Commissioner_Victoria	9/24/2912 17:36	9/24/2012 18:06	0:30:21	Monday, September 24, 2012
327971	7034815	Commissioner_Victoria	9/14/2912 15:39	9/14/2012 16:10	0:30:17	Friday, September 14, 2012
327840	7034633	Commissioner_Victoria	9/20/2912 10:18	9/20/2012 10:49	0:30:17	Thursday, September 20, 2012

Sample Trip Patterns

There are a very large number of drayage trip patterns evident in the PMV GPS data. Two examples are presented below to illustrate both common and uncommon variations. The first sample (Exhibit 4) shows a complete working day for a single truck on September 10, 2012.

- → On the first trip, the truck entered the Commissioner gate at 7:53 a.m. and drove to DPW. After 15 minutes in staging and 32 minutes in the terminal (a 47-minute combined turn time), the truck exited via the Commissioner gate.
- → At 10:48 a.m., the same truck entered the Deltaport Roadway. After 35 minutes on the roadway (due to queuing or a stop), the truck entered the Deltaport terminal/staging geozone. Time in the terminal/staging geozone was 126 minutes, after which the truck took four minutes to drive back up the roadway.
- → On the third trip, the truck entered the Victoria–Clark geozone at 15:41 (3:41 p.m.) and drove through Vanterm pre-staging to join the queue in staging. (The Clark Street entrance would not ordinarily be allowed, but the truck apparently got through.) The driver spent one minute in pre-staging, 22 minutes in staging, and 12 minutes in the Vanterm terminal, for a combined turn time of 35 minutes. The truck then exited via the Commissioner gate five minutes later.

Exhibit 4: First Sample GPS Record

ID	Geozone	Start	End	Min.
7034803	Commissioner_Victoria	9/10/2012 7:53	9/10/2012 7:55	2
7034803	Victoria_Clark	9/10/2012 7:56	9/10/2012 7:57	1
7034803	Clark_Heatley	9/10/2012 7:58	9/10/2012 8:07	9
7034803	DPW-Staging	9/10/2012 8:07	9/10/2012 8:23	15
7034803	DPW_Terminal	9/10/2012 8:23	9/10/2012 8:54	32
7034803	Clark_Heatley	9/10/2012 8:56	9/10/2012 8:58	2
7034803	Victoria_Clark	9/10/2912 8:58	9/10/2912 9:00	1
7034803	Commissioner_Victoria	9/10/2912 9:00	9/10/2912 9:04	4
				67
7034803	Deltaport-Roadway	9/10/2912 10:48	9/10/2912 11:00	35
7034803	Deltaport-Terminal	9/10/2912 11:23	9/10/2912 13:30	126
7034803	Deltaport-Roadway	9/10/2912 13:30	9/10/2912 13:33	4
				165
7034803	Victoria_Clark	9/10/2012 15:41	9/10/2012 15:42	1
7034803	Vanterm Pre-Staging	9/10/2012 15:43	9/10/2012 15:43	1
7034803	Vanterm-Staging	9/10/2012 15:43	9/10/2012 16:06	22
7034803	Vanterm Terminal	9/10/2012 16:06	9/10/2012 16:18	12
7034803	Victoria_Clark	9/10/2012 16:18	9/10/2012 16:19	1
7034803	Commissioner_Victoria	9/10/2012 16:19	9/10/2012 16:24	4
				42

The second sample (Exhibit 5) shows another truck on two different days.

Exhibit 5: Second Sample GPS Record

ID	Geozone	Start	End	Min.
7035248	Clark_Heatley	9/8/2012 11:58	9/8/2012 12:00	2
7035248	DPW-Staging	9/8/2012 12:00	9/8/2012 12:39	39
7035248	DPW-Terminal	9/8/2012 12:39	9/8/2012 12:57	18
7035248	DPW-Staging	9/8/2012 12:57	9/8/2012 13:04	7
7035248	DPW-Terminal	9/8/2012 13:05	9/8/2012 13:16	11
7035248	Clark_Heatley	9/8/2012 13:25	9/8/2012 13:42	17
7035248	Victoria_Clark	9/8/2012 13:43	9/8/2012 13:44	1
7035248	Commissioner_Victoria	9/8/2012 13:44	9/8/2012 13:49	5
				100
7035248	Commissioner_Victoria	9/8/2012 15:25	9/8/2012 15:28	3
7035248	Clark_Heatley	9/8/2012 15:30	9/8/2012 15:32	2
7035248	DPW-Terminal	9/8/2012 15:33	9/8/2012 15:50	17
7035248	Clark_Heatley	9/8/2012 15:53	9/8/2012 15:55	2
7035248	Victoria_Clark	9/8/2012 15:55	9/8/2012 15:56	1
7035248	Commissioner_Victoria	9/8/2012 15:56	9/8/2012 16:01	5
				30
7035248	Commissioner_Victoria	9/24/2012 17:23	9/24/2012 17:28	5
7035248	Victoria_Clark	9/24/2012 17:28	9/24/2012 17:42	13
7035248	Clark_Heatley	9/24/2012 17:52	9/24/2012 17:55	2
7035248	Clark_Heatley	9/24/2012 17:55	9/24/2012 17:57	2
7035248	Clark_Heatley	9/24/2012 17:58	9/24/2012 18:03	6
7035248	Clark_Heatley	9/24/2012 18:04	9/24/2012 18:09	5
7035248	DPW-Staging	9/24/2012 18:13	9/24/2012 18:53	40
7035248	DPW-Terminal	9/24/2012 18:53	9/24/2012 19:25	32
7035248	Victoria_Clark	9/24/2012 19:29	9/24/2012 19:30	1
7035248	Commissioner_Victoria	9/24/2012 19:30	9/24/2012 19:34	4
				111

- On September 8, the data show the truck entering the Clark–Heatley geozone at 11:58 a.m. (which should not have been possible without passing through the Commissioner–Victoria and Victoria–Clark zones first). The truck spent 39 minutes in DPW staging and 18 minutes in the terminal (a 57-minute combined turn time). Instead of exiting the port area, however, the truck apparently re-entered DPW staging (seven minutes) and the terminal (11 minutes) for a second transaction. There is a gap of nine minutes between the terminal exit at 13:16 (1:16 p.m.) and the truck's reappearance in Clark–Heatley at 13:25 (1:25 p.m.)—apparently the truck stopped outside the geozones for some reason. The truck then spent 17 minutes in the Clark–Heatley zone before eventually exiting at the Commissioner gate.
- Later the same day, the GPS data show the truck entering the Commissioner Gate at 15:25 (3:25 p.m.). No data are shown for the Victoria–Clark geozone, but the two-minute gap between exiting Commissioner–Victoria at 15:28 (3:28 p.m.) and entering Clark–Heatley at 15:30 (3:30 p.m.) suggests that the truck spent about two minutes on the Victoria–Clark segment. (Either the GPS data were not received, or the record was lost in the data cleansing process.) The truck showed up in the DPW terminal geozone at 15:33 (3:33 p.m.) with no record of time in staging (which apparently was minimal). The truck spent 17 minutes in the terminal (a combined turn time of 17 minutes, since there are no staging data) and exited via the Commissioner gate.
- On September 24, the same truck entered the Commissioner-Victoria geozone at 17:23 (5:23 p.m.). However, the truck generated four Clark–Heatley geozone records, possibly by stopping off the edge of the roadway or detouring through a parking lot. There is a four-minute gap between the last Clark–Heatley record at 18:09 (6:09 p.m.) and the DPW staging entry at 18:13 (6:13 p.m.), indicating that the truck either stopped in the coverage gap between the two geozones

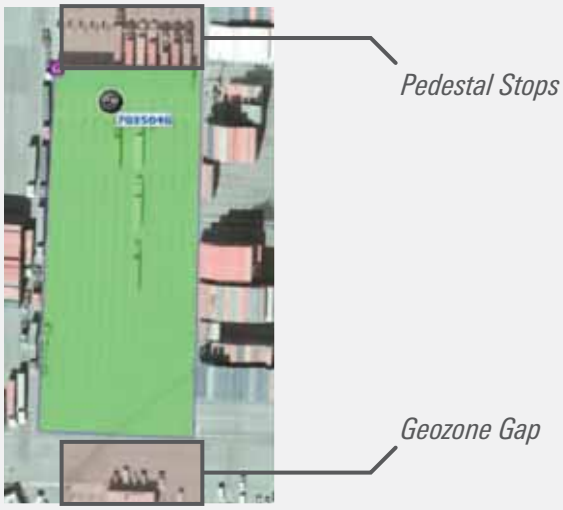
or stopped to one side. The truck spent 40 minutes in DPW staging and 32 minutes in the terminal (a turn time of 72 minutes). The truck apparently spent four minutes unrecorded in Clark–Heatley before exiting via Victoria–Clark and Commissioner–Victoria.

These examples illustrate the variability in both drayage trip patterns and in the GPS data collection. PMV has refined the geozone definitions over time. Periodic adjustments will likely be necessary as terminal configuration, roadway geometry, and driver behaviour all undergo small changes.

Geozone Coverage

There is apparently a specific geozone feature that affects DPW staging and terminal time data. As Exhibit 6 shows, the current PMV GPS staging geozone includes the inbound inspection canopy but not the final set of inbound communication pedestals. Trucks stopped at these pedestals are considered by DPW to still be outside the terminal and in staging, but the PMV data count them as being in the terminal. This geozone boundary issue has the effect of reducing reported staging time and increasing reported terminal time. The effect on the combined turn time is neutral.

Exhibit 6: DPW Staging Geozone Gap



As exhibits 6 and 7 indicate, there is apparently a coverage gap between the DPW staging and the Clark–Heatley geozones. Most trucks spend a minute or less driving through this gap (Exhibit 8), but a few stop there for much longer. The average time "lost" in this gap is about four minutes.

Exhibit 7: DPW Clark–Heatley Geozone Gap

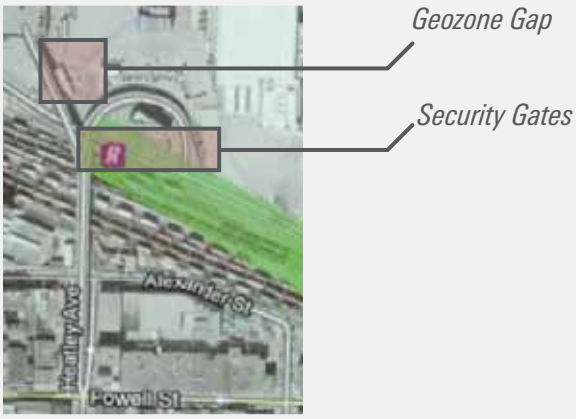
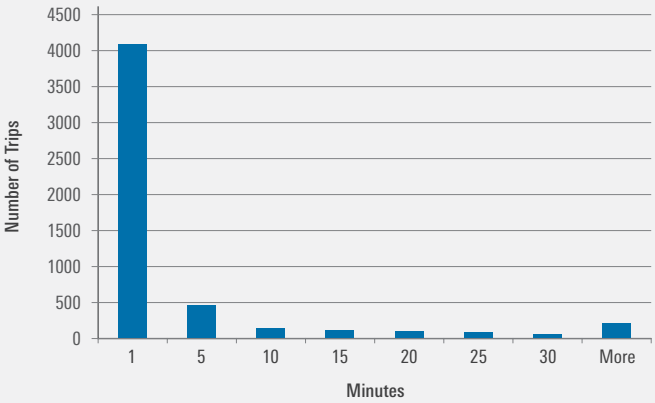


Exhibit 8: Time Spent in DPW Clark–Heatley Geozone Gap *(PMV GPS Data, Jun–Sep 2012)*



The relatively new DPW inbound security gates in front of the DPW office building are actually in the Clark–Heatley roadway zone. DPW contacts indicate that drivers spend only one or two minutes at these gates to swipe their PortPasses, but the placement does tend to slightly over-report Clark–Heatley transit time and slightly under-report DPW staging time.

2 — DPW–Centerm Data

DPW provided Tioga with a complete set of data covering the specific times at which trucks entered and departed the (Centerm) Terminal from June through September as recorded in the terminal's operations computer.

Operational data from the marine terminal were also provided. The marine terminal operations data are a daily summary of the terminal's activities. They include which vessels arrived each day, the number of gangs working each shift (graveyard, day, afternoon), and throughput. These data also show the number of exports and imports for the trucks during each shift.

