Test and evaluation of Bluetooth® technology for measuring freight facility traffic flows: Bayport case study

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Test and evaluation of Bluetooth® technology for measuring freight facility traffic flows: Bayport case study

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The findings presented in this report are the opinions of the authors and do not reflect those of POHA, TXDOT, or H-GAC.

ABSTRACT

This project was a test and evaluation of *Bluetooth* technology for identifying container truck traffic at the Port of Houston Authority Bayport Container Terminal and truck utilization of roadways in the Houston area. The project demonstrated that *Bluetooth* technology can be used to collect information about vehicles calling at the Bayport terminal and other locations on roadways in the Houston MSA. The information can be compiled, ordered, and analyzed to determine traffic patterns for these vehicles and identify, based on those traffic patterns, which vehicles are likely to be container trucks. A 10 percent level of penetration of *Bluetooth* readings in the overall truck traffic flow into and out of Bayport was recorded.

1. INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION

This report presents the results of a test and evaluation of Bluetooth® technology for measuring truck traffic at the Port of Houston Authority's Bayport Container Terminal (Bayport) and on the Houston roadway network. Data were collected for this project on August 22, 2014. Bayport is one of two major container terminals operated by the Port of Houston Authority (POHA); the other is the Barbours Cut Container Terminal (Barbours Cut). Altogether, the Port of Houston, Texas, accounted for over 1.9 million 20-foot equivalent units (TEUs), corresponding to nearly 1.2 million total containers, with combined cargo weight of over 17.3 metric tons in 2013 (*1*). Port of Houston container traffic was greater than all other ports in the Gulf of Mexico region combined, in 2013.

Bayport is located off State Highway (SH) 146 near the City of Shoreacres on Galveston Bay. Barbours Cut is located off SH 146 at Morgan's Point, about 5 miles north of Bayport near the City of LaPorte on Galveston Bay. The Houston–The Woodlands–Sugarland Metropolitan Statistical Area (Houston MSA), which includes Shoreacres and LaPorte, encompasses 8,778 square miles (*2*) and has an estimated population of over 6.3 million people (*3*). The Houston MSA includes eight counties; Bayport and Barbours Cut are located in Harris County, which has the largest population of counties in the Houston MSA with over 4.3 million people (*4*).

The Houston area is bisected by two interstate highways: IH-10, which runs approximately east-west, and IH-45, which runs approximately north-south. IH-69/US 59 (US 59) runs roughly northeast-southwest. IH-10, IH-45, and US 59 intersect near Downtown Houston. There are two major roadway loops in Harris County: IH-610 and Beltway 8 (Sam Houston Tollway). North of Barbours Cut, SH 146 intersects with SH 225 before crossing the Houston Ship Channel via the Fred Hartman Bridge and then intersecting with IH-10 at Baytown. SH 225 runs parallel to the Houston Ship Channel in an east-west direction and connects with Beltway 8 and IH-610 west of SH 146. US 290 is a major arterial highway that intersects with the loop roadways on the northwest side of Harris County.

Figure 1 shows locations of Bayport and Barbours Cut relative to the Houston MSA, other freight facilities, and major roadways (including future roads). Note that the facility labeled "Union Pacific Bayport" should instead be labeled "Union Pacific Barbours Cut."

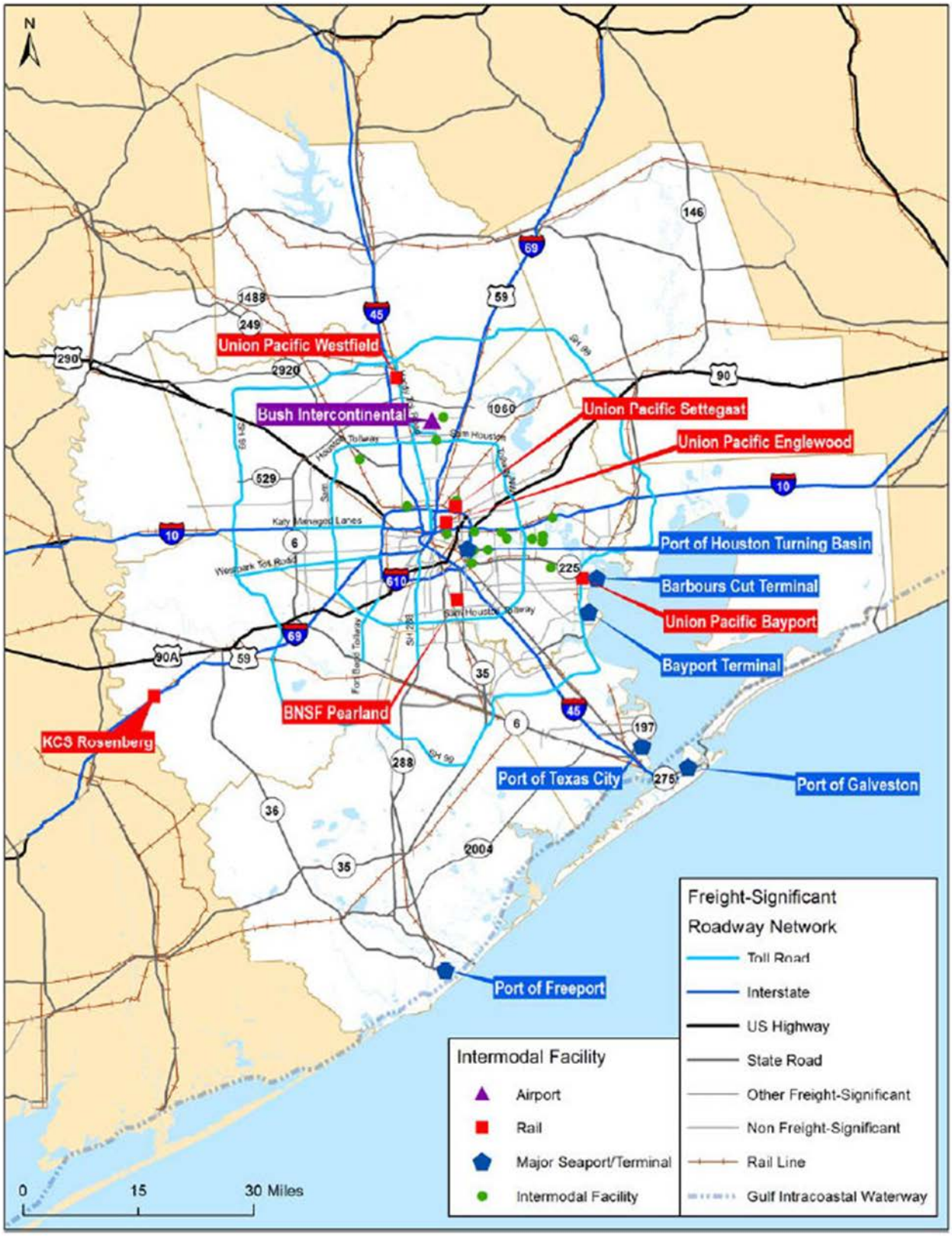

Figure 1. Freight-Significant Corridors and Facilities in Houston MSA
(Source: Cambridge Systematics Inc., as cited in H-GAC Regional Goods Movement Plan (*5*).

1.2. PROJECT OBJECTIVE AND GOALS

The primary objective of this project was to test and evaluate *Bluetooth* technology for its ability to address key uncertainties about freight facility truck traffic flows, using Bayport as a case study. There were several associated goals:

a. Determine which *Bluetooth* signals recorded at Bayport can be identified as heavy-duty container trucks;
b. Determine the percentages of heavy-duty container trucks calling at Bayport that utilize *Bluetooth*, and the percentages of associated truck trips;
c. Determine the transportation patterns of *Bluetooth*-utilizing trucks calling at Bayport on local and regional roadway networks;
d. Determine the heavy-duty truck traffic levels on SH 225 and SH 146; and
e. Using b, c, and d above, estimate the percentages of heavy-duty truck traffic on SH 225 and SH 146 that are associated with Bayport container shipments.

1.3. ORGANIZATION OF REPORT

Further sections of this report are organized as follows:

- Section 2 reviews the technologies used for the test and evaluation and their configuration for the Bayport case study.
- Section 3 reviews outcomes of the test and evaluation.
- Section 4 provides conclusions and recommendations.

2. BLUETOOTH TECHNOLOGY AND TEST CONFIGURATION

2.1. BLUETOOTH TECHNOLOGY

TTI researchers have been working with systems that utilize *Bluetooth* technology for traffic applications since 2008. According to the researchers:

> The *Bluetooth*® protocol is a widely used, open standard, wireless technology for exchanging data over short distances. The technology is frequently embedded in mobile telephones, Global Positioning Systems (GPS), computers, and in-vehicle applications such as navigation systems. Each Bluetooth device uses a unique electronic identifier known as a Media Access Control (MAC) address. Conceptually, as a *Bluetooth*-equipped device travels along a roadway, it can be anonymously detected at multiple points where the MAC address, time of detection, and location are logged (*6*).

Previous transportation applications for *Bluetooth* MAC address readings have most often been as data sources for estimating vehicle travel times between points on roadway networks to conduct origin-destination studies or intersection passage/delay studies. TTI researchers describe the requirements for this system as follows:

> Several key components are required for a system to be able to estimate vehicle travel times and speeds using *Bluetooth* devices as probes, including the following:
>
> a. A roadside system must be able to detect and process *Bluetooth* MAC addresses as the vehicle travels along the monitored roadway. Typically, a roadside system will be housed inside of a traffic equipment cabinet [or portable suitcase] in close proximity to the roadway being monitored.
> b. The system must also include a radio capable of reading the MAC address of *Bluetooth* devices. The radio can be embedded either into the Central Processing Unit (CPU) system board or in the form of an external adapter. External adapters are typically connected to a Universal Serial Bus (USB) port of the CPU processing device. The radio may also be connected to an external antenna for extending the detection range of the *Bluetooth* equipment.
> c. The detection and processing of *Bluetooth* devices take place on a field-located CPU capable of running software for detecting, processing, and forwarding *Bluetooth* device addresses and other information to a central location.
>
> Similar to other probe-based techniques for determining travel times, multiple roadside systems are necessary to provide traffic data from a roadway. Data received from multiple reader locations allow for the re-identification of MAC addresses at adjacent locations and make the subsequent estimation of elapsed travel times possible. In one model, a central software component receives and processes MAC address data from each roadside reader location. The central host software then is used to determine individual travel times and estimate average travel times over time intervals for configured roadway segments based on the given locations of the *Bluetooth* reader systems at the roadside (*6*).

Antennas help extend the functional range of *Bluetooth* readers. There are several factors that can affect the ability readers and their antennas to receive a MAC address signal from vehicles that have *Bluetooth*-enabled devices:

- Elevation of the antenna;
- Fixed barriers that shield the antenna from *Bluetooth* signal sources (e.g., concrete jersey barriers, topography, buildings, other vehicles);
- Presence of a source signal;
- Strength of the source signal, when present;
- Proximity of the source signal to other source signals; and
- Shielding of source signal on or in vehicle.