Sample Size

Unlike the GPS system used by PMV, DPW data account for all of the trucks using Centerm, as opposed to a sample. There are roughly 2,500 trucks represented in the DPW data.

File Format

The truck data column labels (Exhibit 9) include appointment ID, truck ID, appointment time, license number, transaction number, entered, and exited.

The marine terminal operations data include the date, shift, vessel, throughput moves and gangs. The first page of the report is illustrated in Exhibit 10.

Exhibit 9: Sample DPW Truck Data File Structure

Year-Month	Appointment ID	Appointment Time	Pre Swipe	Main Swipe	Entered	Handled	Exited	OCR Swipe	Out Swipe
201208	3104983	Aug 30 2012 10:00AM	8.30.12 21:29	8.30.12 21:32	8.30.12 21:33	–	8.30.12 22:20	–	8.30.12 22:20
201209	3117118	Sep 13 2012 09:00AM	9.13.12 20:15	9.13.12 20:17	9.13.12 21:13	9.13.12 21:13	9.13.12 21:25	9.13.12 21:25	9.13.12 21:28
201209	3123251	Sep 13 2012 09:00AM	9.13.12 19:10	9.13.12 19:42	9.13.12 19:48	9.13.12 19:48	9.13.12 20:23	9.13.12 20:23	–
201208	3106124	Aug 30 2012 10:00AM	8.30.12 19:46	8.30.12 19:48	8.30.12 21:03	–	8.30.12 21:34	–	8.30.12 21:34
201209	3123253	Sep 13 2012 10:00AM	9.13.12 19:10	9.13.12 19:42	9.13.12 19:48	9.13.12 19:48	9.13.12 20:22	9.13.12 20:22	–
201209	3131064	Sep 20 2012 10:00AM	9.20.12 19:36	9.20.12 19:37	9.20.12 19:43	9.20.12 19:43	9.20.12 19:59	9.20.12 19:59	9.20.12 19:59
201208	3106186	Aug 30 2012 10:00AM	8.30.12 18:29	8.30.12 19:35	8.30.12 19:36	–	8.30.12 21:01	–	8.30.12 20:22
201209	3131065	Sep 20 2012 10:00AM	9.20.12 19:31	9.20.12 19:33	9.20.12 19:36	9.20.12 19:36	9.20.12 19:53	9.20.12 19:53	9.20.12 19:53
201209	3131309	Sep 20 2012 10:00AM	9.20.12 19:31	9.20.12 19:32	9.20.12 19:34	9.20.12 19:34	9.20.12 19:49	9.20.12 19:49	9.20.12 19:46
201209	3123256	Sep 13 2012 11:00AM	9.13.12 19:50	9.13.12 20:08	9.13.12 20:12	9.13.12 20:12	9.13.12 21:23	9.13.12 21:23	9.13.12 21:18
201209	3123258	Sep 13 2012 11:00AM	9.13.12 19:50	9.13.12 20:08	9.13.12 20:12	9.13.12 20:12	9.13.12 21:21	9.13.12 21:21	9.13.12 21:18

Exhibit 10: Centerm Daily Summary

Vessel

Day	Shift	Vessel	Throughput Moves	Gangs
Wed, Aug 08, 2012	Graveyard	COSCO SHENZHEN	433	3
		MOL PRESENCE	255	2
Tue, Aug 07, 2012	Day	COSCO SHENZHEN	552	3
	Afternoon	COSCO SHENZHEN	864	4
		MOL PRESENCE	142	1

Truck Gate

Day	Shift	Empties In	Empties Out	Export	Import	Others	Total
Tue, Aug 07, 2012	Graveyard	–	–	–	–	–	–
	Day	10	169	416	313	4	912
	Afternoon	–	–	–	–	–	–

Rail

Day	Shift	Moves	Gangs
Tue, Aug 07, 2012	Graveyard	–	–
	Day	172	1
	Afternoon	136	1

DPW–Centerm provided truck transaction data files for June–September 2012. Because the PMV GPS data were found to be more reliable for August–September, the study team analyzed the Centerm data for the same period.

The key data items provided for each truck trip were date and times for each of the following events:

- Appointment time
- PRESWIPE: swipe at the security in-gate
- MAINSWIPE: swipe at main pedestal
- ENTERED: completion of in-gate processing
- HANDLED: CHE marks job completed
- EXITED: completion of appointment transaction
- OCRSWIPE: swipe at OCR pedestal for automated transactions
- OUTSWIPE: swipe at out-gate

These times would be slightly different from the PMV GPS times for the same trip (see exhibits 6 and 7):

- The Centerm Preswipe point is the security gate in front of the Centerm office, which is in the Port's Clark–Heatley geozone. The Centerm data thus capture the terminal entry time slightly sooner than the port GPS data.
- The PMV GPS geozones have a gap between the Clark–Heatley and DPW staging zones. Trucks spend an average of four minutes in this gap, so the PMV data slightly under-count staging time. The Centerm data are derived from card swipes and data entry, and do not have a gap.
- The Centerm data consider the terminal entry point to be the pedestals inside of the inbound canopy. The Port's DPW terminal geozone starts at the canopy itself, so the Centerm data pick up terminal entry slightly later than the GPS data.

The net effect is that the staging and terminal times will vary between the two datasets, although the key patterns will be the same.

The trips were also identified by transaction type as follows:

- DE—Deliver Export
- DI—Deliver Import
- DM—Deliver Empty
- RE—Receive Export
- RI—Receive Import
- RM—Receive Empty

These distinctions enabled the study team to analyze the Centerm data in ways that were not possible with the PMV GPS data. Note that the data do not flag double transactions, so the study team was not able to separately analyze single and double moves.

Centerm Turn Time Data

Exhibit 11 shows staging, terminal, and combined turn times for the six Centerm transaction types. Import deliveries (loads), empty deliveries, and export receipts (loads) make up 97% of the transactions, so further analysis concentrated on these segments. For this purpose:

- Staging time is defined as the elapsed time between "Preswipe" and "Entered" timestamps. The overall average is 43 minutes.
- Terminal time is defined as the elapsed time between "Entered" and "Exited" timestamps. The overall average is 21 minutes.
- Turn time is defined as staging time plus terminal time. The overall average is 64 minutes.

Centerm staff note that the turn times for pick-up (import and empty) transactions would be inflated in instances where there they are part of a multi-transaction truck visit. When a truck with multiple appointments is processed, the appointments are all processed at the in-gate by the Checker so they will all have about the same start time even though the truck can only be physically serviced for one appointment at a time. A truck visit may have up to 4 transactions (2 drop off and 2 pickup).

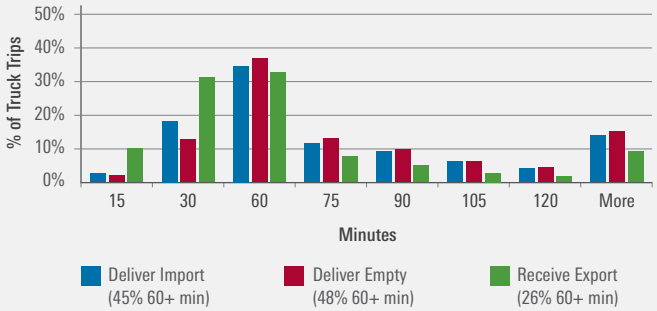
Exhibit 11: Centerm Data and Averages by Transaction Type, Aug–Sep 2012

Move Type	Count	% of Total	Staging Time	Terminal Time	Turn Time
Deliver Export	10	0%	38	34	71
Deliver Import	10389	28%	39	29	68
Deliver Empty	8407	23%	42	31	73
Receive Export	17113	46%	46	12	58
Receive Import	135	0%	37	13	49
Receive Empty	937	3%	37	9	49
Total	**36991**	**100%**	**43**	**21**	**64**

Exhibit 11 indicates that staging times for the three main transaction types are similar, but that in-terminal times vary greatly. Delivering an import or empty container takes 29–31 minutes on average, but receiving an export takes only 12 minutes on average. The shorter time for export loads may be due to the more frequent use of speed gates for that segment.

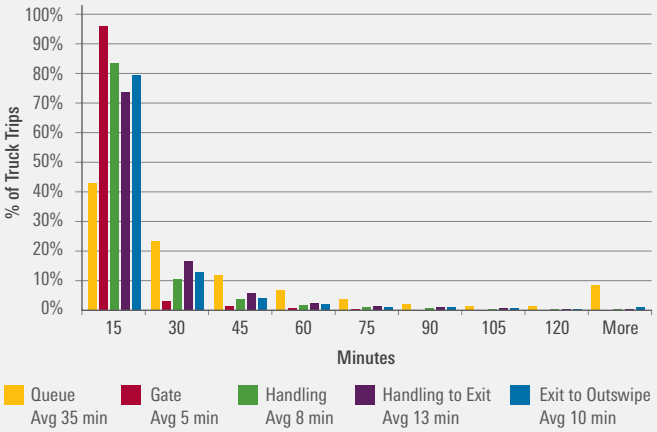
Combining the staging and terminal times to create the turn time distribution in Exhibit 12 shifts the distribution to the right, with almost half of the import and empty transactions taking 60 minutes or longer and about a quarter of the export loads taking that long.

Exhibit 12: Centerm Turn Times by Major Transaction Type, Aug–Sep 2012



The availability of multiple timestamps in the Centerm data enabled the study team to separate the overall turn time into its constituent parts, as shown in Exhibit 13. This analysis is inevitably imprecise, as some of the times are entered by clerks or equipment operators and may not be as precise as data collected from card swipes.

Exhibit 13: Centerm Time Segments, Aug–Sep 2012



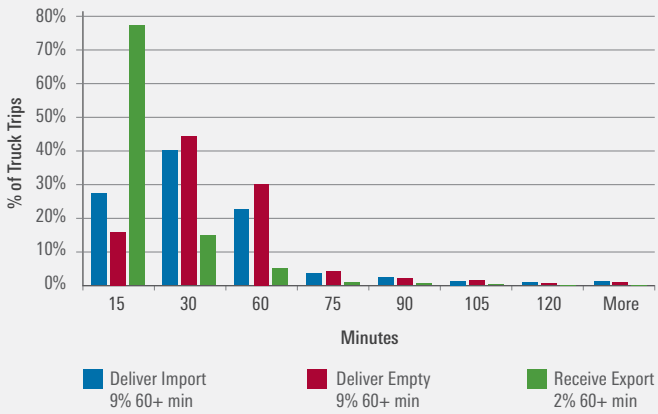
» "Queue" time—defined as time spent between Preswipe (security) and Mainswipe at the gate pedestal—averaged 35 minutes, with the widest distribution of the time segments shown.

- "Gate" time—defined here as the difference between the main pedestal swipe (mainswipe) and "Entered" (entry time)—averaged five minutes and was tightly distributed, with more than 90% of trucks under 15 minutes. This observation is consistent with gate processing data obtained by Tioga for other port terminals.
- "Handling" time—defined here as the difference between "Entered" and "Handled"—averaged eight minutes, with more than 80% of trucks under 15 minutes.
- "Handling to Exit" time averaged 13 minutes, with the "exit" time being the point at which the terminal considers the appointment transaction to be complete. This is also the endpoint for the terminal time as defined by Centerm.
- The remaining "Exit to Outswipe" time averaged 10 minutes. This time could include queuing at outgates, time spent checking container/chassis securement, or time spent on the phone to the trucking company dispatcher before exiting the terminal.

Centerm Terminal Time Data

The Centerm data also show differences between the transaction types. A much higher proportion of export receipts appear to be handled quickly, again perhaps due to speed gates. About 9% of the import and empty transactions take more than 60 minutes, but only 2% of the export loads do so.

Exhibit 14: Centerm Terminal Times by Major Transaction Type, Aug–Sep 2012



The mix of transaction types is unlikely to cause major differences between terminals since, as Exhibit 15 shows, the three major terminals all have very similar mixes.