In field situations, these factors are often found in combination. For example, previous tests by TTI of *Bluetooth* readers along an interstate highway in Ohio indicated that:

> [D]eployment of the equipment on ground level resulted in fewer matches from the opposing travel lanes when they were obstructed by concrete barrier…When mounted on top of the concrete barrier, the additional height of the Bluetooth reader afforded the ability for the antenna to gather a significantly higher number of reads from the traffic flow on the travel lanes farther away from the device, even when it was separated by a median barrier. It appeared that positioning the antenna at (or near) the windshield height of typical passenger cars provided enhanced collection opportunities (*6*).

Further information about TTI's initial test and evaluation of *Bluetooth* technology for transportation applications can be found Reference No. 6 listed at the end of this report. Since then, *Bluetooth* readers have been installed by TTI, TXDOT, Harris County, and the City of Houston in the Houston MSA as well as other locations in Texas and throughout the United States. For example, there are over 600 permanent *Bluetooth* readers installed on roadways in and around Houston as of late 2014. Multiple ITS equipment vendors offer *Bluetooth* readers and software for monitoring traffic flow.

For this test, the majority of the roadside *Bluetooth* systems used were battery-powered, portable suitcase-based configurations. In several locations, permanent *Bluetooth* readers were already installed in TXDOT traffic or ITS cabinets, so those readers were utilized rather than deploying additional portable units. Each system consisted of the following equipment:

- ARM-based single board computer as the roadside processor.
- Class 1 *Bluetooth* USB adapter with external antenna.
- USB cellular modem for communications back to the data processing software.

A host software component, used for storing and processing reads from all the devices in the roadside network, was running at a central location. *Bluetooth* readers were configured to receive signals as soon as an active *Bluetooth* device was in range, and at one minute intervals thereafter to eliminate a majority of duplicate reads. Signals from *Bluetooth* devices that were within range of *Bluetooth* readers but were not discoverable would not be recorded. Upon reading a *Bluetooth*

device, the MAC address identifier of the device, location, and timestamp of the read were instantaneously sent back to the host software via the cellular modem for processing and storage (Figure 2). In more permanent deployments, the *Bluetooth* MAC addresses may be truncated and encoded to provide an enhanced layer of anonymization. Researchers used the true MAC address in this test to enable use of the highest fidelity of data possible, but are still unable to conclusively associate any individual MAC address to any particular vehicle if it is not known in advance.

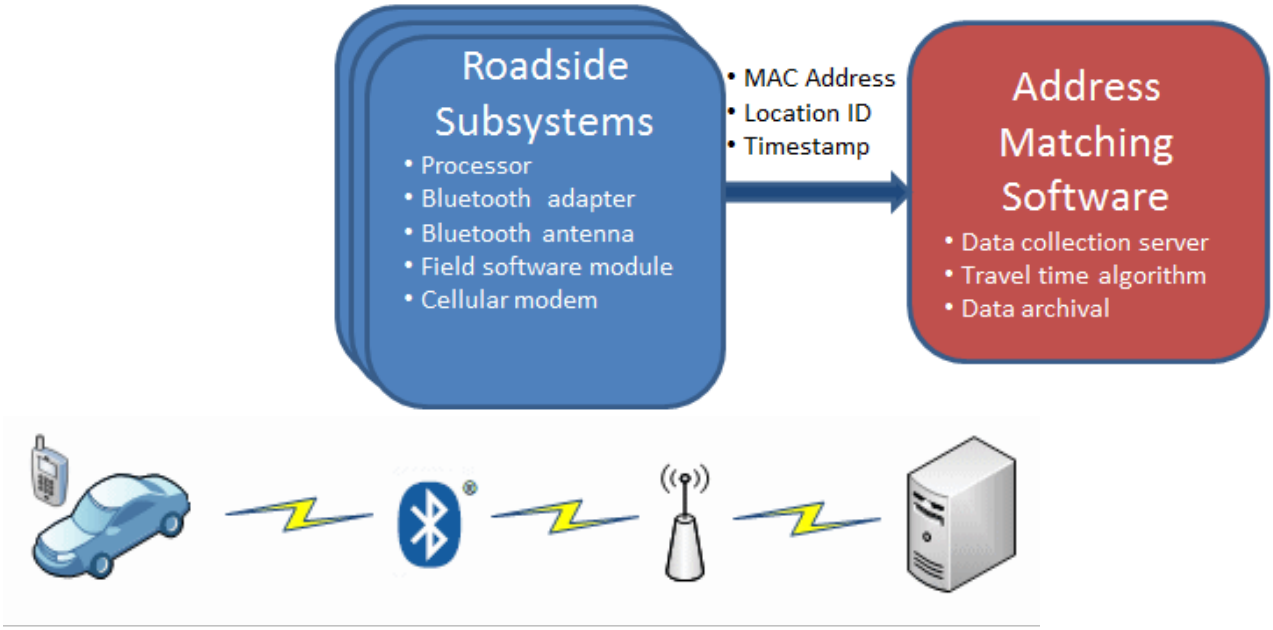

Figure 2. *Bluetooth* Data Flow Process for Collection and Analysis of Traffic Data.

2.2. BAYPORT FACILITY

The Bayport Container Terminal opened in 2007. It is located on Port Road east of SH 146. The typical traffic flow pattern for trucks calling at Bayport at the time of this study, depicted in Figure 3, is as follows:

1. A truck approaches from the west toward the east on Port Road;
2. The truck exits Port Road and loops around through the Bayport entry gate complex on the south side of Port Road;
3. After being approved for entry, the truck passes back under Port Road and into the container terminal yard on the north side of Port Road;
4. From the container terminal yard, the truck passes through a U.S. Customs inspection facility and then through the Bayport exit gate; and
5. After passing through the Bayport exit gate, the truck departs toward the west on Port Road.

An average of 2,500 transactions are conducted at the Bayport container terminal, corresponding to thousands of truck trips, during daily operations. A truck can perform combinations of the following transactions on a single visit to the Bayport terminal:

- Receive an import containerized shipment;
- Deliver an export containerized shipment;
- Receive an empty container;
- Deliver an empty container;
- Receive a chassis; or
- Deliver a chassis.

A dual transaction occurs when multiple transactions occur on the same terminal visit by a truck. According to POHA, over 65 percent of truck visits at Bayport are dual transactions.

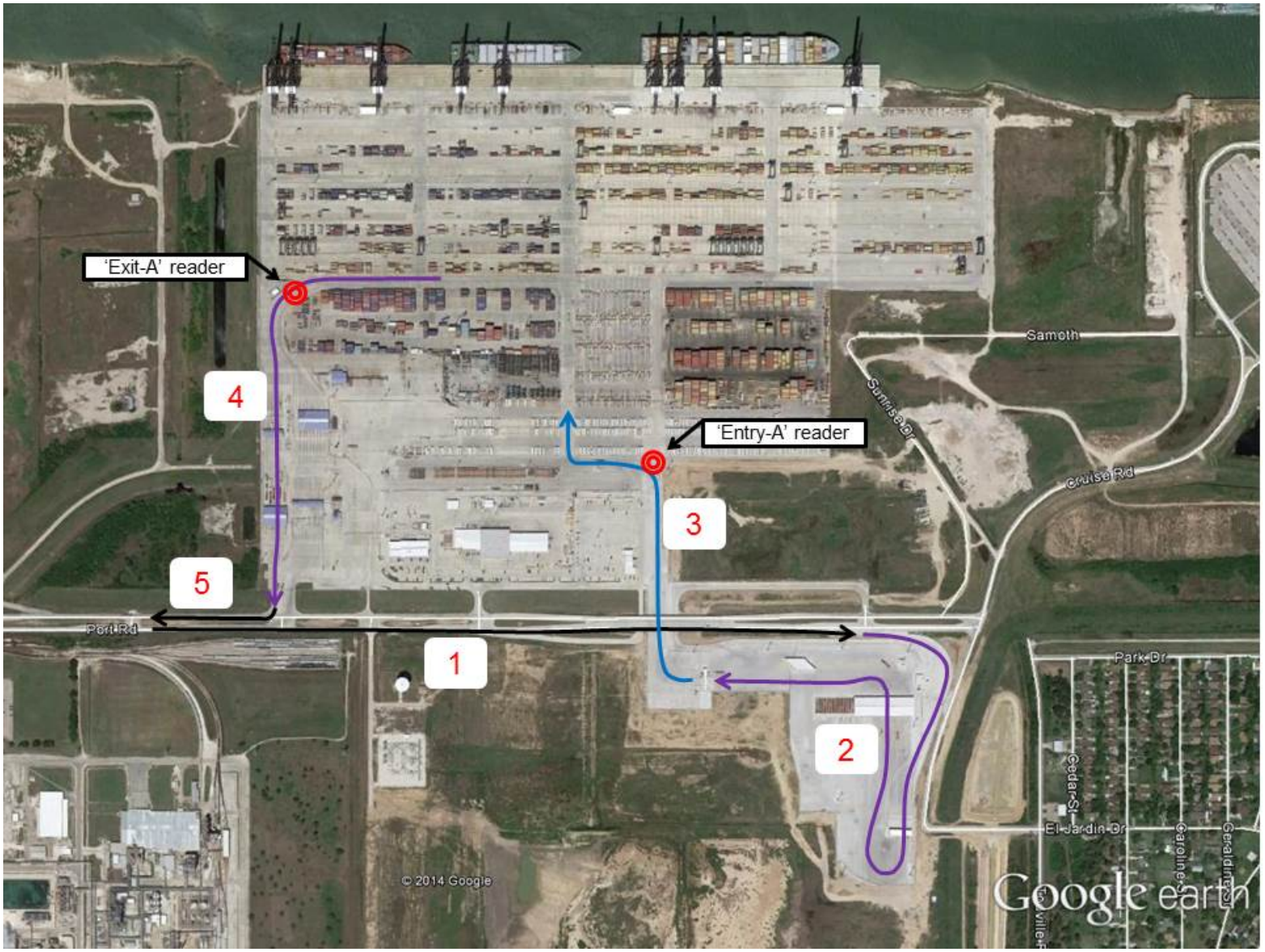

Figure 3. Typical Truck Traffic Pattern at Bayport Container Terminal
(background image source: Google Earth with aerial photo by Landsat).

2.3. TEST SET-UP FOR IDENTIFYING BAYPORT TRUCKS

Two of the project's goals, as outlined in Section 1.2, were to determine which *Bluetooth* signals recorded at Bayport can be identified as likely coming from heavy-duty container trucks, and determine the percentages of heavy-duty container trucks calling at the Bayport that utilize *Bluetooth*, and the percentages of associated truck trips. Two approaches were used to collect data for these goals: 1) installation of *Bluetooth* readers in the Bayport terminal to read (as much as possible) only container truck traffic, and 2) combined use of video recorders, manual observation, and deployment of a *Bluetooth* reader on Port Road near the Bayport exit gate.

2.3.1. Bluetooth Readers in Bayport Terminal

The first test approach for identifying Bayport trucks was to collect MAC address signals inside the Bayport container terminal. This was done by installing *Bluetooth* readers inside the Bayport container terminal area, such that the likelihood of MAC address readings corresponding to container trucks calling at Bayport would be maximized and the likelihood of other MAC address readings (e.g., from other vehicles passing by on Port Road) would be minimized. The pairing of MAC address readings from multiple locations in the Bayport container terminal further increases the likelihood that the vehicle is a Bayport truck, as opposed to other passing traffic or stationary *Bluetooth* sources, provided the configuration of *Bluetooth* reader locations is suitable. Data were collected during all hours of August 22, 2014; however, standard operating hours for the Bayport terminal are 0600 to 1800.

Two locations in the Bayport terminal were selected where trucks with *Bluetooth*-enabled devices would pass within sufficient proximity to generate a reading, and at the same time minimize the likelihood that other traffic with *Bluetooth*-enabled devices would generate readings (false positives). These locations are shown as Entry-A reader and Exit-A reader on the image in Figure 3.[1] The *Bluetooth* reader for Entry-A was placed behind concrete barriers at a location in the terminal where trucks typically stop and queue before being allowed to continue into the facility. The reader utilized a 3 dbi antenna and was uniquely positioned to be within *Bluetooth* read distance for every truck entering the terminal without capturing significant reads of traffic on Port Road. Figure 4 shows a ground-level photo image of the Entry-A *Bluetooth* reader/antenna location. The *Bluetooth* reader for Exit-A was placed between two concrete barriers on the last curve section that leads to the Bayport terminal exit gates. The reader utilized a 3 dbi antenna and was situated such that it was within *Bluetooth* read distance for every truck

[1] The *Bluetooth* readers deployed at the Bayport container terminal used 3 dB antennas. Based on previous research by TTI, the corresponding distance at which *Bluetooth* signal capture rate using a 3 dB antenna is most consistent is around 825 feet. However, this distance is with minimal line-of-sight interference between a *Bluetooth* source and the *Bluetooth* reader/antenna. Shielding of a *Bluetooth* source (by a vehicle cab/body, buildings or other structures) can greatly reduce the effective antenna range. The distance from Entry-A to Port Road was around 830 feet, and the distance from Exit-A to Port Road was around 1,710 feet, with metal structures (U.S. Customs and Bayport exit gate) and vehicles (exiting trucks) between the reader and Port Road.

leaving the facility. The location was about a 1/3 of a mile from Port Road, so the chances of reading traffic with *Bluetooth*-enabled devices on Port Road were minimal.

2.3.2. Video Recorders and Bluetooth Readers on Port Road

The second test approach for identifying Bayport trucks was to collect *Bluetooth* MAC address signals and video data of truck traffic at a location near the Bayport terminal where the traffic flow was still expected to have a significant proportion of Bayport container trucks. This approach was based on matching of timestamps for MAC address signals with timestamps of video records, providing confirmation of whether or not the MAC address could, with a high probability through correlation of visual and electronic data, be identified as a truck.

Four video streams in total were recorded for this purpose. Two video streams were recorded of eastbound and westbound traffic (one video stream per direction) on Port Road, using a trailer equipped with video data collection equipment that was located in the median of Port Road. These video streams were collected for all hours of August 22, 2014.

A third video stream was recorded facing south, perpendicular to Port Road. This video stream captured both eastbound and westbound traffic on Port Road. A fourth video stream was recorded of a computer screen that displayed MAC addresses as they were collected 'live' by a *Bluetooth* reader/antenna. These latter two video streams were recorded from inside a parked vehicle from about 0900 to 1700 on August 22, 2014.

The location for the video and MAC address data collection is shown on the aerial photo image in Figure 5 as 'Ref-1'. Ref-1 is located approximately 750 feet to the west of the Bayport exit gate. Another *Bluetooth* reader/antenna location on Port Road to the west of Ref-1 toward SH 146, 'Ref-2', is also shown on Figure 5. As with the *Bluetooth* readings in the Bayport terminal, *Bluetooth* readings were collected at Ref-1 and Ref-2 for all hours of August 22, 2014.

Figure 6 is a ground-level photo image of the data collection setup at Ref-1, facing east toward the Bayport terminal. Westbound traffic exiting Bayport is coming toward (into) the image view. The video trailer in the median of Port Road with mast-mounted cameras is shown in the right side of the image, the *Bluetooth* reader/antenna is shown in the center of the image,[2] along with a cable that transmitted MAC address readings to the computer screen inside the nearest parked TTI vehicle. The video cameras used to record the perpendicular view of Port Road and computer screen displaying the MAC addresses were inside this vehicle.

[2] As with *Bluetooth* readers at Entry-A and Exit-A in the Bayport terminal, the readers at Ref-1 and Ref-2 were initially set up using 3 dB antennas. However, it was determined during the data collection that the TTI vehicle parked at Ref-1 was partially blocking the range of that *Bluetooth* reader's antenna. The antenna at Ref-1 was switched out with a 5 dB antenna (providing a stronger signal for the reader) at noon on August 22.

Figure 4. 'Entry-A' *Bluetooth* Reader Location in Bayport Terminal, Facing South toward Bayport Entry Gate and Port Road (Source: TTI).

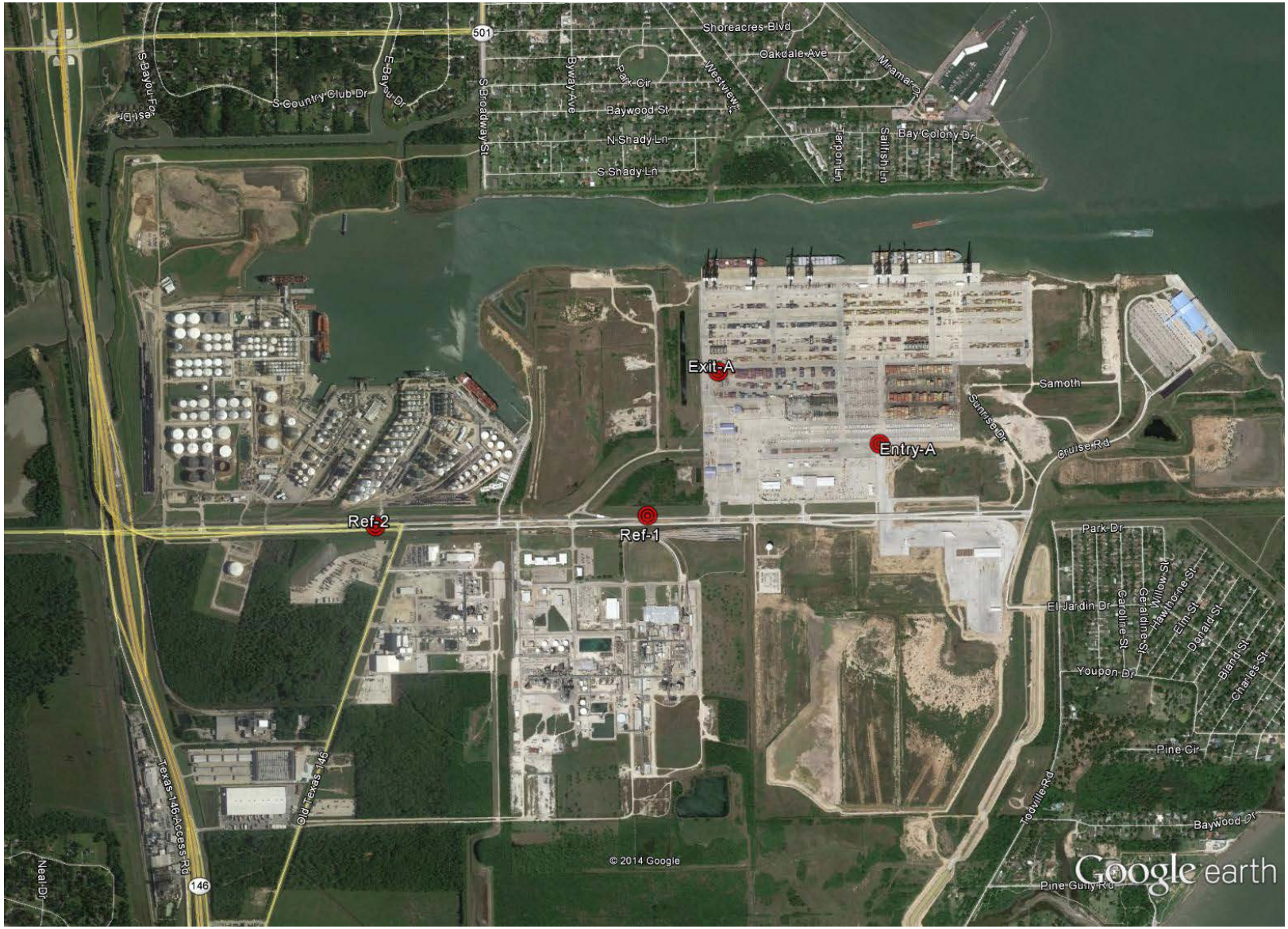

Figure 5. *Bluetooth* Reader Locations in Bayport Facility and on Port Road near Bayport (Source: Google Earth with Aerial Photo Image by Landsat).

Figure 6. 'Ref-1' Video Data Collection and *Bluetooth* Reader Location on Port Road near Bayport Terminal (Source: TTI).

2.4. TEST SET-UP FOR DETERMINING TRUCK TRANSPORTATION PATTERNS

A third project goal was to determine the transportation patterns of *Bluetooth*-utilizing trucks calling at the Bayport Terminal on local and regional roadway networks. To collect data for this goal, *Bluetooth* readers/antennas[3] were installed along roadways in the immediate Bayport area (Figure 7) at locations that:

1. Were on major arterials expected to have substantial levels of container truck traffic (e.g., two locations on SH 225 and two locations on SH 146, north of Bayport);
2. Represented locations on minor arterials where heavy-duty truck traffic was expected to be higher (e.g., at Barbours Cut; Bay Area Blvd. to the west of SH 146 and leading to commercial and industrial facilities, SH 146 south of Bayport); or
3. Represented other locations on minor arterials where heavy-duty truck traffic was expected to be lower but were in convenient proximity to Bayport (e.g., Red Bluff Road leading to residential areas in Southeast Houston).

Bluetooth readers/antennas[3] were also installed at major U.S. and Interstate highway locations around the Houston MSA (Figure 8) to identify potential movements of Bayport truck traffic outside the central Houston area.

[3] These readers used 5 dB antennas to increase their effective range for collecting MAC address signals.