Exhibit 15: Terminal Transaction Types

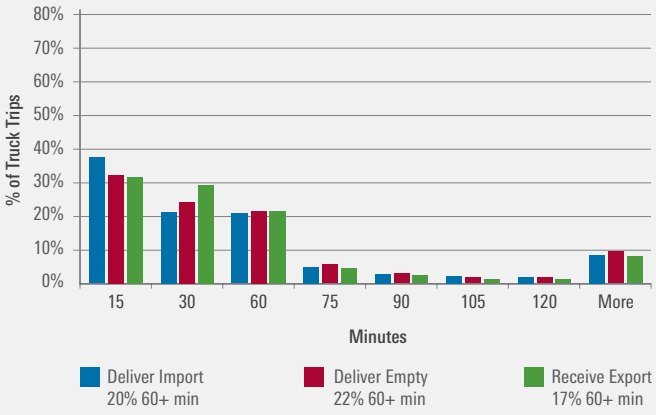
Move Type	Centerm	Vanterm	Deltaport	Average
Export In	45%	44%	46%	45%
Import Out	29%	28%	29%	29%
Empty Out	23%	20%	21%	21%
Empty In	3%	7%	3%	4%
Other	1%	1%	1%	1%
Total	**100%**	**100%**	**100%**	**100%**

Centerm Staging Time Data

Exhibit 16 shows the distribution of staging times for the three major transaction types at Centerm. About 17–22% of the staging times are longer than 60 minutes, which is higher than the Centerm average in PMV's GPS data. As noted earlier, the geozone coverage gap for Centerm (Exhibit 6) tends to understate staging time there, which likely accounts for some of the difference.

The distribution pattern is very similar for all three transaction types, which is to be expected since the trucks are all in the same waiting area. Speed gate trucks may be given separate entry gates, but the percentage of speed gates at Centerm is relatively small (Exhibit 34). If similar data were available for Vanterm, which has a greater percentage of speed gates, the patterns might differ more.

Exhibit 16: Centerm Staging Times by Major Transaction Type, Aug–Sep 2012



3 — Harbour Link Data

These data come from Harbour Link Container Services and were collected using the company's PDA-enabled communications system. The data show the trucks' dwell times (in-gate) and turn times (terminal), recorded by the drivers' cell phones. The data range from May to June 2013. The geozones are Centerm, Deltaport and Vanterm.

File Format

The column labels are Job Number, Type, Date, Truck, Container, Reservation Number, Ingate and Terminal Time (Exhibit 17).

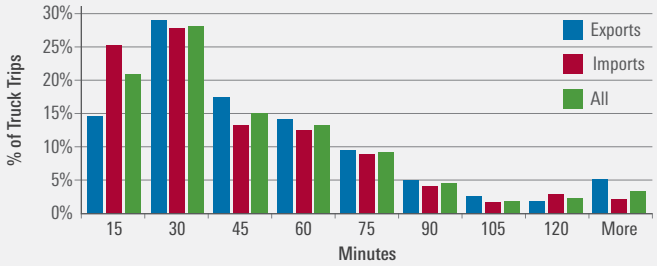
Exhibit 17: Sample Harbour Link Terminal Data File Structure

Container #	Job ID	Job Type	Date	Truck	Container	Reservation #	Pre-Terminal Time	Terminal Time	Total Time
DS001182	100096558	Import	22-May-13	H010 - 010	CBHU8252905	3361442	11	23	**34**
DS001182	100096560	Import	22-May-13	H520 - 040	CBHU8784889	3361402	14	11	**25**
DS001183	100096562	Import	25-May-13	H003 - 002	APHU4520727	3362089	4	27	**31**

Harbour Link Terminal Time Data

Exhibit 18 shows GPS terminal time data compiled by Harbour Link for Centerm trips in the spring of 2013. These data show a similar distribution to the PMV and Centerm data (e.g. Exhibit 14), reinforcing the common implications that 1) there are many timely transactions and a smaller number of exceptions that raise the average, and 2) that this pattern persists over time. Harbour Link uses somewhat different geozone definitions, so there are slight differences in the time values recorded.

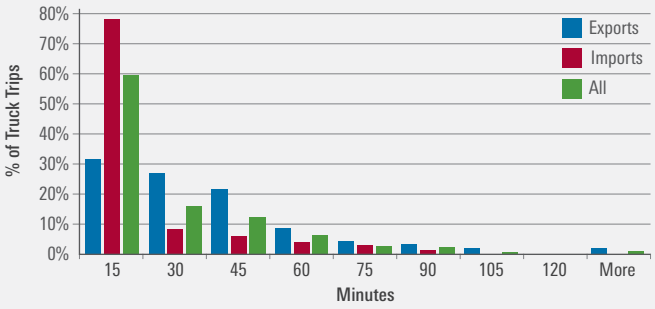
Exhibit 18: Harbour Link Centerm Terminal Time Data



Harbour Link Staging Time Data

Exhibit 19 shows Centerm staging time data provided by Harbour Link. Although basically similar to PMV and Centerm data, these data show a tighter concentration of import pickup times in the 0–15 minute range than the Centerm data (e.g. Exhibit 16). This difference may be due to Harbour Link's own dispatching practices or improved performance in the later time period. There may also be slight differences in geozone definitions.

Exhibit 19: Harbour Link Centerm Staging Time Data



4 — Canadian Tire Data

Canadian Tire Corporation, Ltd., a large retailer, is a major PMV user. Canadian Tire has GPS tracking units installed on its fleet of chassis and provided a subset of this data to the Tioga team. This was useful in that it was the first full data set available to the team and the data's structure allowed wait time and dwell time to be directly associated with a particular movement order to produce full turn times.

Geozone

Data were provided for the Centerm Terminal and an associated staging area.

Sample Size

About 240 chassis are included in this data set.

File Format

The columns labeled include Location, Move ID, Date, Port Pass, Driver Name, Chassis ID, Wait/Dwell Time, Time and Date, as illustrated in Exhibit 20 below.

Exhibit 20: Canada Tire Data Structure

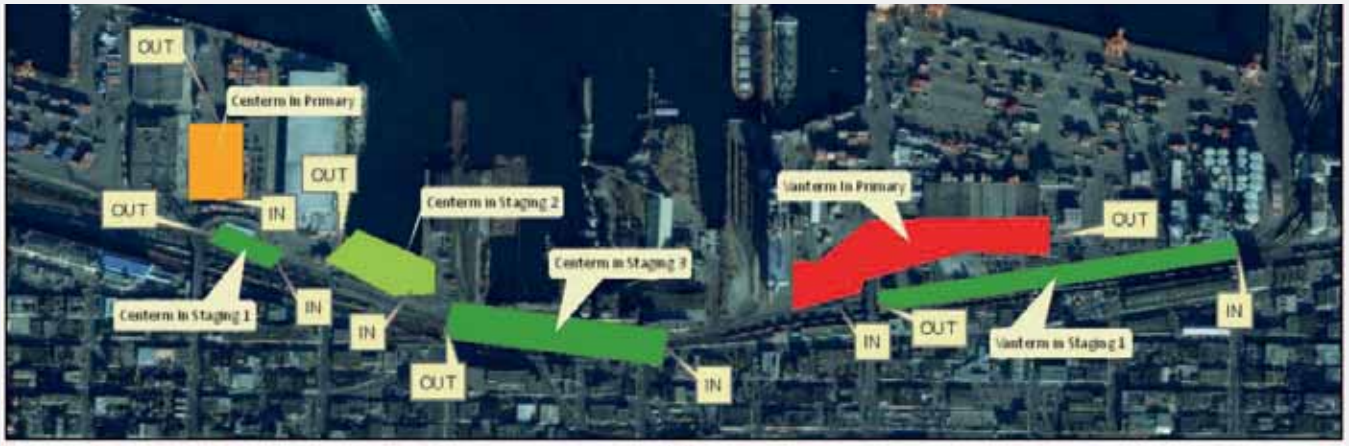
Location	Move ID	Date	Port Pass	Driver	Chassis ID	Wait/Dwell Time	Time
Centerm	1000258729	1/25/2012	11111	A. Driver	CDAZ6785	Dwell Time	75
Centerm	1000262543	2/6/2012	22222	B. Driver	CDAZ6943	Dwell Time	16
Centerm	1000279603	3/30/2012	33333	C. Driver	CDAZ6821	Dwell Time	99
Centerm	1000280664	3/30/2012	44444	D. Driver	CDAZ6809	Dwell Time	25
Centerm	1000297681	6/1/2012	55555	E. Driver	CDAZ6867	Dwell Time	66

5 — Transport Canada GPS Dwell Time Data

Transport Canada has obtained sample GPS data for heavily used truck routes and locations, including areas that overlap the PMV GPS geozones.

Exhibit 21 shows a summary of the Transport Canada GPS data for April 2012. A comparison with Exhibit 2 shows the differences in geozone definitions.

Exhibit 21: Transport Canada GPS Dwell Time Data



Geofence	Count	Average Dwell Time
Centerm In Staging 1	394	1.42
Centerm In Staging 2	35	5.86
Centerm In Staging 3	398	1.50
Centrem In Primary	470	19.61
Deltaport Berth 3 In Primary	157	12.49
Deltaport In Primary	471	10.95
Deltaport In Staging 1	474	3.96
Deltaport In Staging 2	604	1.67
FSD In Primary	155	13.69
Vanterm In Primary	301	32.35
Vanterm In Staging 1	653	2.30
Grand Total	**4112**	**Weighted Average 8.25**

The dwell time for each fence was calculated by using GPS data from a trucking fleet operating in the lower mainland. Geofences were created in known congestion spots within the Port of Metro Vancouver.

The dwell time was calculated by taking the last point before entering the geofence and the first point out of the fence.

Exhibit 22 provides a comparison between the Transport Canada data in Exhibit 21 and the closest equivalent in the PMV GPS data. Overall, the two data sources show very similar patterns.

Exhibit 22: Transport Canada and PMV GPS Data Comparison

Transport Canada Data April 2012		PMV GPS Data June–September 2012	
TC GPS Geofence	TC Avg Min	PMV Geozone	PMV GPS Avg Min
Centerm In Staging 1	1	Clark-Heatley	5
Centerm In Staging 2	6		
Centerm In Staging 3	2		
Total	**9**	**Total**	**5**
Centerm In Primary	**20**	**DPW Staging**	**19**
Deltaport Berth 3 In Primary	12	Deltaport Terminal_Staging	52
Deltaport In Primary	11		
Deltaport3 In Staging 1	4		
Total	**27**	**Total**	**52**
Deltaport3 In Staging 2	**2**	**Delta Port Roadway**	**7**
FSD In Primary	**14**	**FSD Staging**	**12**
Vanterm In Primary	32	Vanterm Pre-Staging	5
		Vanterm Staging	20
Total	**32**	**Total**	**25**
Vanterm In Staging 1	**2**	**Victoria-Clark**	**4**

Where the geozone definitions are close (as in the Centerm In Primary and the FSD In Primary), the recorded average dwell time is close. Where the times are markedly different, the geozone differences apparently account for much of the differential.

- The Transport Canada Centerm In Staging 2 geozone includes a parking area north of the main roadway. Trucks that park in this area between assignments or while waiting for appointments would incur longer dwell times than those travelling on the roadway itself.
- The Transport Canada Deltaport geozones do not include the terminal itself, while the PMV Deltaport Terminal Staging geozone does. The 25-minute difference is almost certainly due to time spent in the terminal.
- The PMV Deltaport Roadway geozone includes the entire causeway, while the Transport Canada Deltaport 3 In Staging area includes only a portion.
- The Transport Canada Vanterm In Primary geozone may include small portions of the Vanterm terminal area or the Clark Street off-ramp that the PMV Vanterm staging geozones do not.
- The Transport Canada Vanterm In Staging 1 area includes only part of the PMV Victoria–Clark roadway zone.

6 — PMV Vessel Performance

PMV also provided a report on marine vessel on-time performance (Exhibit 23). The data include the vessels' scheduled and actual arrival times at Centerm, Deltaport, Vanterm, and FSD from January through September 2012.

File Format

Data were provided on a Microsoft Excel spreadsheet. They include the shipping line, vessel name, planned arrival time, actual arrival time and departure time.

7 — PMV Terminal Daily Transaction Reports

PMV provided a summary of daily gate moves from June 1 through October 15 for Centerm, Deltaport, and Vanterm. The data (Exhibit 24) display the number of imports, exports, day gates, night gates and the total moves.

File Format

The column labels include day, date, threshold, forecast, day gate, night gate, and actual day and night.

Exhibit 23: Sample PMV Vessel Schedule File Structure

Fiscal	Service Abbr	Shipping Line	Vessel Name	Plan Arrival	Call Arrival	Call Departure (Actual Berth Departure)	Terminal
Jan-12	PS1	APL LOGISTICS	APL COMMODORE	18.01.12 16:30	23.01.12 2:36	26.01.12 18:23	Centerm
Jan-12	TP9	MAERSK LOGISTICS CANADA INC	MAERSK SENANG	1.1.12 16:30	1.5.12 7:34	07.01.12 9:42	Deltaport
Jan-12	UAM	EVERGREEN SHIPPING AGENCY (AMERICA) CORP	EVER UNICORN	15.01.12 1:00	1.13.12 19:04	16.01.12 6:48	Deltaport

Exhibit 24: Sample PMV Gate Data File Structure

Day	Date	Threshold	Forecast	Export	Empty		Import	Other	Day	Day	Night Gate	Actual
				Out	In	Out	In		Total	Gate	Total	Day & Night
Fri	01. Jun	900	423	228	4	106	359	3	700	700	0	700
Sat	02. Jun	900	0	0	11	0	157	0	166	**166**	0	166
Sun	03. Jun	900	0	0	19	0	78	–	97	**97**	0	97

8 — PMV Rail Crossing Data

Through PMV, the railroads provided the road blockage availability percentages for each day from August 19 to September 30, 2012 for both morning (7:00 a.m. to noon) and afternoon (noon to 5:00 p.m.) (Exhibit 25). The percentages show how often the roads were available, i.e., not blocked by railroad crossings.

File Format

Exhibit 25: Sample Railroad Availability File Structure

Date	Availability (%)	
	7 AM—12 PM	12 PM–5 PM
Sunday, August 19, 2012	84%	63%
Monday, August 20, 2012	76%	73%
Tuesday, August 21, 2012	71%	74%

9 — Gate Camera Data

On September 28, Tioga downloaded webcam photos from the PMV website every half hour from 5:00 a.m. to 1:00 p.m. PST. The photos were of the following areas: Centerm In Gate, Centerm Pre-In Gate, and Ballantyne Staging.

On October 16, Tioga downloaded webcam photos (examples in Exhibit 26) of every geozone at every half hour of the day from 7:00 a.m. to 2:00 p.m. PST.

Exhibit 26: Gate Camera Examples

APPENDIX B APPOINTMENT PUNCTUALITY IMPACT ANALYSIS

The Centerm data included the appointment time for each transaction. Exhibit 27 compares the appointment time with the arrival time as indicated by the security Preswipe and the gate Mainswipe. In August–September 2012, 67% of the trucks arrived at the Preswipe within the two-hour appointment window. About 23% were earlier and the rest were later. At the Mainswipe (gate), 66% were within the two-hour window. About 34% were later and the rest still earlier.

Exhibit 28 shows the relationship between appointment punctuality at the Preswipe and turn time (staging plus terminal time). As the shape of the scatter diagram suggests (and the trend line confirms), trucks that arrived earlier tended to get through somewhat more quickly. Driver experience may thus be an incentive to arrive early for appointments.

Exhibit 27: Centerm Arrivals at Preswipe (Security) and Mainswipe (Gate), Aug–Sep 2012

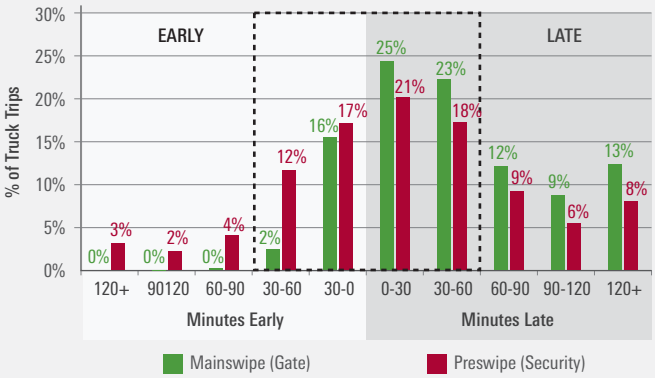
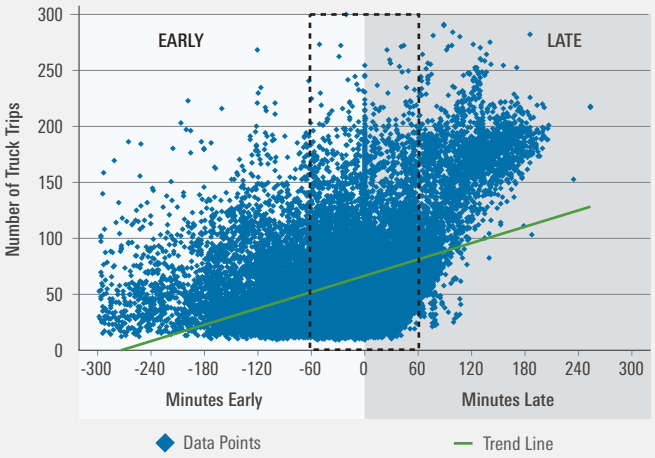


Exhibit 28: Centerm Appointment Punctuality at Preswipe vs. Turn Time, Aug–Sep 2012



APPENDIX C TRUCK VOLUME IMPACT ANALYSIS

The PMV GPS data suggest that truck volume alone has relatively little impact on terminal times. Exhibits 29 through 31 below show considerable variability in daily volume and daily average terminal times in June through September 2012. There is, however, no clear relationship in the data. The lack of impact suggests that the reservation system has been effective in rationing or metering terminal access and preventing truck congestion in the terminals.

As discussed in a following section, however, truck volume and truck volume peaking can have an impact on staging time.

Exhibit 29: DPW Truck Terminal Time vs. Truck Volume

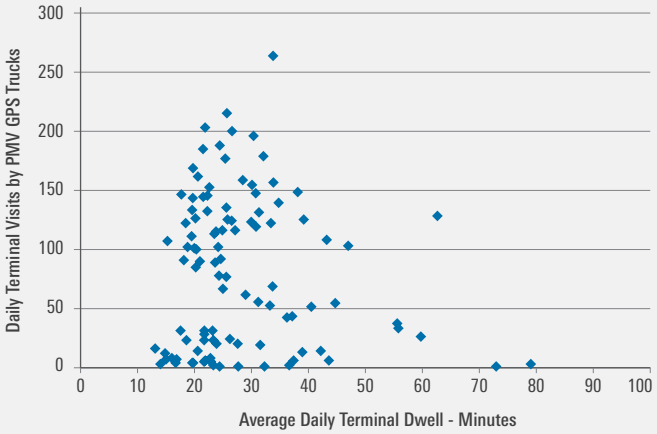


Exhibit 30: Deltaport Truck Terminal Time vs. Truck Volume

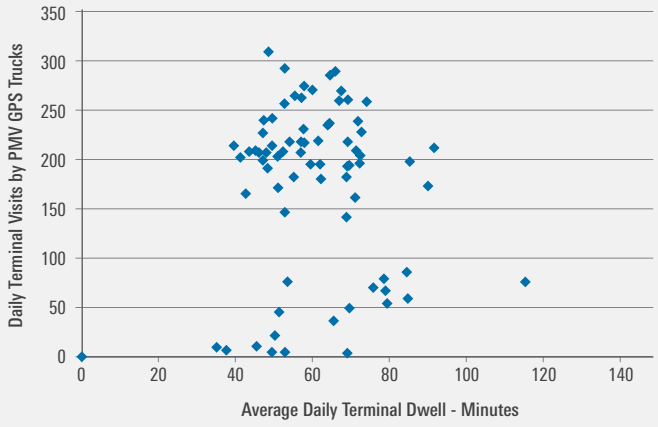


Exhibit 31: Vanterm Truck Terminal Time vs. Truck Volume

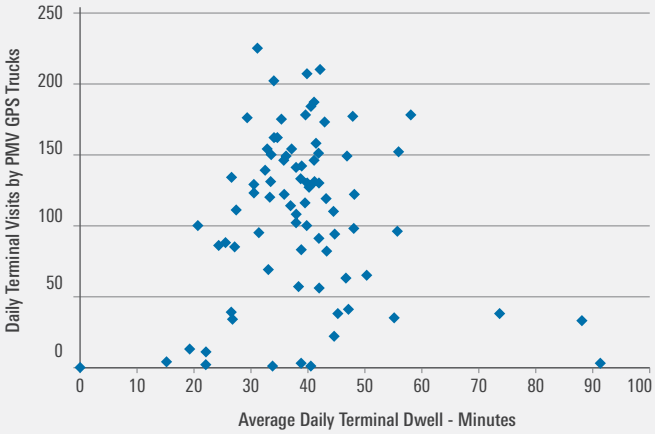


Exhibit 32 compares the total day shift gate volume at Vanterm (all trucks, not just GPS trucks) with the average terminal time reported in the PMV GPS data. There is no clear pattern, although variability in both was reduced in August and September compared to June and July.

Exhibit 33 provides a scatter diagram with a linear trend line. The trend line is flat, confirming that any relationship between day gate volume and average terminal time is slight.

Exhibit 32: Vanterm Gate Volume and Terminal Time History

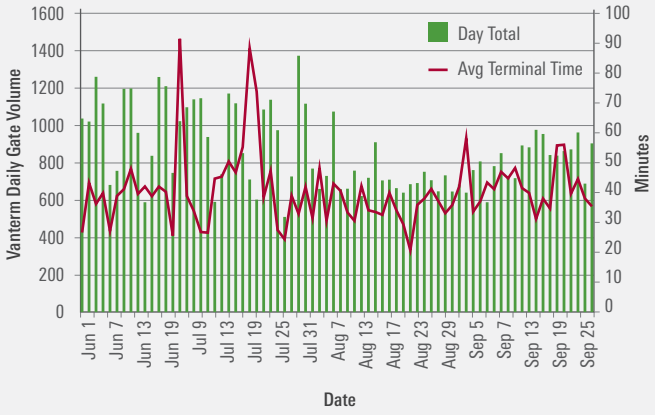
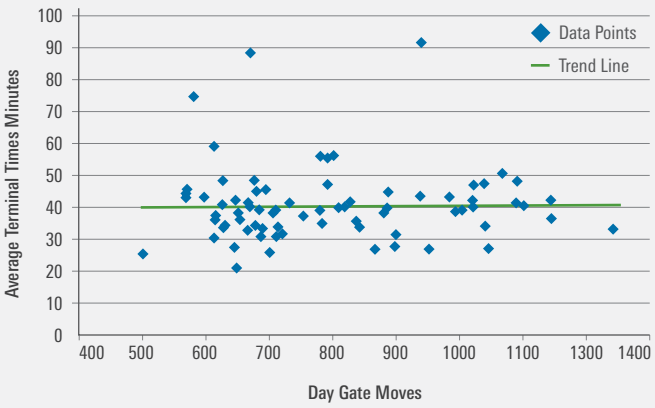


Exhibit 33: Vanterm Terminal Time vs. Day Gate Volume



APPENDIX D SPEED GATE IMPACT ANALYSIS

"Speed gates" are special, simplified transactions set up to handle large volumes of containers for single customer-voyage combinations. Some major importers use speed gates to retrieve containers from a single vessel call quickly, while transloaders use them to dray multiple export containers quickly for the same outbound voyage.

Speed gates are understood by all parties to result in faster terminal times, and should bring down average times where they are heavily used. However, the study team was unable to obtain data on speed gates separately from other transactions.

Centerm has used relatively few speed gates, averaging only about 4% of the day shift volume (Exhibit 34).

Exhibit 34: Centerm Speed Gate Shares

June	July	August	September
6%	4%	4%	3%

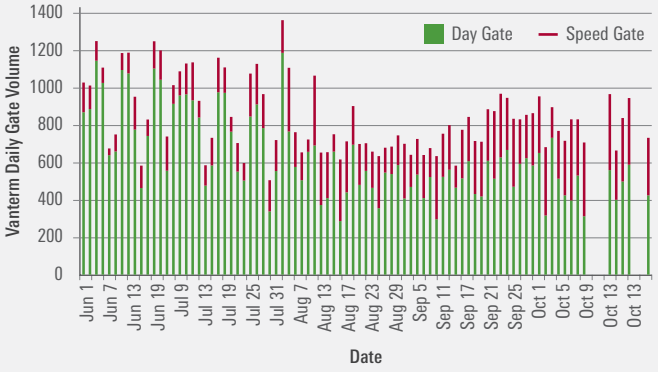
As Exhibit 35 shows, TSI greatly increased the use of speed gates at Vanterm in August and September of 2012. The limited data available do suggest that this action helped reduce and stabilize terminal times compared to previous months with fewer speed gate transactions.