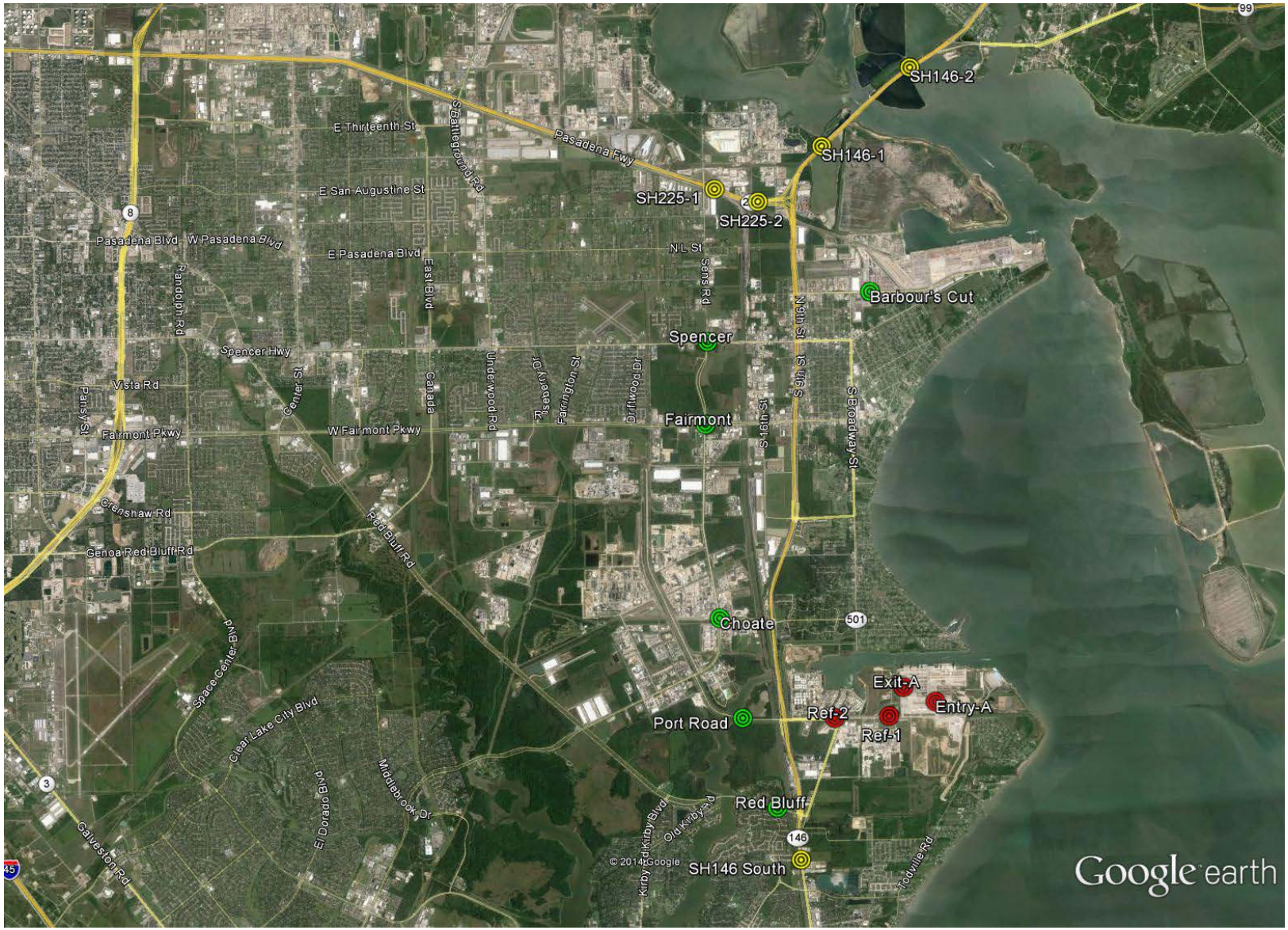

Figure 7. *Bluetooth* Reader Locations in Bayport Area
(Source: Google Earth with Aerial Photo Image by Landsat).

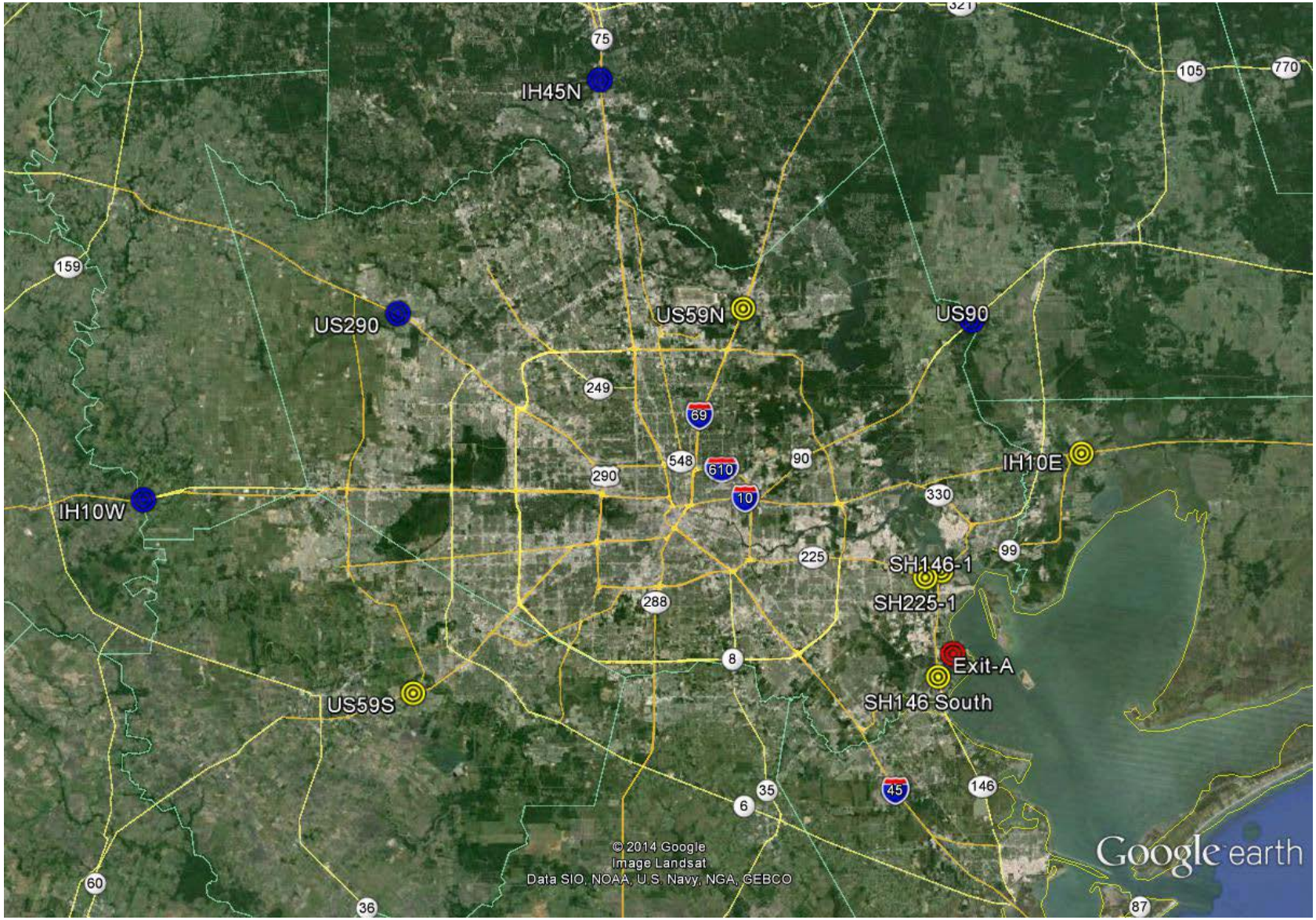

Figure 8. *Bluetooth* Reader Locations along U.S. and Interstate Highways in Houston MSA (Source: Google Earth with aerial photo image by Landsat).

2.5. TEST SET-UP FOR DETERMINING TRUCK TRAFFIC LEVELS

A fourth project goal was to determine the heavy-duty truck traffic levels on SH 225 and SH 146. To collect data for this goal, TTI utilized video data for August 22, 2014, from TXDOT's Houston TranStar traffic camera system for locations shown on Figure 9 for SH 225 ('225 La Port @ Sens') and SH 146 ('146 @ 225 (N)'). These camera locations were selected to match locations of *Bluetooth* readers on these roadways, as shown in Figure 7. For each location, the traffic cameras show traffic in both directions, including feeder/access roads on SH 225. The video data were analyzed by TTI staff for heavy-duty truck traffic counts in each direction by truck classification (straight, tractor-trailer, and multi-trailer) and type (box van, container, dry tank, flatbed, other, liquid tank, and utility).

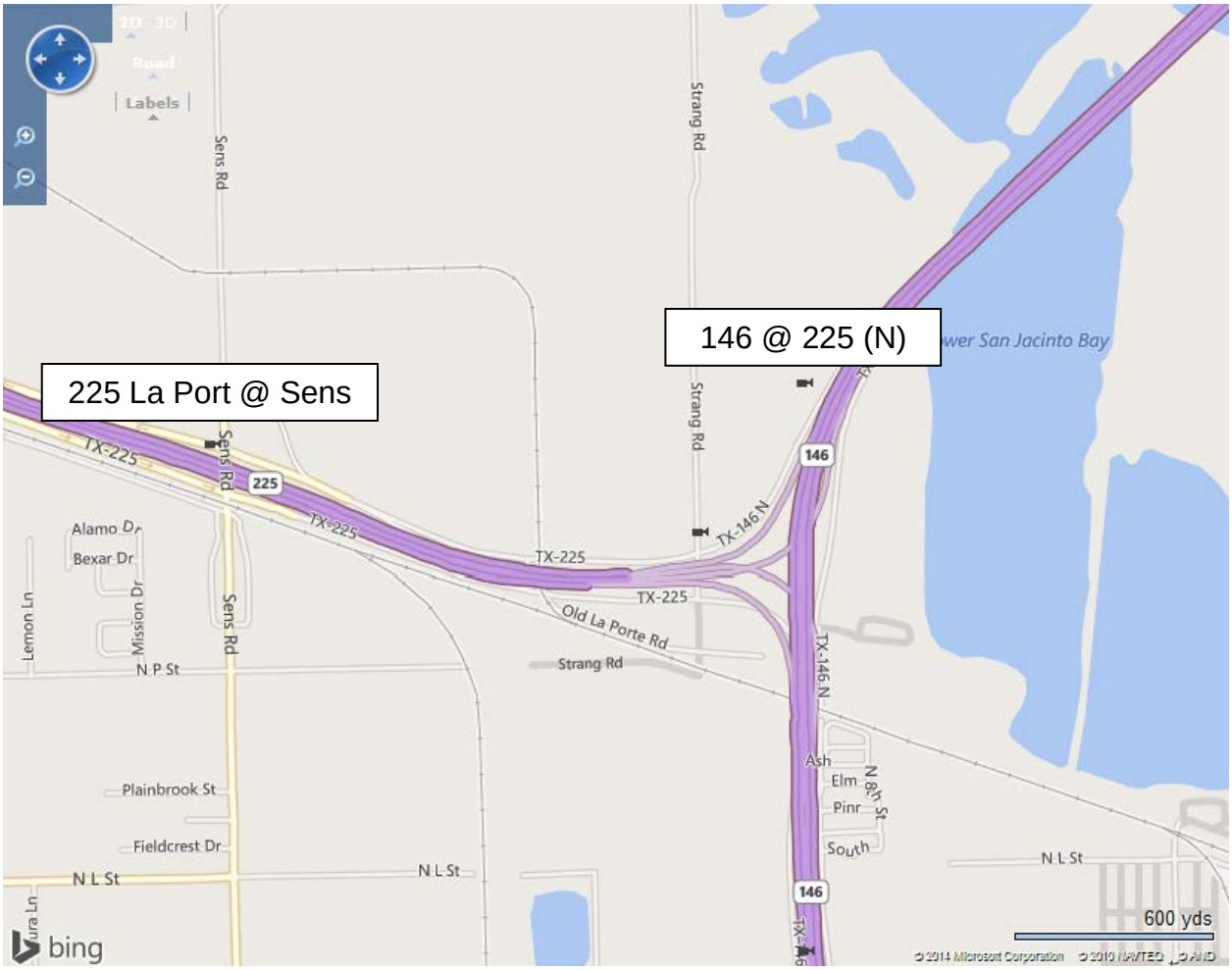

Figure 9. Locations of TXDOT Traffic Cameras on SH 225 and SH 146 Used for Video Data Collection (Source: Houston TranStar Traffic Map, Bing Maps Interface; Labels Added Using Information from TXDOT Traffic Camera IDs).