Exhibit 35: Vanterm Speed Gate Shares

June	July	August	September
15%	17%	29%	34%

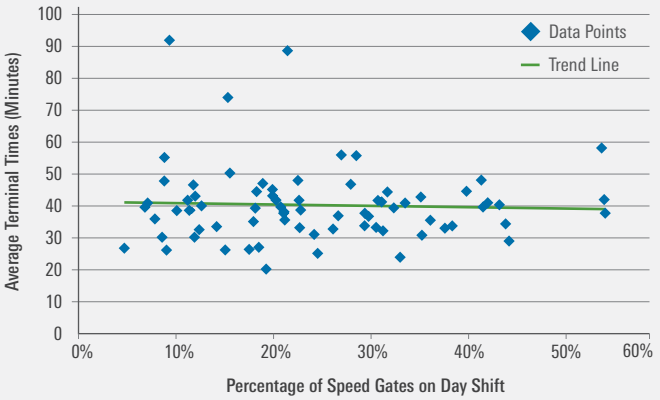
Before-and-after comparisons in Exhibit 36 suggest that the increased use of speed gates may have been part of a multi-step strategy that reduced and stabilized terminal times at Vanterm.

Exhibit 36: Vanterm Day Gates and Speed Gates, Jun–Sep 2012



In Exhibit 37, however, the greater use of speed gates by itself seems to have had relatively little impact on overall average terminal time. It appears, then, that speed gates are helpful in reducing or at least stabilizing terminal times, but that to be most effective, their use must be part of an overall strategy.

Exhibit 37: Vanterm Speed Gate Use vs. Terminal Time



APPENDIX E VESSEL ACTIVITY AT THE TERMINALS ANALYSIS

The association of long truck terminal times and vessel activity is clear. This association has been mentioned in every stakeholder contact.

As Exhibit 38 shows, long terminal times are more likely at Centerm later in the week, when vessel schedules overlap and late vessels are likely to complicate the terminal workload. At Vanterm (Exhibit 39), schedules tend to overlap earlier in the week, and long terminal times are more common then. At Deltaport (Exhibit 40), long terminal/staging times are spread throughout the week but peak on Thursday and Friday, when all three berths can be working scheduled or late vessels.

Exhibit 38: Centerm Long Turn Times by Day of Week

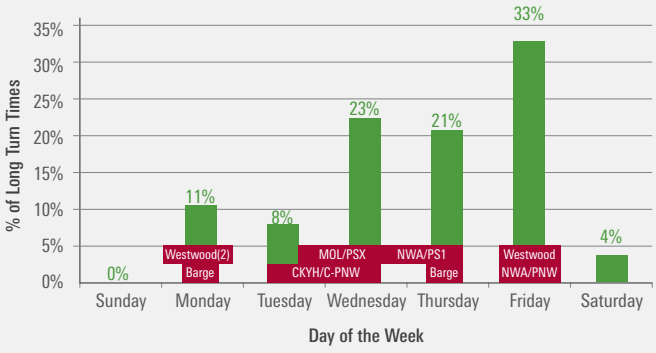


Exhibit 39: Vanterm Long Turn Times by Day of Week

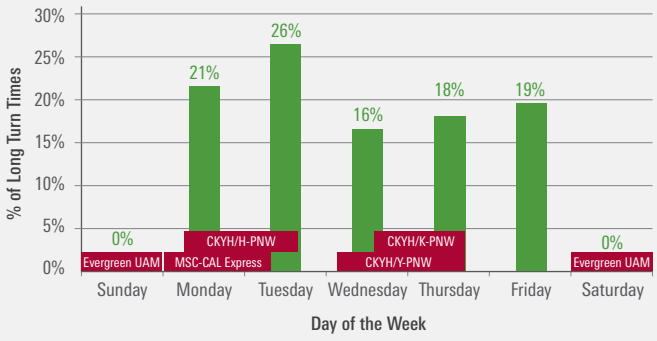
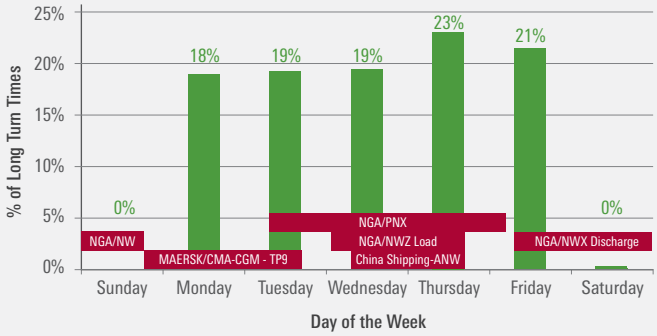
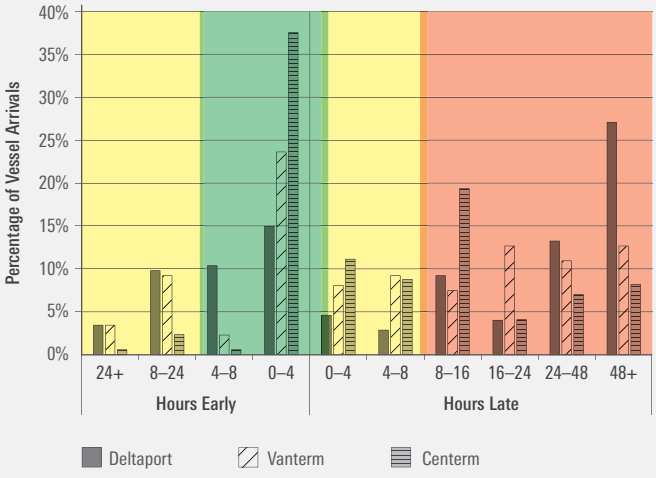


Exhibit 40: Deltaport Long Turn Times by Day of Week



As Exhibit 41 shows, it is very common for vessels to be late. At Centerm, 39% of the vessels were more than eight hours late (the red zone in Exhibit 41). About 44% of Vanterm vessel arrivals and 54% of Deltaport vessel arrivals were more than eight hours late. Depending on the timing, vessels a few hours late (the late yellow zone in Exhibit 41) may actually be worked a day late. A terminal will avoid incurring the expense of a full shift for two or more vessel gangs if the late vessel can only be worked for half a shift or less, so the vessel will not be worked until the following day. Vessels arriving more than a day early are rare (1% at Centerm, 3% at Vanterm and Deltaport), but can cause problems when the terminal is pressured to work them early as well.

Exhibit 41: On-time Vessel Performance



Unreliable vessel arrival times are a problem that is common to most North American ports with multiple vessel services. Vessel schedule reliability reportedly declined during the trade slump due to slow-steaming and multiple complex vessel-sharing agreements, and remains low. Vessel reliability problems, however, can have greater impact at terminals operating close to or above their single-shift capacity, which is the case at PMV.

With more extensive information for Centerm, the study team was able to correlate the average terminal time for August–September 2012 with the number of vessels being handled, the number of vessel gangs working, the vessel throughput, and the number of day gate truck transactions. As Exhibit 42 shows, the terminal times average correlated about equally well with the number of vessels, gangs and vessel moves. That should be expected, because as Exhibit 42 also shows, those three measures correlate closely with one another.

Finally, Exhibit 42 shows that the number of day gate truck transactions does not correlate with average terminal time. This last observation is significant, as it suggests that the longer terminal times are not due to trucks congesting the terminals. It also suggests that the appointment system is effective in controlling the flow of trucks and preventing truck congestion in the terminal. This finding may also reflect proactive terminal management practices: both Vanterm and Centerm report occasionally holding trucks in staging (outside the gates) when the terminal itself approaches congestion.

Exhibit 42: Centerm Data Correlation Factors, Aug–Sep 2012

	Terminal Minutes	# of Vessels	# of Gangs	Throughput Moves	Day Gate
Terminal Minutes	1.00	–	–	–	–
# of Vessels	0.45	1.00	–	–	–
# of Gangs	0.40	0.94	1.00	–	–
Throughput Moves	0.36	0.62	0.73	1.00	–
Day Gate	0.04	0.25	0.18	0.13	1.00

As Exhibit 43 shows, average terminal time at Centerm rises slightly—from 23 to 24 minutes—when the terminal handles a single vessel. It jumps by another nine minutes when Centerm is handling two vessels simultaneously.

Exhibit 43: Centerm Terminal Times & Vessels

23min	24min	33min
by 0 Vessels	by 1 Vessel	by 2 Vessels

Exhibit 44 shows the same data presented in terms of the probability of a 60+ minute terminal time. The probability is 4% when no vessel is being handled.

Exhibit 44: Centerm Long Terminal Times & Vessels

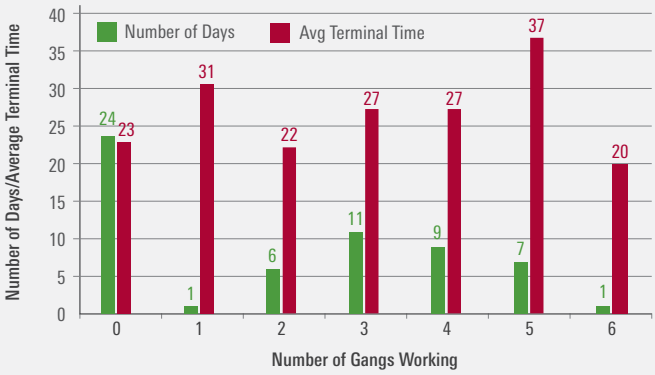
4%	6%	13%
by 0 Vessels	by 1 Vessel	by 2 Vessels

As suggested above, this 4% average indicate process exceptions—that is, "broken" transactions—independent of terminal activity. The average rises to 6% when one vessel is being handled, but more than doubles to 13% when two are being worked.

Exhibit 45 shows a related analysis for the number of vessel gangs working (not including longshore clerks and others working the gates or yard).

The green columns show the number of days with 0–6 vessel gangs working. There was only one day with one gang and one day with six gangs, so those data are probably less reliable.

Exhibit 45: Centerm Terminal Times & Gangs Working *(Number of Days & Avg. Terminal Times by Number of Gangs Working)*

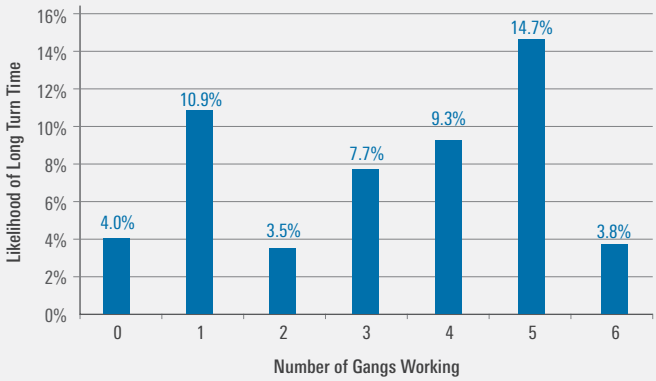


The red columns show the average terminal times on those days. The average is essentially the same when two vessel gangs are working as when more are working. This observation corresponds to the lack of terminal time difference between no vessel and one vessel in Exhibit 45.
The average jumps by five minutes when either three or four vessel gangs are working, corresponding to having two vessels active at the terminal. The average jumps again to 37 minutes (14 minutes over the no-vessel/one-vessel norm), when five vessel gangs are working.

This difference suggests that five gangs are typical of extra-busy days when large vessel discharges and loads are being handled or when extra labour is called to expedite the handling of a late vessel.

Exhibit 46 shows the same data in terms of the likelihood of a 60+ minute terminal time. The odds of taking longer than 60 minutes at the terminal are about 4% with either no vessel gangs or two gangs, suggesting that the terminal can comfortably handle one vessel with two gangs without affecting truck terminal times. The odds of a long terminal time increase substantially when three or four vessel gangs are working, and even more when five gangs are working.

Exhibit 46: Centerm Long Terminal Times and Gangs Working



As expected, the odds of long terminal times also rise with the number of vessel container moves being made during the day, peaking when throughput moves range from 1,500–2,000. (The drop for 2,000–2,500 moves may not be representative, as there were few days when the terminal reached those volumes.)

Exhibit 47: Centerm Vessel Moves and Long Terminal Times

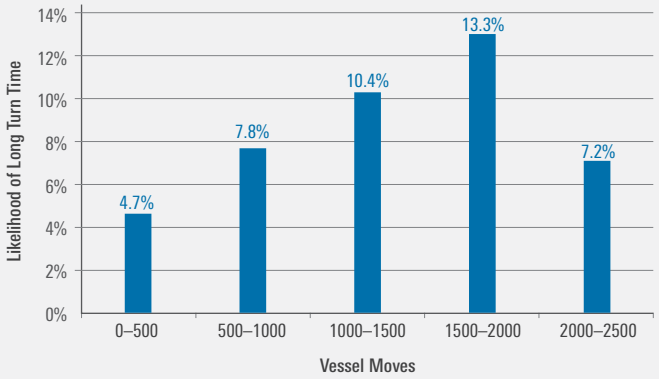
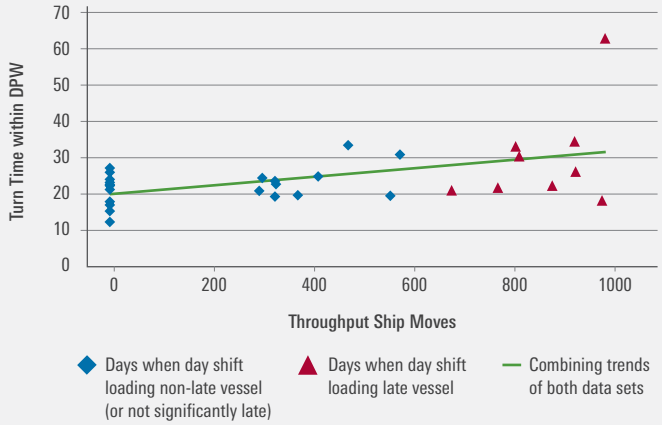


Exhibit 48 shows that, at least at Centerm, late vessels are associated with heavier terminal workloads (in terms of container moves off and on the vessel) and longer average truck turn times. As Exhibit 48 also suggests, however, late vessels and high throughput volumes do not inevitably result in longer turn times. On four occasions in August 2012, Centerm was able to keep average truck terminal times close to 20 minutes while working a late vessel.

Exhibit 48: Centerm Ship Moves & Terminal Times



APPENDIX F MORNING AND LUNCH BREAK IMPACT ANALYSIS

The dynamics of truck and terminal interactions at morning gate opening and lunch-time breaks lead to a higher percentage of combined staging and terminal times longer than 60 minutes. As Exhibit 49 through 51 show, terminal times over 60 minutes are concentrated at specific times of the day at all three terminals. In all three cases, the largest share of long in-terminal dwell times are incurred by trucks that enter between 11:00 a.m. and 12:00 noon. As further analysis reveals, some of these trucks remain in the terminal through the 12:00–12:30 p.m. lunch break. The other concentration of long terminal times occurs when trucks enter right after the gates open at 7 a.m.

Exhibit 49: Long Centerm Terminal Times by Time of Day

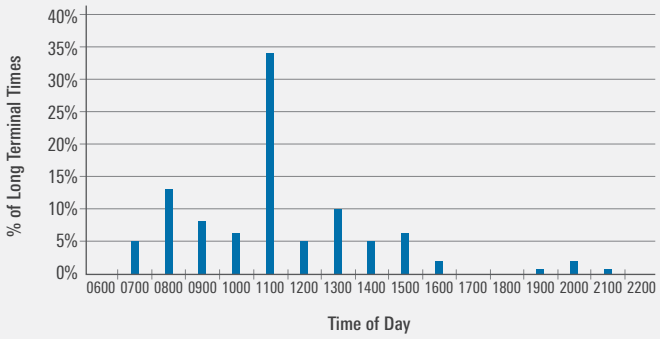


Exhibit 50: Long Vanterm Terminal Times by Time of Day

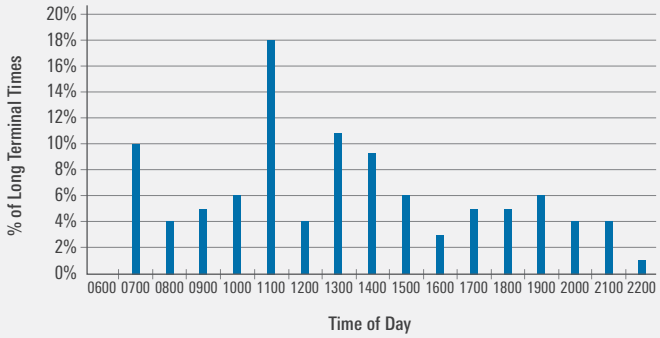
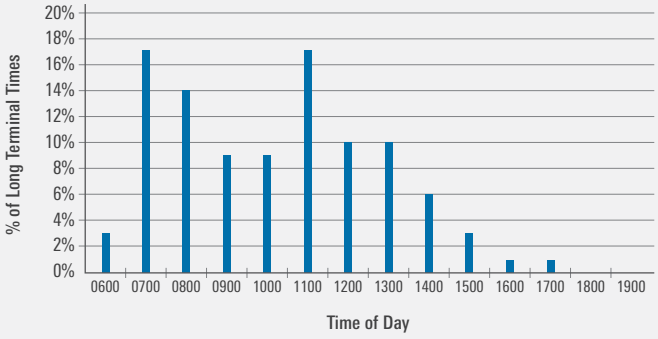


Exhibit 51: Long Deltaport Terminal Times by Time of Day



Morning Queuing and Start-up

Exhibit 52 shows average Centerm truck arrivals and gate entrances during the morning hours. Trucks begin arriving and joining the entrance gate queue at 6:30 a.m. for the 7:00 a.m. opening. Some of these drivers have accepted 30-minute staging times to get the earliest possible start. Gate acceptance starts at about 7:00 a.m. and begins to reduce the queue. The rate of entrances increases between about 7:20 a.m. and 8:00 a.m. as all the gates are opened and reach full functionality. After about 7:35 a.m., gate entrance flows tend to match truck arrival flows.

Exhibit 54 displays the entrance and exit gate activity at Centerm. The initial gate exits begin at about 7:20–7:30 a.m., about 20–30 minutes after the gates open. The rate of gate exits increases roughly parallel to the entrances until both level off around 8:20 a.m.

The data for Vanterm (Exhibit 54) show a similar pattern, with admission to the terminal starting at 7:00 a.m. and gradually meeting the demand for processing inbound trucks.

Exhibit 52: Centerm Morning Arrivals

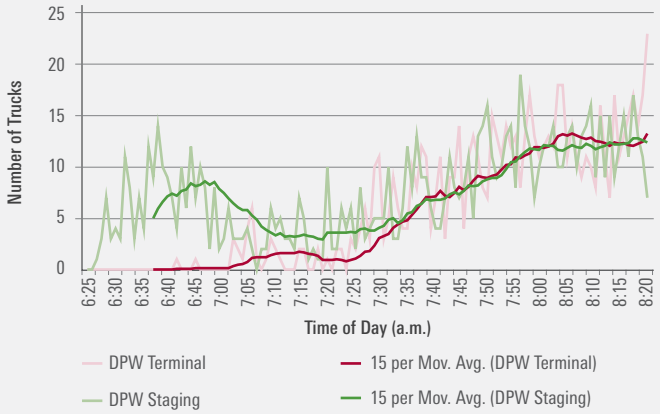


Exhibit 53: Centerm Morning Gates

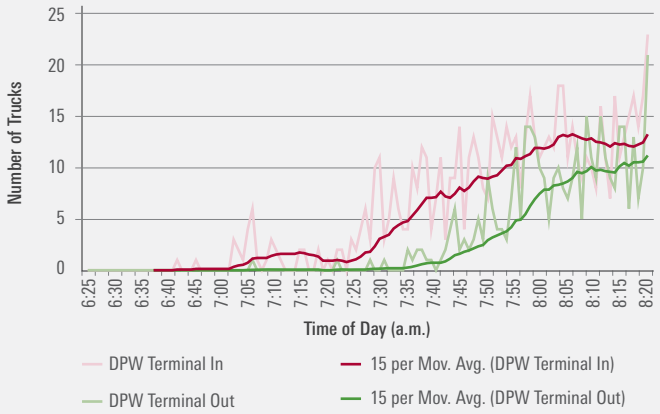
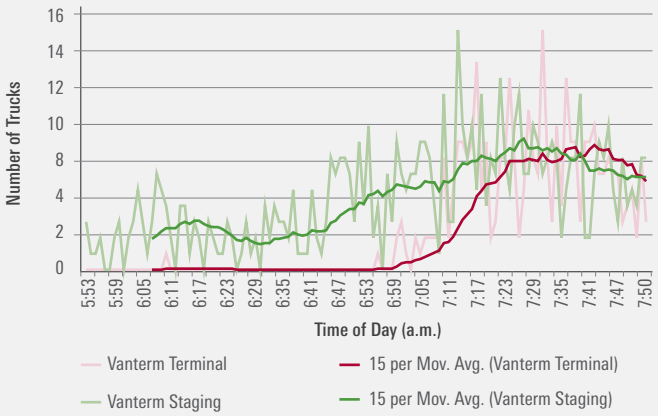
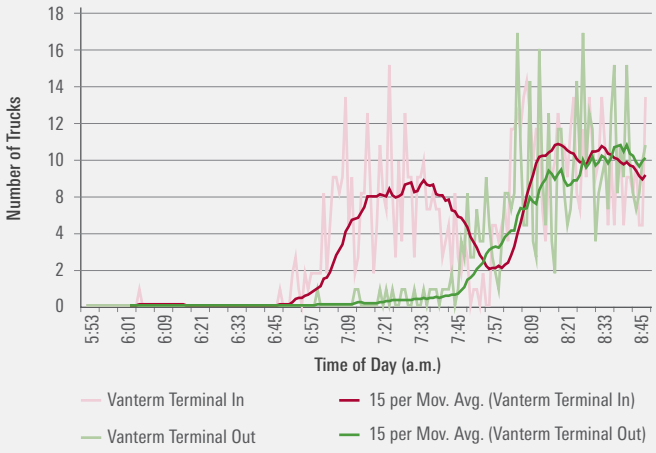


Exhibit 54: Vanterm Morning Arrivals



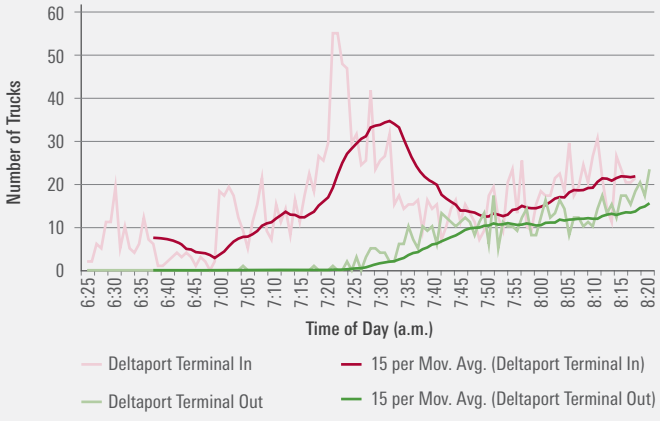
As shown in Exhibit 55, In-gate transactions at Vanterm tend to drop off after the first rush is over, and then pick up again after 8:00 a.m. In parallel, the terminal is processing and releasing the trucks that entered in the first rush.

Exhibit 55: Vanterm Morning Gates



There are no separate GPS staging data for Deltaport, so Exhibit 56 effectively combines arrival and processing trends. The morning inbound rush peaks at about 7:30 a.m., just as the first outbound trucks are exiting the terminal.

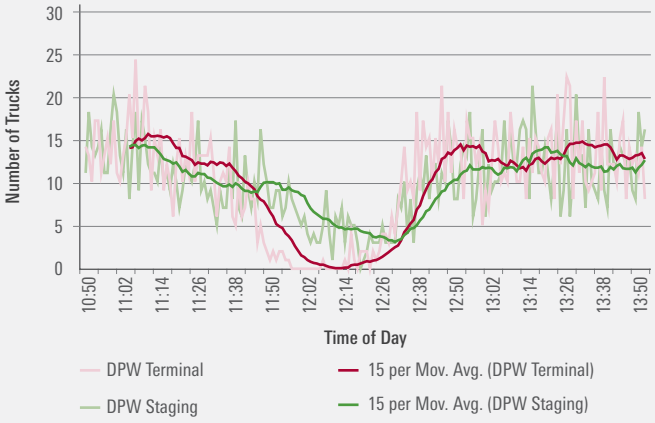
Exhibit 56: Deltaport Morning Gates



Lunch-time Staging and Entrances

Exhibit 57 shows the pattern of lunch-time staging arrivals and terminal gate entrances at Centerm. Both arrivals and entrances decline after about 11:00 a.m. Gate entrances drop off quickly starting between 11:40 and 11:45 a.m., before the scheduled lunch-time gate closure at noon. It is not possible to tell from the GPS data whether some gates are actually closed before noon, or if their processing rate slows. In either case, the entrances drop to zero by 12:09. Trucks continue to arrive so the staging area queue builds up during the lunch break. (The data show some truckers entering between 12:15 and 12:30 p.m. The Centerm terminal geozone, however, includes a small area outside the final entrance pedestals. See Exhibit 6. These data may reflect trucks moving up to these pedestals but not actually entering the terminal.)