2.6. TEST SET-UP TECHNICAL SUMMARY

Table 1 summarizes the test data collection locations and technical equipment set-up used for collecting *Bluetooth* readings on August 22, 2014.

Table 1. Bluetooth Data Collection Locations and Equipment Set-Up.

Location	Reader	Antenna	Antenna Mounting
Bayport Terminal			
Entry-A	TS-7200 Portable	3 dB	Roadside monopod
Exit-A	TS-7200 Portable	3 dB	Roadside monopod
Port Road			
Ref-1 (east of SH 146)	TS-7200 Portable	3 dB (until 1200) 5 dB (after 1200)	Roadside monopod
Ref-2 (east of SH 146)	TS-7200 Portable	3 dB	Roadside monopod
Port Road (west of SH 146)	TS-7200 Portable	5 dB	Roadside monopod
SH 225			
SH225-1 (@ Sens Rd.)	TS-7200 Portable	5 dB	Jersey barrier
SH225-2 (@ Strang Rd.)	TS-7200 Portable	5 dB	Jersey barrier
SH 146			
SH146-1 (south end Fred Hartman Bridge)	TS-7200 Portable	5 dB	Jersey barrier
SH146-2 (north end Fred Hartman Bridge)	TS-7200 Portable	5 dB	Jersey barrier
SH146 South (Bluetoothw. Red Bluff Rd and E. Meyer Ave.)	TS-7200 Portable	5 dB	Roadside monopod
E. Barbours Cut Blvd.			
@ Barbours Cut Terminal Entry Pre-Check Facility	TS-7200 Portable	5 dB	Roadside monopod
Bay Area Blvd.			
@ Choate Rd.	TS-7200 Portable	5 dB	Roadside monopod
@ W. Fairmont Pkwy	TS-7200 Portable	5 dB	Roadside monopod
@ Spencer Hwy	TS-7200 Portable	5 dB	Roadside monopod
Other Local Roads			
Red Bluff Rd. @ Lakeside Dr.	TS-7200 Portable	5 dB	Roadside monopod
Regional Highways			
IH-10E @ FM 3180	TS-7200 Portable	5 dB	Roadside monopod
IH-10W @ Brazos River	TS-7800 Cabinet	5 dB	Cabinet surface
IH-45N @ FM 1488	TS-7800 Cabinet	5 dB	Cabinet surface
US59N @ Will Clayton Pkwy.	TS-7200 Cabinet	5 dB	Cabinet surface
US59S @ Grand Pkwy.	TS-7200 Portable	5 dB	Roadside monopod
US90 @ Shady Ln.	TS-7200 Portable	5 dB	Roadside monopod
US290 @ Mueschke Rd.	TS-7200 Cabinet	5 dB	Cabinet surface

3. TEST AND EVALUATION OUTCOMES

3.1. BLUETOOTH SIGNAL IDENTIFICATION AS HEAVY-DUTY CONTAINER TRUCKS

3.1.1. Truck Identification Using Bluetooth Reader Network Information

The primary method of identifying MAC addresses for heavy-duty container trucks that called on the Bayport terminal was examining the patterns of *Bluetooth* readings by location and time. To accomplish this, researchers used the following steps:

1. The complete data set was ordered by timestamp and location.
2. An Excel-based Visual Basic for Applications (VBA) macro was developed and used to identify MAC addresses that were recorded at both Entry-A and Exit-A. There is around a 90 percent likelihood that a container truck visiting the Bayport terminal would be read at both the terminal entry and the exit if the *Bluetooth* source were active during that time.
3. For each MAC address with an Entry-Exit combination, the VBA macro pulls all other corresponding locations with a match on that same MAC address (since the readings were initially ordered by timestamp, these locations are ordered by timestamp in the data output).
4. A similar VBA macro was used to identify MAC addresses that had readings only at Entry-A or Exit-A locations, but not both, and also pull other corresponding network locations and timestamps for readings for the same MAC address.
5. The data sets for MAC address, location, and timestamp sequences comprise information about vehicle travel routes or 'loops'. Each loop, which has an origin and destination on the *Bluetooth* reader network, were individually examined by researchers to determine, based on the researchers' best estimates, whether the travel behavior suggests the vehicle is a container truck or another type of vehicle, and where the vehicle was coming from and going to.
6. Based on the travel behavior assessment, information about MAC address/vehicle loops were compiled for:
    a. Calls to Bayport terminal, Barbours Cut terminal, or neither (binary);
    b. Turn times in Bayport terminal, as applicable (interval); and
    c. Use of SH 225 and/or SH 146 in origin and destination routes (binary).

Thus, where a vehicle had a reading at both the entrance to and exit from the container terminal facility, researchers classified the vehicle as a potential truck. Each truck's trip data were examined to see if vehicle locations and timestamps were consistent with truck activity. For instance, if a vehicle had two entry readings in a very short time period and with an Exit-A or Port Road (Ref-1 or Ref-2) reading in between, it was highly probable that the vehicle was not a truck moving a container. The same would be true of a vehicle that had a very short time lapse

between the entry and exit points (e.g., a few minutes), or had an extremely long duration at a particular point (e.g., several hours at Entry-A or Exit-A).

A total of 121 different MAC addresses that were recorded at the Bayport terminal at least once on August 22, 2014, were identified as having a high likelihood of being heavy-duty container trucks, and had an Entry-A and Exit-A location combination. Altogether, there were a total of 166 trips made by these trucks through the Bayport on August 22, for an average of 1.37 trips per truck. Of these, 86 vehicles made 1 trip through Bayport, 26 vehicles made 2 trips each (for a total of 52 trips), 8 made 3 trips each (for a total of 24 trips) and 1 vehicle made 4 trips. The table in Appendix A is a summary of truck trip information from the *Bluetooth* readers, listed by MAC address and ordered by time of the first-recorded Bayport Exit-A timestamp. The table includes information for all identified truck loops or segments, not just those associated with Bayport trips. Note that the MAC addresses (Device IDs) in the table are masked from the actual address IDs.

The researchers also examined the trip data for all vehicles that had a reading at either the entry or exit to the container terminal but not both. An additional eight different MAC addresses were identified as 'maybe' (truck) vehicles that called the Bayport terminal at least once on August 22, 2014. Altogether, there were a total of 11 trips made by these vehicles through the Bayport on August 22, for an average of 1.38 trips per vehicle. Of these, six vehicles made one trip through Bayport, one vehicle made two trips, and one vehicle made three trips.

3.1.2. Truck Identification Using Video Recording Data and Bluetooth Reader Information on Port Road

Researchers were unable to use the video recording data and MAC addresses readings to link identification of specific trucks with specific *Bluetooth* signals at Ref-1 on Port Road. There were several contributing factors:

- *Bluetooth* reader sample rates. In order to keep the size of the data set manageable, *Bluetooth* readers recorded MAC addresses as soon as signal strength was sufficient, and cycles of every minute thereafter. This limited the ability to track duration of time (e.g., in number of seconds) that a truck is within proximity to a *Bluetooth* reader.
- Road traffic volumes. In addition to container truck traffic, there were significant volumes of other vehicle types on Port Road, including other vehicles with business at the Bayport terminal and traffic to/from residential areas including the El Jardin del Mar community to the east of Bayport and other communities to the south of Bayport along Todville Road.
- Differing and variable truck speeds. Trucks approaching and departing the Bayport terminal in proximity to Ref-1 had differing speeds. Truck speeds on eastbound lanes were higher and more consistent, compared with truck speeds on westbound lanes started from zero at the Bayport terminal exit drive intersection with Port Road and increased gradually approaching and past Ref-1. Since the *Bluetooth* signal was received when the

source vehicle still some distance away from the reader, and distance and time are related to speed, then the time required for eastbound and westbound trucks to reach the Ref-1 location after the signal was first received also differed significantly. This inhibits the observer's ability to identify specific vehicles that are generating a *Bluetooth* signal, even when traffic volumes are relatively low.

- Video data collection. Two different video systems were used. The timestamps and sampling rates differed for the two systems.

Researchers combined the four video streams (two from each video system deployed) onto one screen view (quad screen): one quad showing the recording of the MAC addresses on a computer screen, and the other three quads showing eastbound, westbound, and perpendicular views of traffic on Port Road. This was done for one hour of data, which required significant manipulation of video data files given the differing timestamps and sample rates. Upon examination of the combined data, it was determined that the durations between *Bluetooth* reader sample rates (1 minute), traffic volumes of both Bayport container trucks and other vehicles, and problems with image clarity (30 frames per second) made it impossible to assign MAC addresses to individual trucks in the large majority of cases.

3.2. PERCENTAGE OF BAYPORT TRUCKS UTILIZING BLUETOOTH

As discussed in Section 3.1.1, researchers identified 166 truck trips through the Bayport facility made by 121 different trucks on August 22, 2014. An additional 11 vehicle trips by 8 trucks were classified as 'maybe' truck trips through Bayport. Port records indicate a total of 1,748 exits from the Bayport gates on August 22 by 1,163 different trucks, an average of 1.5 trips per truck.

Thus, around 10 percent of the Bayport truck traffic on August 22, 2014, whether measured as individual trucks or truck trips, were using *Bluetooth* devices that were detected by *Bluetooth* readers installed at the Bayport facility.

Section 3.1.1 indicates that some MAC addresses were recorded as having multiple loops through Bayport. Compared with an average of 1.37 trips per truck that was recorded using Bluetooth readers, the population of trucks that called at Bayport on August 22, 2014, had an average of 1.5 trips per truck. Table 2 compares the recorded number of truck trips through Bayport from the Bluetooth readings and from license plate reader data provided by POHA.

Table 2. Recorded Number of Visits by Trucks to Bayport on August 22, 2014.

Number of Recorded Truck Trips	Bluetooth Reader*	License Plate Reader (POHA)
1	92	762
2	27	283
3	9	85
4	1	15
5		11
6		4
7		
8		1
9		2
Total	129	1,163

* Includes trucks and 'maybe' trucks.