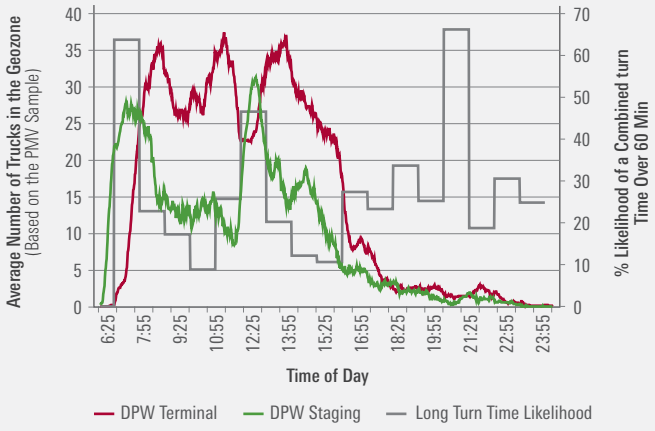
Exhibit 57: Centerm Lunch-time Arrivals



Gate entrances resume between 12:30 and 12:35 p.m., and the staging queue starts to decline. The rate of gate entrances increases until about 12:45 p.m., when it reaches approximately the same level as before the lunch break. As Exhibit 53 suggests, it takes the terminal gates and container yard 15–20 minutes after opening to reach full production. As Exhibit 57 likewise suggests, it also takes the terminal about 15 minutes before lunch to slow down and another 15 minutes after lunch to regain full productivity.

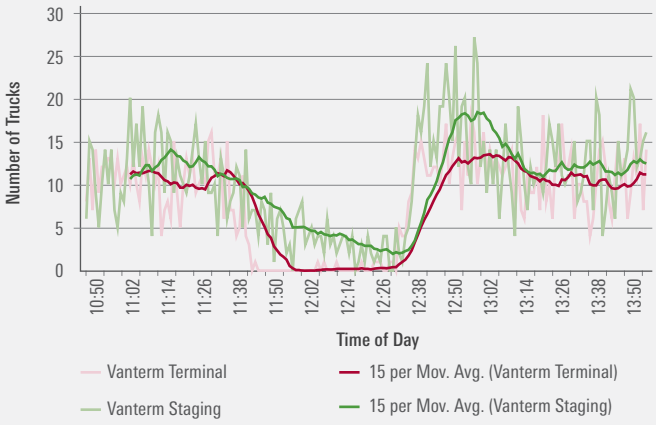
Exhibit 58 combines these data to show the relationship between the number of trucks in staging, the number of trucks in the terminal, and the likelihood of long turn times. These PMV GPS data have been roughly "normalized" to estimate the actual number of GPS and non-GPS trucks involved.

Exhibit 58: Centerm Occupancy & Long Turn Times



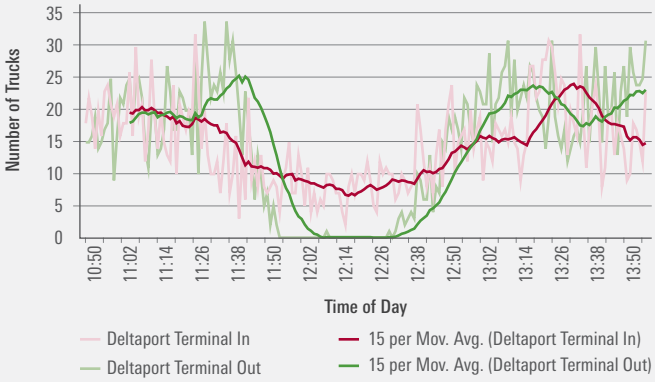
- As the green line on Exhibit 58 shows, the queue in Centerm staging builds up starting at about 6:30 a.m. and peaks at about 25 trucks between 7:30 and 8:00 a.m. As these trucks are processed, the staging queue drops to an average of between 10 and 15 trucks from 8:30 to 11:30 a.m., and declines to about seven or eight trucks by 11:55 a.m. The queue builds again until about 12:40 p.m., when the gates have been reopened and are reducing the backlog. The staging queue declines, but rises slightly at the 2:00 p.m. coffee break. After that, the staging queue drops to less than five trucks on average.
- The number of trucks in the terminal (red line) rises to an average of about 36 after the gates open, then declines to about 26 as that first wave is processed and exits. There is a small uptick associated with the 10:00 a.m. coffee break. The number in the terminal then builds to a peak backlog of about 37 trucks by 11:20 a.m. As these trucks are processed and exit, the number declines to an average of about 23 trucks that remain unprocessed in the terminal between 12:00 p.m. and 12:30 p.m. Centerm has an automated exit gate, so these trucks could have exited if they had finished their transactions. The on-terminal backlog rises to about 37 again as the staging queue is processed through the gates. The backlog declines until the terminal closes.
- The black lines on Exhibit 58 show the impact on turn time. About 67% of the trucks that enter staging before the gates open have long (60 minutes or more) turn times. The odds of a long turn time drop to a low of about 8% for trucks that arrive between 10:00 and 11:00 a.m. About 46% of the trucks that arrive around the lunch break have long turn times, and then the likelihood drops again. Long turn times are very likely during the evening shift "lunch," but since Centerm runs few evening shifts, the data support for that observation is weaker.

Exhibit 59: Vanterm Lunch-time Arrivals



Vanterm has a roughly similar pattern, with terminal entrances dropping off after about 11:30 a.m. before the official gate closure from 12:00 to 12:30 p.m. Both staging entrances and gate entrances pick up after 12:30 p.m. As shown in Exhibit 60, trucks that arrive before the gates open are very likely to experience turn times over 60 minutes because: 1) They have chosen to incur substantial waiting time to get into the terminal as soon as possible; and 2) The terminal is not operating at full efficiency until 30 to 40 minutes after the gates first open. Lunch-time closure and slower processing before 12:00 noon and after 12:30 p.m. also makes it very likely (83 %) that trucks will have long turn times during that period. Finally, there is a high probability of long turn times during the evening shift "lunch" break. This result is more significant at Vanterm because Vanterm does frequently schedule night shifts. The analysis for Deltaport (Exhibit 61) is different because the staging and terminal data are combined there.

Exhibit 61: Deltaport Lunch-time Arrivals



The basic occupancy pattern is again similar (Exhibit 62), with a high likelihood of long turn times in the early morning and at lunch. The evening "lunch" does not result in long turn times as frequently at Deltaport as it does at Vanterm.

Exhibit 60: Vanterm Occupancy & Long Turn Times

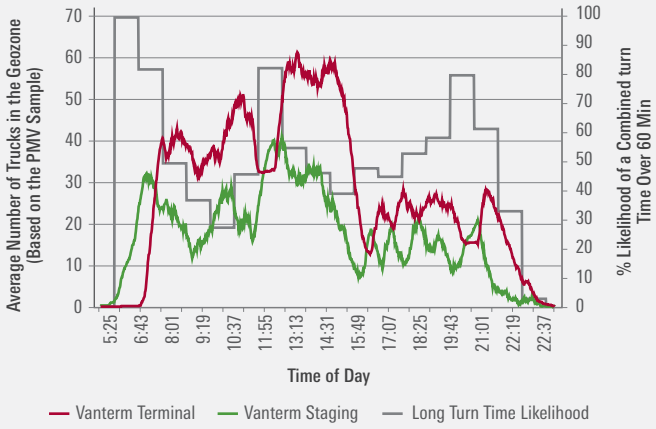
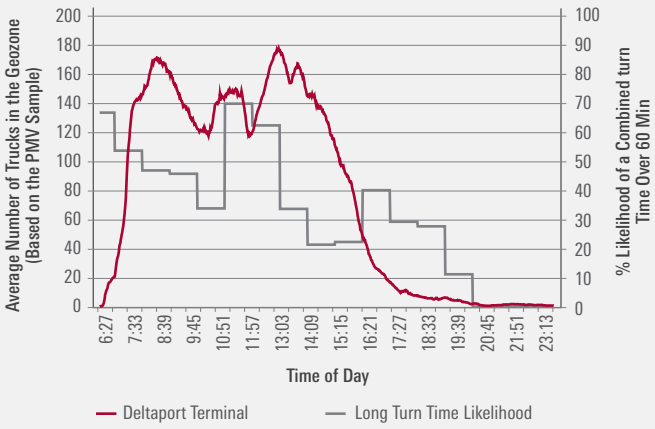


Exhibit 62: Deltaport Occupancy & Long Turn Times



APPENDIX G SOUTH SHORE ROADWAY TIMES ANALYSIS

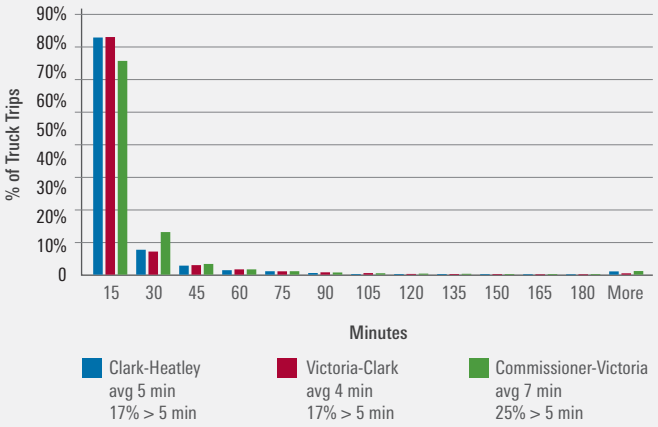
The analysis of roadway travel times initially focussed on the South Shore road and terminal complex. The issues there are more complex and the impacts more significant than on the Deltaport approach road. The South Shore roadway is divided into three geozones:

- The *Commissioner–Victoria geozone* stretches from the intersection of Commission and McGill past the port complex entry gate (also called the McGill gate) opposite the foot of N. Renfrew Street to the foot of Victoria Drive (now blocked off). This geozone covers about two kilometres (1.23 miles). It includes access to the Columbia and Marco container storage depots as well as the staging areas being developed by PMV along Commission Street. This road segment is crossed by active railway tracks in two places.
- The *Victoria–Clark geozone* starts at the foot of Victoria Street and follows Stewart Street to the intersection of Centennial Road and Clark. Clark was formerly the main entrance and exit route for Centerm and Vanterm, but is now an exit only for trucks. The Victoria–Clark geozone is crossed by multiple active railway tracks leading to industrial customers on the north side of Stewart Street. This section of roadway is about 0.76 kilometres (0.47 miles).
- The *third roadway zone, Clark–Heatley,* extends along Centennial Road from Clark to Heatley, about one kilometre or 0.64 miles. This geozone covers the entrances to Vanterm and Centerm and, like the Victoria–Clark segment, is crossed by multiple railway tracks.

Trucks are allowed to enter the system only from the east end through the gate on Commissioner Street. They can exit at Clark or at Commissioner.

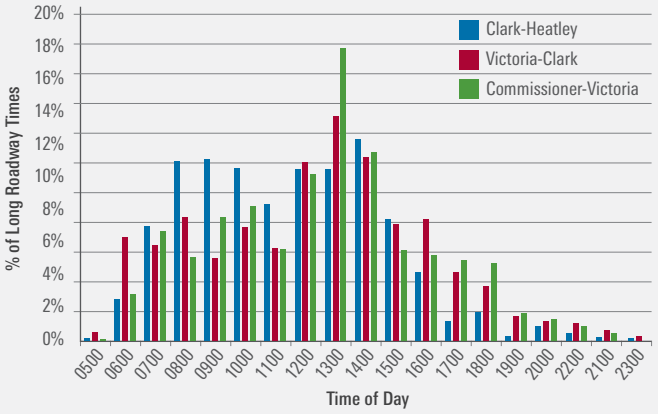
As Exhibit 63 shows, more than 90% of the transit times on each roadway segment are less than 10 minutes, and most transit times are less than five.

Exhibit 63: Roadway Times—PMV GPS Data



When longer transit times do occur, they tend to be in mid-afternoon, as shown in Exhibit 64.