3.3. TRANSPORTATION PATTERNS OF BAYPORT TRUCKS UTILIZING BLUETOOTH

Transport patterns of Bayport terminal truck trips, discussed in Section 3.1.1, were analyzed for use of key roadway and intermodal facilities. Of the 166 Bayport trips that were identified as trucks, there were 81 trips that included SH 225 on the originating route and 79 trips that included SH 225 on the destination route. There were 26 trips that included SH 146 on the originating route and 16 trips that included SH 146 on the destination route.

Note that calls to or from the Barbours Cut container terminal assumed that specific facility as the point of origin or destination, as applicable. This is because the intent was to track truck movements specifically associated with container traffic for the Bayport terminal. For instance, say that after travelling on eastbound on SH 225, a container truck stopped at the Barbours Cut terminal, and then traveled from Barbours Cut to Bayport, completed its Bayport transaction(s), and traveled outbound up SH 146 without (apparently) making any other stops. On this loop, SH 225 is not included on the inbound route for Bayport, rather, the loop starts at Barbours Cut. SH 146 is included on the outbound route, but had the truck instead called at Barbours Cut after Bayport, the loop would have stopped at Barbours Cut. There were 19 Bayport truck trips with origins at Barbours Cut and 49 Bayport truck trips with destinations at Barbours Cut. There were also 17 trips (almost 19 percent of the total) where there were no data points outside the immediate Bayport area; therefore, it was impossible to determine where they originated or terminated.

Researchers calculated the 'turn times' for trucks that had both and entry and exit timestamps at the Bayport terminal (163 truck trips). Turn times were calculated based on the difference between the time of the first reading at Entry-A and the last reading at Exit-A. The median turn time was 22 minutes. The first and third quartiles of turn times were 14 and 31 minutes, respectively.

Researchers also examined timestamps from *Bluetooth* readers owned and installed by TTI at other locations around Houston to see if these trucks were appearing at other points on the broader network. Six inbound trucks and one outbound truck were detected on IH-45 at FM 1488 on the north side of the Houston MSA. Seven inbound trucks and one outbound truck were detected on IH-10 in the Mont Belvieu area on the east side of town. One inbound truck was detected at Mueschke Road on Highway 290, one outbound truck was detected at Dewitt Road and IH-10, and two outbound trucks were detected on US 59 in the Humble area on the northeast side of town.

3.4. HEAVY-DUTY TRUCK TRAFFIC LEVELS ON SH 225 AND SH 146

Video data of truck traffic on SH 225 and SH 146 were analyzed for August 22, 2014, from 9 a.m. to 5 p.m. Counts of trucks, by configuration and type, were obtained and summarized. Figure 10 and Figure 11 show the traffic levels for total trucks and container trucks between 9 a.m and 5 p.m. on August 22, 2014, for SH 225 and SH 146, respectively. On SH 225, container truck traffic remained relatively constant throughout most of the daytime, with between about 350 and 400 trucks per hour (in both directions), and then dropped off in the 4 p.m. to 5 p.m. hour. On SH 146, container truck traffic was highest in the late morning/early afternoon with a peak of between 150 and 200 trucks per hour (in both directions).

Table 3 and Table 4 list truck configuration and type counts between 9 a.m. and 5 p.m. on August 22, 2014, for SH 225 and SH 146, respectively. On SH 225, container trucks comprised 27 percent of all commercial trucks. On SH 146, container trucks comprised 22 percent of all commercial trucks. Tractor-trailer configurations of all types comprised nearly three-quarters of all commercial trucks on both roads.

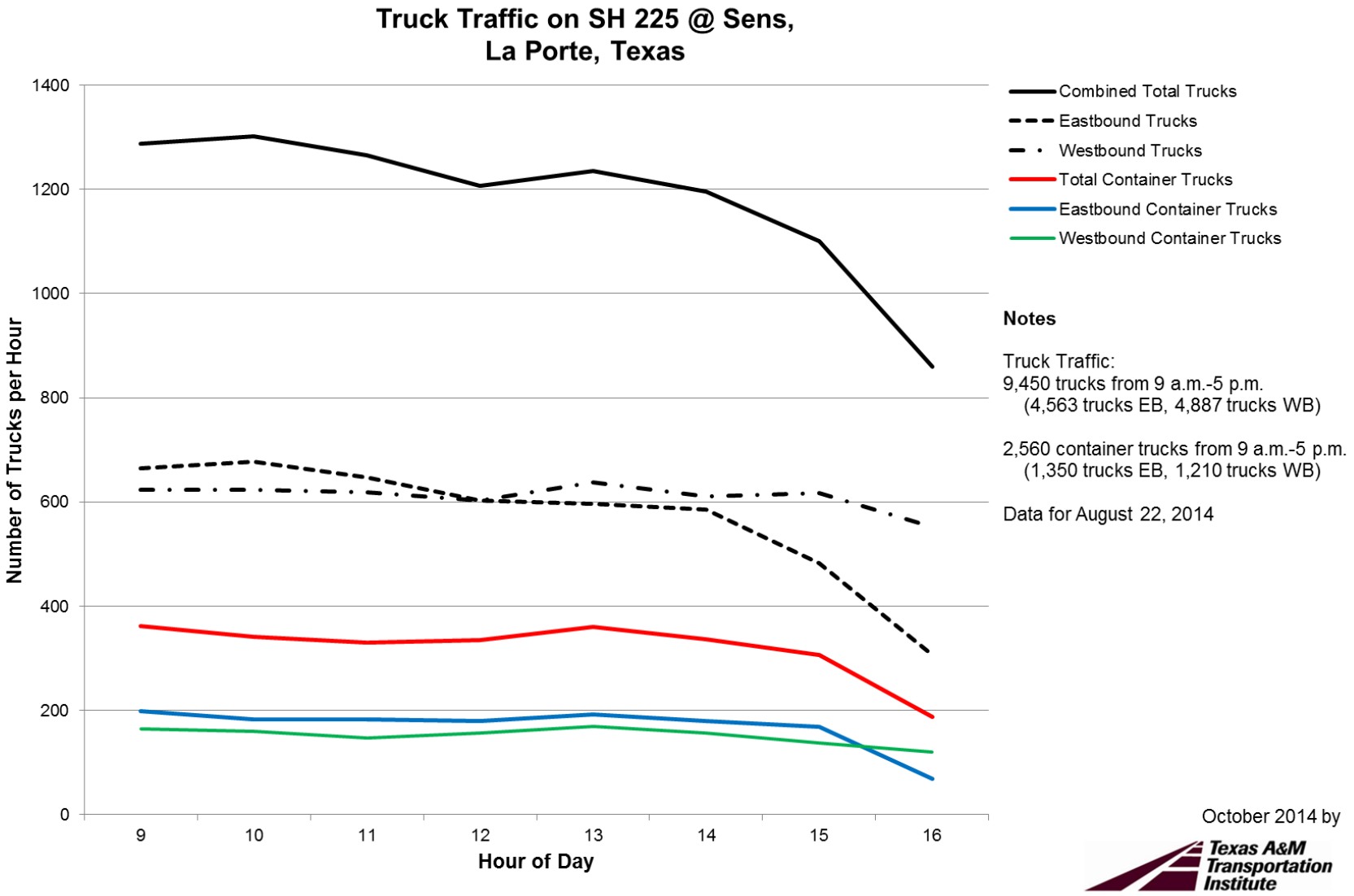

Figure 10. Truck Traffic and Container Truck Traffic Counts on SH 225 for 9 a.m. to 5 p.m. on August 22, 2014.

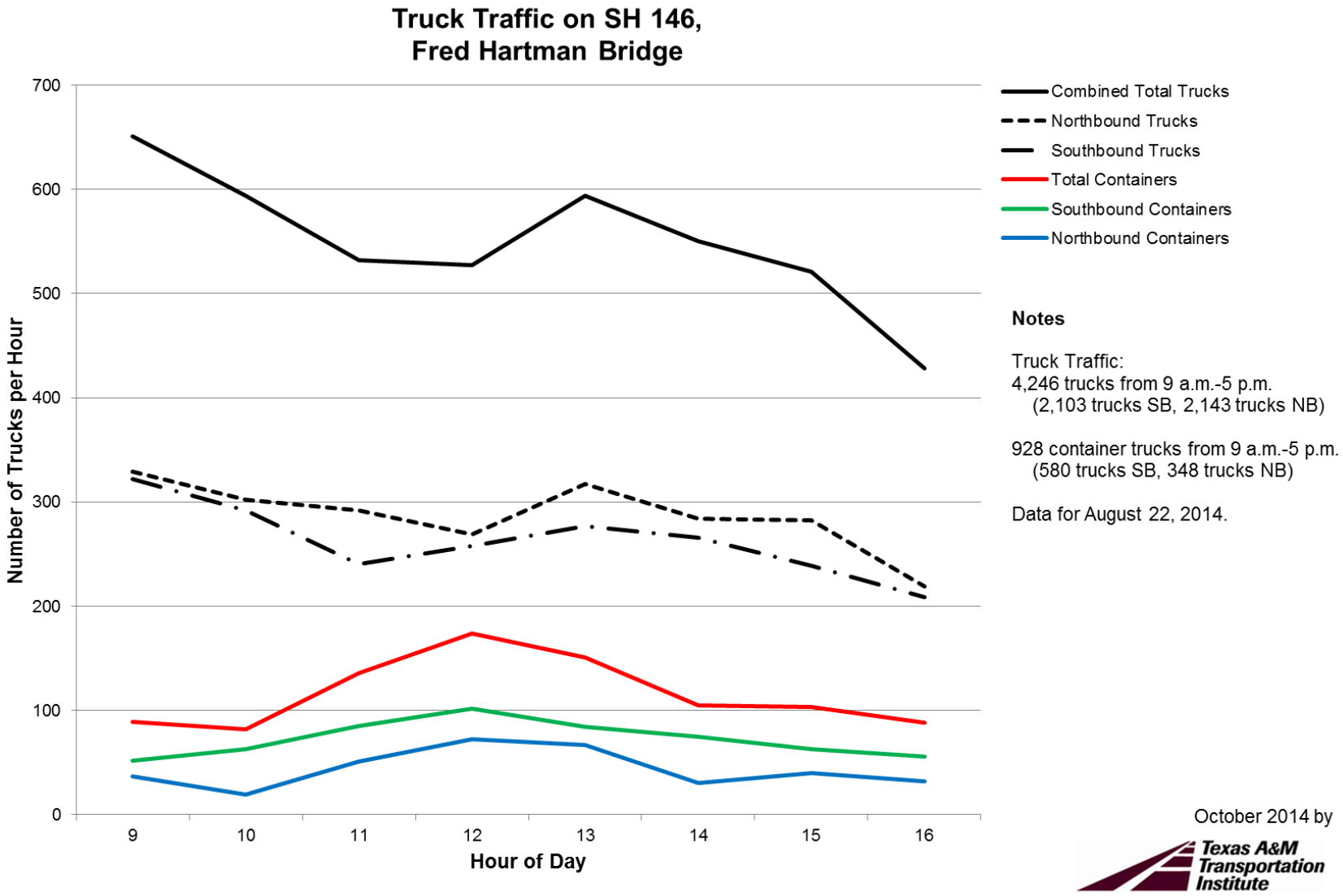

Figure 11. Truck Traffic and Container Truck Traffic Counts on SH 146 for 9 a.m. to 5 p.m. on August 22, 2014.

Table 3. Truck Counts by Configuration and Type on SH 225 from 9 a.m. to 5 p.m. on August 22, 2014.

Truck Configuration	Truck Type	Number of Trucks Observed	Percent of Total Trucks Observed
Straight	Box	425	4.5%
	Flatbed	190	2.0%
	Other	1735	18.4%
	Tank	87	0.9%
	Subtotal	**2437**	**25.8%**
Tractor-Trailer	Box	1304	13.8%
	Container	2560	27.1%
	Dry Tank	87	0.9%
	Flatbed	599	6.3%
	Other	1367	14.5%
	Tank	1083	11.5%
	Subtotal	**7000**	**74.1%**
Multi-Trailer	Other	7	**0.1%**
	Subtotal	**7**	**0.1%**
Unknown	Unknown	6	0.1%
	Subtotal	**6**	**0.1%**
All Trucks	**Grand Total**	**9450**	**100.0%**

Table 4. Truck Counts by Configuration and Type on SH 146 from 9 a.m. to 5 p.m. on August 22, 2014.

Truck Configuration	Truck Type	Number of Trucks Observed	Percent of Total Trucks Observed
Straight	Box	211	5.0%
	Flatbed	70	1.6%
	Other	783	18.4%
	Tank	42	1.0%
	Utility	3	0.1%
	Subtotal	**1109**	**26.1%**
Tractor-Trailer	Box	484	11.4%
	Container	928	21.9%
	Dry Tank	38	0.9%
	Flatbed	462	10.9%
	Other	382	9.0%
	Tank	834	19.6%
	Subtotal	**3128**	**73.7%**
Multi-Trailer	Other	9	0.2%
	Subtotal	**9**	**0.2%**
All Trucks	**Grand Total**	**4246**	**100.0%**

3.5. PERCENTAGE OF HEAVY-DUTY TRUCK TRAFFIC ON SH 225 AND SH 146 ASSOCIATED WITH BAYPORT CONTAINER SHIPMENTS

According to POHA records, a total of 1,508 trucks exited the Bayport terminal between 9 a.m. and 5 p.m. on August 22, 2014. During this same time, there were 141 *Bluetooth*-recorded truck trips through Bayport. Of these, there were 69 truck trips that had SH 225 as part of the origin route and 64 truck trips that had SH 225 as part of the destination route. There were 26 truck trips during this period that had SH 146 as part of the origin route and 14 truck trips that had SH 146 as part of the destination route.

Thus, on average there were 0.94 truck trips on SH 225 (origin or destination) and 0.28 truck trips on SH 146 (origin or destination) for every container truck trip through Bayport during this period. Under the assumption that the *Bluetooth* truck readings were representative of the general population of trucks calling at the Bayport terminal (and there are reasons this assumption may not be valid, as discussed in Section 4), this corresponds to around 1,420 trips by Bayport container trucks on SH 225 and around 430 truck trips on SH 146 from 9 a.m. to 5 p.m. on August 22, 2014.

Using truck count information for SH 225 as listed in Table 3, it can then be estimated that around 56 percent of container trucks and 15 percent of all trucks on SH 225 were Bayport container truck trips from 9 a.m. to 5 p.m. on August 22, 2014. Using truck count information for SH 146 as listed in Table 4, it can also be estimated that around 46 percent of container trucks and 10 percent of all trucks on SH 146 were Bayport container truck trips from 9 a.m. to 5 p.m. on August 22, 2014. Since the Bayport terminal's hours are generally 6 a.m. to 6 p.m., but truck traffic continues on these SH 225 and SH 146 (albeit at reduced levels) throughout the nighttime (and increases especially during early morning hours for some types of trucks), the 24-hour percentages of truck traffic on these roads that is associated with the Bayport facility will in all likelihood be lower than the daytime percentages described above.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

This test and evaluation project demonstrated that *Bluetooth* technology can be used to collect information about vehicles calling at the Bayport terminal and other locations on roadways in the Houston MSA. The information can be compiled, ordered, and analyzed to determine traffic patterns for these vehicles and identify, based on those traffic patterns, which vehicles are likely to be container trucks.

A 10 percent level of penetration of *Bluetooth* readings in the overall traffic flow into and out of Bayport was observed in this project. This level of sampling could be used to analyze the local and regional traffic patterns of trucks calling at the Bayport terminal or other freight terminals in the Houston MSA, provided that the sample data adequately represent the corresponding population.

In addition to previous work conducted by TTI using *Bluetooth*, other studies have used *Bluetooth* to identify vehicle origins and destinations and distinguish between inter- versus intra-city travel (*7*), and evaluate driver behavior in different driving environments such as rurual and urban work zones (*8*). Studies have noted that *Bluetooth* sensors currently in commission are less costly than other sensor technologies; hence, any time a *Bluetooth*-based system can be effectively deployed, it makes economic sense to do so (*9*). As *Bluetooth* device usage rates continue to increase in the general population, using corresponding data will become statistically more reliable (*8,9*).

Potential uses of *Bluetooth* data that could be of value to the Port of Houston Authority include:

1. The time to travel between readers at certain locations could be used to determine levels of congestion at certain times of day or over a period of time.
2. The flow patterns could be tracked over time to see if development or congestion issues are affecting the routing decisions of trucks.

The primary challenge with using *Bluetooth* or any other technology system to represent truck traffic patterns is assessing the generalizability of trucks that are using particular technology systems and the corresponding ability to make accurate inferences about the population as a whole. For this project, there was an average of 1.37 trips through Bayport per truck on August 22, 2014, for the sample of *Bluetooth* trucks, compared with an average of 1.50 Bayport trips per truck for the truck population on that date, based on POHA data.

The general patterns of trucks with multiple trips was similar for both the *Bluetooth* sample and truck population, but there were no trucks in the *Bluetooth* sample with more than four recorded trips on August 22, while 18 out of 1,163 trucks in the population had five or more Bayport trips according to the port's data. While this represents only 1.5 percent of the truck population on that date, it corresponds to 6.0 percent of the truck trips through Bayport. The bias

introduced by the sample of trucks with *Bluetooth*-enabled devices relative to the overall Bayport truck population is uncertain, but the results might suggest that trucks utilizing *Bluetooth* were somewhat less likely to be engaged in locally-intensive short-haul drayage activities than trucks that were not using *Bluetooth* technology.

Researchers were not able to link specific *Bluetooth* signals with specific trucks with the collected data, due to limited resolution of the *Bluetooth* and video recorded data, as discussed in Section 3.1.2. This might have provided information about the generalizability of the sample. Although this was not possible using the *Bluetooth* reader and video technologies as implemented for this particular test and evaluation project, it is potentially feasible, although it would be very data-intensive. This would require:

- A *Bluetooth* reader configured to receive MAC address signals on one-second intervals or less.
- Digital recordings at high-speed frame rates for perpendicular views of roadway traffic corresponding to *Bluetooth* reader locations. All video recordings should be made from the same or similar camera technologies at the same frame rates, and each camera view should be synced exactly with the others and the *Bluetooth* reader.
- *Bluetooth* readings should be collected at a point where vehicle speeds are consistent in both directions.
- There should be additional readers set up in both directions of the roadway from the *Bluetooth* reader where video data are collected to assist with determining direction of travel.
- Because of the amount of data involved, collecting information over several hours to a day will require sufficient memory storage capabilities, which are greater than the memory-card based technologies that are currently available.
- Because examination of video data requires manual observation and analysis (at least in the immediate term), significant personnel time might be required to review and compile truck traffic information. Alternately, an appropriate sampling framework might be developed to analyze a subset of information.

An alternative to using a video-based vehicle identification/confirmation systems is selecting a stratified or randomized sample of trucks that call at a freight facility such as Bayport and equipping the sample with *Bluetooth*-enabled devices (or other technology), collecting data on the roadway networks, and analyzing it for the selected sample.

Finally, an efficient means of analyzing a significant volume of roadway network data is required. The general approach taken with this project could be applicable to a larger project with more data. This might be accomplished through written code using VBA, or another programming language that is better suited for large data sets. The code could be used to create reduced data sets by identifying truck trips versus other vehicles, and eliminating repeated (duplicative) readings while including sufficient cross-checks to recognize when a duplicative reading represents a new trip or loop. Applying macros that reduce the data set and identify

truck patterns allows for a larger project scope without a significant increase in human resources needed. For freight purposes, this includes identifying and distinguishing between different trips on a freight network. The system should enable a level of accuracy for trip identification that provides for a reasonable estimate of truck movements on transportation networks.

4.2. RECOMMENDATIONS

TTI recommends that POHA, TXDOT, H-GAC, and other stakeholders review the outcomes of this test and evaluation project and assess utility of results for a) Port Authority operations; b) local, regional, and state transportation agencies; and c) private/other stakeholders. Based on the outcomes of the review, the next step would be to identify candidate stakeholders and locations for further case studies and/or technology implementation. A second pilot test at Bayport, Barbours Cut, or other freight facilities in the Houston MSA to refine project approach (e.g., modifying the number, gain, and locations/elevations of *Bluetooth* readers/antennas), and develop data analysis programs, or compare use of *Bluetooth* technology with other technology systems (e.g., LPR, GPS) should also be considered. This test might utilize the large number of readers that have already been installed in the Houston MSA and along other roadways in Texas to provide more specific and comprehensive information about commercial vehicle traffic patterns.