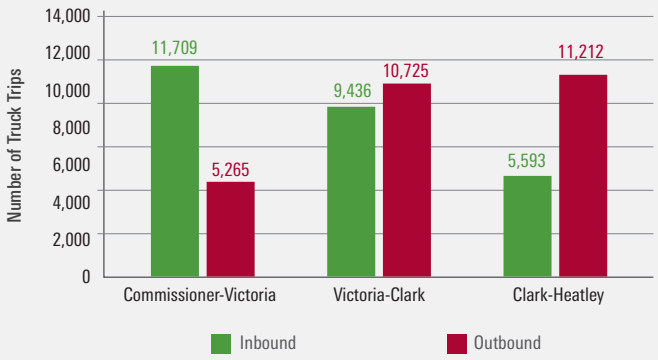
Exhibit 64: Long Roadway Times by Time of Day



The restrictions on entry and exit lead to imbalanced truck flows on the roadway segments (Exhibit 65).

- Inbound data suggest that about 20% of the trucks that enter at Commissioner–Victoria stay on that segment then leave.
- About 81% of inbound trucks pass through Victoria–Clark, and 48% make it to Clark–Heatley.
- Outbound data suggest that about 26% of the trucks that reach Vanterm or Centerm leave via Commissioner–Victoria, the rest via Clark.

Exhibit 65: Roadway Segment Trip Balance



The fact that 81% of inbound trucks pass through Victoria–Clark but only 48% show up in Clark-Heatley suggests that 33% are entering Vanterm without passing through the Clark–Heatley geozone.

Exhibit 66 through 68 show the inbound and outbound transit time distributions for the three roadway geozones. For all segments, delays are more common inbound than outbound

Exhibit 66: Commissioner–Victoria Transit Times

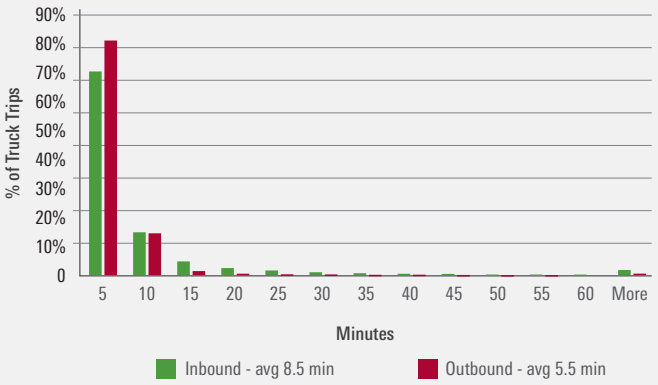


Exhibit 67: Victoria–Clark Transit Times

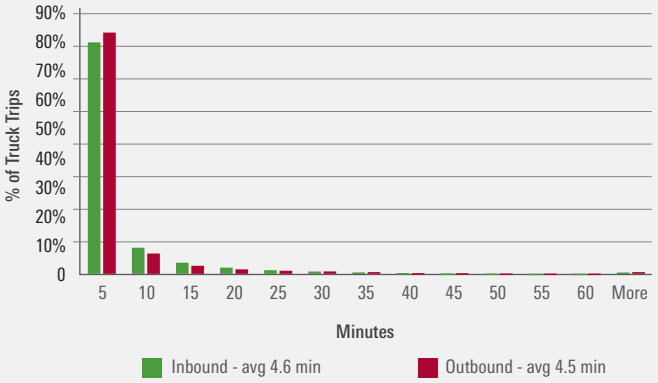
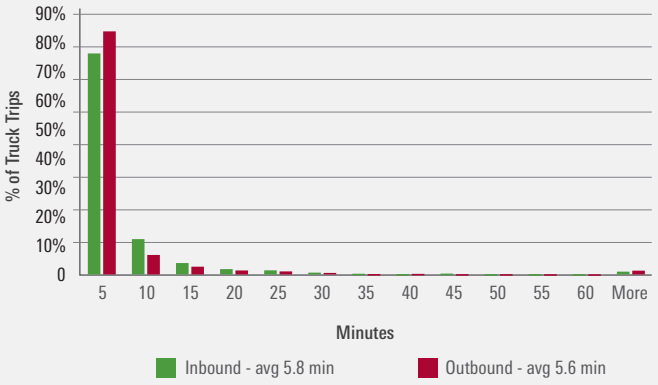


Exhibit 68: Clark–Heatley Transit Times



Inbound, the Commissioner–Victoria segment shows the most frequent delays, with 29% of inbound trips taking longer than five minutes (an average speed of less than 24 kilometres per hour). This segment also had a longer average time, but that is expected, since it is about twice as long as the other two. The more frequent inbound delays are consistent with:

- Inbound staging along the roadway when terminal queues are backed up;
- Waits for appointment windows (enforcement of appointment windows at the Commissioner gate began after these data were collected); and
- The need to travel the full length from the Commissioner gate.

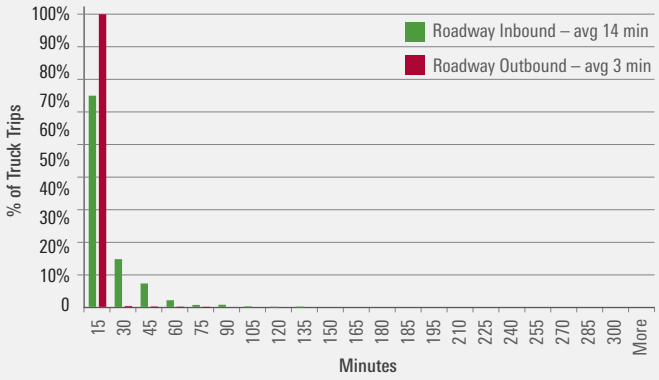
Outbound, Victoria–Clark (8%) and Clark–Heatley (8%) are more likely to have long outbound times (over 10 minutes) than Commissioner–Victoria.

The 20 % of the inbound trucks that use only the Commissioner–Victoria segment are most likely moving to and from the Marco or Columbia container depots without visiting Vanterm or Centerm.

APPENDIX H DELTAPORT ROADWAY TIMES ANALYSIS

The Deltaport roadway geozone covers the causeway (Exhibit 2). As Exhibit 69 shows, the average inbound trip takes 14 minutes while the outbound average is three minutes. The difference implies an average delay, stop or queue time of 11 minutes inbound before the truck reaches the Deltaport staging/terminal geozone.

Exhibit 69: Deltaport Roadway Time Distribution



APPENDIX I ROADWAY RAIL BLOCKAGE ANALYSIS

The relationship between roadway times and rail blockages is complex. To create exhibits 70 through 72, the study team graphed PMV data on the percentage of the day blocked or available against the percentage of trips taking more than 10 minutes.

The Commissioner–Victoria segment showed the strongest relationship, with the likelihood of a long transit increasing more rapidly as rail blockage increased. The two other segments also showed increased likelihood of long transit times with increased rail blockage (as expected), but the correlation not as strong as the Commissioner-Victoria segment (as noted by the flatter sloping trend lines).

Exhibit 70: Commissioner–Victoria Roadway Delays vs. Rail Blockage

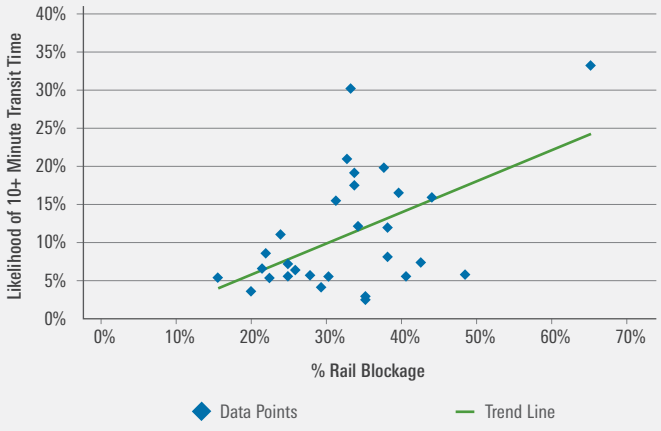


Exhibit 71: Victoria–Clark Roadway Delays vs. Rail Blockage

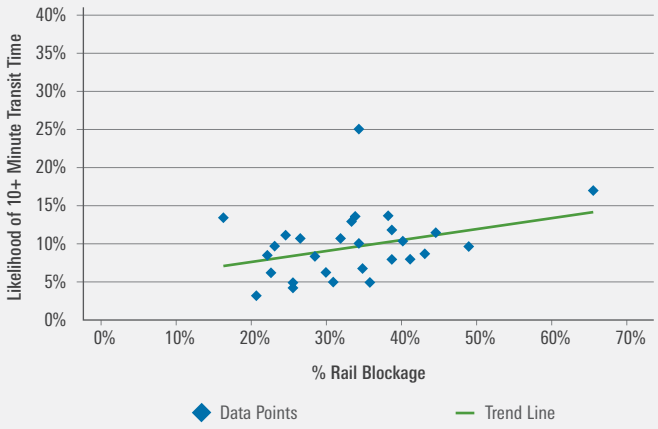
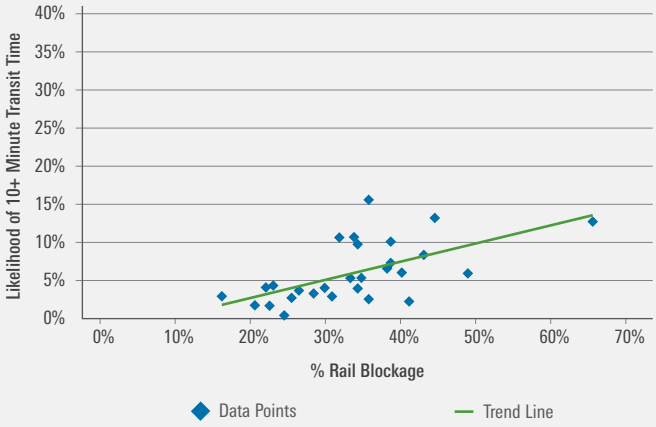
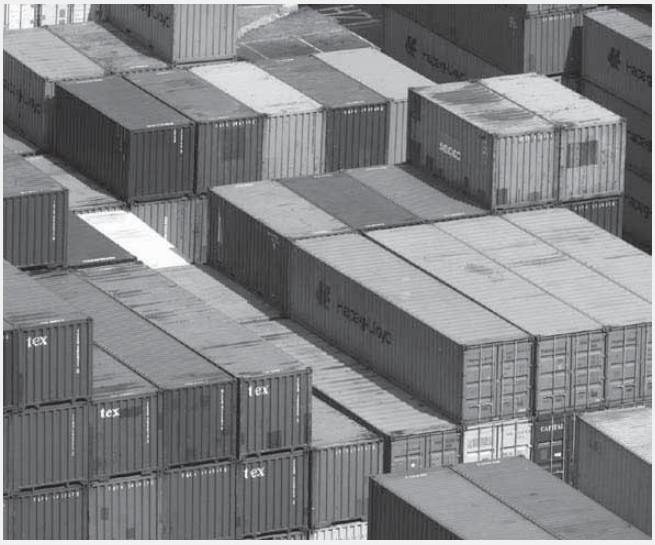


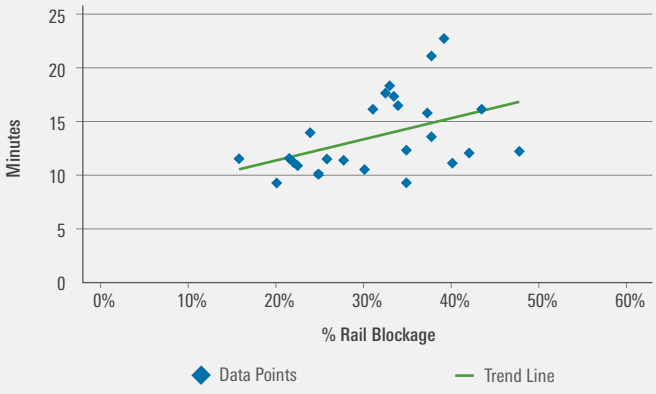
Exhibit 72: Clark–Heatley Roadway Delays vs. Rail Blockage





There is a clear relationship between the percentage of time during which the roadway is blocked and the average length of the transit time (Exhibit 73). The average blockage time is about 30% of the dayshift hours, which appears to raise the weighted average transit time to Vanterm by about three minutes and to Centerm by about seven minutes.

Exhibit 73: South Shore Roadway Time and Rail Blockage



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