APPENDIX A. BLUETOOTH SIGNAL AND NETWORK ANALYSIS DATA SUMMARY TABLE

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
A	Truck	516	929	1	64	0	1	1			IH-45_FM-1488, SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-2, IH-45_FM-1488
B	No	617	727	1	49	0	1				SH225-1, Ref-2, Entry-A, Exit-A
B	No	748	955	1	126	0					Entry-A, Exit-A
B	No	1130	1153	?	**	0					Exit-A, Entry-A
B	No	1242	1315	1	14	0					Ref-2, Ref-1, Entry-A, Exit-A
B	No	1512	1738	?	**	0					Exit-A, Entry-A, Ref-1, Red Bluff
C	Truck	631	742	1	20	0	1	1			SH225-1, SH225-2, Ref-2, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
D	Truck	634	812	1	39	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-1
E	No	643	941	1	24	0					Port Road, Ref-2, Entry-A, Exit-A, Entry-A, Ref-2
E	No	1438	1502	?	**	0					Ref-2, Ref-1, Entry-A, Ref-1, Ref-2, Red Bluff
F	Truck	648	749	1	13	0		1			Ref-2, Entry-A, Exit-A, Ref-2, SH225-1
F	Truck	1138	1230	0		0					IH10E, IH10_DewittRd
G	No	649	655	?	**	0					Exit-A
G	No	656	815	1	79	0					Entry-A, Exit-A
G	No	819	835	1	16	0					Entry-A, Exit-A
G	No	837	909	?	**	0					Entry-A
H	Maybe	653	807	1	74	0					Entry-A, Exit-A
I	No	442	655	?	**	0	1				SH225-1, Ref-2, Exit-A
I	No	946	946	?	**	0					Exit-A
I	No	1038	1046	1	8	0					Entry-A, Exit-A
I	No	1255	1305	1	10	0					Entry-A, Exit-A
I	No	1340	1402	?	**	0		1			Entry-A, Ref-1, Ref-2, SH225-1
I	No	1738	1844	?	**	0	1				SH225-1, Ref-2, Ref-1, Entry-A
J	Truck	657	933	1	87	0		1			Fairmont, Ref-2, Entry-A, Exit-A, Ref-2, Fairmont, SH225-1
J	Truck	1240	1324	0		0			1		SH146-2, SH146-1, Choate, Fairmont
K	Truck	707	800	1	20	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
K	Truck	800	1009	0		1					Barbours Cut, SH225-2, SH225-1, SH225-1, Barbours Cut
K	Truck	1054	1149	1	14	1				1	Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-2, SH146-1, SH146-2

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
K	Truck	1255	1258	0		0		1	1		SH146-2, SH146-1, SH225-1
L	Truck	707	744	1	10	0	1	1			SH225-1, Entry-A, Exit-A, Ref-2, SH225-1
L	Truck	940	1018	1	10	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-1
L	Truck	1235	1318	1	15	0		1			Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
M	Truck	717	825	1	10	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
M	Truck	1243	1243	0		0					IH-45_FM-1488
N	Truck	718	829	1	40	0	1	1			SH225-1, SH225-2, Ref-2, Entry-A, Exit-A, Ref-2, SH225-1
N	Truck	1125	1309	1	60	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
O	Truck	727	830	1	26	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
O	Truck	925	1015	0		1					Barbours Cut, SH225-2, SH225-1, Barbours Cut
O	Truck	1103	1135	0		1					Barbours Cut, SH225-1, SH225-1, Barbours Cut
O	Truck	1219	1224	0		1		1			Barbours Cut, SH225-2, SH225-1
O	Truck	1253	1343	1	14	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
O	Truck	1418	1521	0		1	1	1			SH225-1, Barbours Cut, SH225-2, SH225-1
P	No	727	916	1	24	1					Barbours Cut, Ref-2, Entry-A, Exit-A
P	No	919	1007	1	45	0					Entry-A, Exit-A, Ref-2
P	No	1035	1155	1	44	0					Ref-2, Entry-A, Exit-A, Ref-1, Ref-2
P	No	1229	1354	1	68	0					Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2
P	No	1509	1630	0		0	1				SH225-2, SH225-1, IH-45_FM-1488
Q	No	715	815	?	**	0	1				SH225-1, Exit-A, Spencer
Q	No	912	1007	1	6	0		1			Fairmont, Entry-A, Exit-A, Ref-2, SH225-1
Q	No	1250	1334	1	10	1	1				SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
Q	No	1358	1454	0		1					Barbours Cut, Spencer, Fairmont, Barbours Cut
Q	No	1533	1541	0		1					Barbours Cut, Spencer
R	Truck	736	841	1	29	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
R	Truck	954	1047	1	20	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
R	Truck	1205	1310	1	35	0	1				SH 225-1, SH225-2, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, Port Road, Choate
R	Truck	1325	1415	1	24	0				1	Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
R	Truck	1525	1525	0		0					SH146South
R	Truck	1727	1736	0		0		1			SH146South, SH225-2, SH225-1
S	Truck	746	924	1	31	0		1			Fairmont, Ref-2, Entry-A, Exit-A, Ref-2, Fairmont, SH225-1
S	Truck	1044	1203	0		1		1			Fairmont, Barbours Cut, SH225-1
T	Truck	748	838	1	21	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
T	Truck	1010	1105	1	18	0	1			1	SH225-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
T	Truck	1152	1155	0		0		1	1		SH146-2, SH146-1, SH225-1
T	Truck	1236	1241	0		1	1				SH225-1, Barbours Cut
T	Truck	1443	1524	1	9	1				1	Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
T	Truck	1557	1559	0		0		1	1		SH146-2, SH146-1, SH225-2, SH225-1
T	Truck	1622	1658	0		1	1	1			SH225-1, Barbours Cut, SH225-1
U	Truck	751	834	1	**	0	1	1			SH225-1, Ref-2, Entry-A, SH225-2, SH225-1
U	Truck	943	943	0		1					Barbours Cut
U	Truck	1054	1218	0		1					Barbours Cut, SH225-2, SH225-1, SH225-1, Barbours Cut
U	Truck	1342	1430	1	33	0					Ref-2, Ref-1, Entry-A, Exit-A, Ref-1
V	Truck	333	333	0		0					IH10E
V	Truck	734	836	1	21	0			1	1	IH10E, SH146-1, Ref-2, Entry-A, Exit-A, Ref-2, SH146-1
W	Truck	740	859	1	42	0	1	1			SH225-1, Entry-A, Exit-A, SH225-2, SH225-1
W	Truck	1234	1320	1	23	0		1			Ref-1, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
X	Truck	809	844	1	8	1					Ref-2, Entry-A, Exit-A, SH225-1, Barbours Cut
X	Truck	949	954	0		1		1			Barbours Cut, SH225-1
Y	Maybe	808	848	1	17	0			1		SH146-1, Ref-2, Entry-A, Exit-A, Ref-2
Y	Maybe	922	1056	1	48	0				1	Ref-2, Entry-A, Exit-A, Ref-2, SH146-1, SH146-2, IH10E
Y	Maybe	1448	1552	1	9	0			1		IH10E, SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2
Z	No	808	834	1	17	0	1				SH225-1, SH225-2, Ref-2, Entry-A, Exit-A

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
Z	No	836	925	1	24	0		1			Entry-A, Exit-A, BP122_Spare, Ref-2, SH225-2, SH225-1
Z	No	1153	1247	1	27	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
Z	No	1447	1618	0		1	1	1			Barbours Cut, SH225-2, SH225-1, SH225-1, SH225-2, Barbours Cut
Z	No	1700	1705	0		1		1			Barbours Cut, SH225-2, SH225-1
AA	Truck	639	639	0		1					Barbours Cut
AA	Truck	800	1110	1	7	1				1	Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-2, SH146-1, SH146-2, IH10E, IH10_DewittRd
AA	Truck	1439	1541	0		0					IH10_DewittRd, IH10E
AB	Truck	729	733	0		1	1				SH225-1, SH225-2, Barbours Cut
AB	Truck	820	900	1	16	1		1			Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
AB	Truck	1148	1254	1	41	0	1	1			SH225-1, SH225-2, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
AB	Truck	1516	1524	0		1	1	1			SH225-1, SH225-2, Barbours Cut, SH225-2, SH225-1
AC	Truck	740	745	0		1	1				SH225-1, Barbours Cut
AC	Truck	819	851	1	10	1					Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-2
AC	Truck	940	945	0		1	1				SH225-1, Barbours Cut
AC	Truck	1654	1654	0		0					IH-45_FM-1488
AD	Truck	823	851	1	**	1	1				SH225-1, SH225-2, Ref-2, Entry-A, Ref-2, Barbours Cut
AD	Truck	938	1024	1	20	1		1			Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
AD	Truck	1345	1431	1	24	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AD	Truck	1454	1458	0		1		1			Barbours Cut, SH225-2, SH225-1
AE	Truck	744	749	0		1	1				SH225-1 SH225-2, Barbours Cut
AE	Truck	826	909	1	11	1		1			Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
AE	Truck	1342	1425	1	10	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AE	Truck	1442	1447	0		1		1			Barbours Cut, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
AF	Truck	548	548	0		0	1				SH225-1
AF	Truck	840	922	1	24	0					Ref-2, Entry-A, Exit-A, Ref-2
AF	Truck	1027	1027	0		1					Barbours Cut
AF	Truck	1222	1324	1	45	0					Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2
AF	Truck	1428	1458	1	14	0					Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2
AF	Truck	1548	1718	0		1		1			Barbours Cut, SH225-1
AG	Truck	848	928	1	16	0				1	Ref-2, Entry-A, Exit-A, SH146-2
AH	Truck	834	931	1	26	1	1				SH225-1, SH225-2, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AH	Truck	950	1149	0		1					Barbours Cut, SH225-2, SH225-1, SH225-1, SH225-2, Barbours Cut
AH	Truck	1244	1500	0		1		1			Barbours Cut, SH225-2, SH225-1, SH225-1, SH225-2
AH	Truck	1602	1602	0		0		1	1		SH146-1, SH225-2, SH225-1
AI	Truck	759	804	0		1	1				SH225-1, SH225-2, Barbours Cut
AI	Truck	847	934	1	17	1		1			Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
AI	Truck	1235	1347	1	30	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
AJ	Truck	902	959	1	10	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
AJ	Truck	1041	1046	0		1	1				SH225-1, Barbours Cut
AK	Truck	901	950	1	13	1			1		SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AK	Truck	1255	1255	0		0					Ref-2
AK	Truck	1552	1602	0		0				1	Ref-2, SH146-1, SH146-2
AL	Truck	859	949	1	20	0	1	1			SH225-1, Entry-A, Exit-A, Ref-2, SH225-2
AL	Truck	1415	1503	0		1	1			1	SH225-1, Barbours Cut, SH146-1
AM	Truck	719	720	0		0	1			1	SH225-1, SH146-1
AM	Truck	907	951	1	12	0		1	1		SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
AM	Truck	1111	1114	0		0	1			1	SH225-1, SH225-2, SH146-1, SH146-2
AM	Truck	1226	1348	0		1			1	1	SH146-2, SH146-1, Barbours Cut, SH146-1, SH146-2
AM	Truck	1505	1507	0		0		1	1		SH146-1, SH225-1
AN	Truck	918	1005	1	33	0		1			Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
AN	Truck	1313	1352	1	13	0		1			Ref-2, Ref-1, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
AO	Truck	914	953	1	16	0					Fairmont, Ref-2, Entry-A, Exit-A
AP	Truck	915	1004	1	10	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
AP	Truck	1058	1101	0		1		1			Barbours Cut, SH225-2
AP	Truck	1327	1423	1	13	0	1			1	SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
AQ	Truck	916	1021	1	30	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
AQ	Truck	1317	1317	0		0	1				SH225-2, SH225-1
AR	Truck	844	849	0		1	1				SH225-1, SH225-2, Barbours Cut
AR	Truck	909	1014	1	22	1		1			Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-2, SH225-2, SH225-1
AR	Truck	1302	1426	1	62	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AR	Truck	1523	1527	0		1		1			Barbours Cut, SH225-2, SH225-1
AS	Truck	844	849	0		1	1				SH225-1, SH225-2, Barbours Cut
AS	Truck	917	1000	1	10	1		1			Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
AS	Truck	1419	1459	1	10	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AS	Truck	1527	1531	0		1		1			Barbours Cut, SH225-2, SH225-1
AT	Truck	921	1026	1	21	0					Fairmont, Ref-2, Entry-A, Exit-A, Ref-2, Fairmont
AU	Truck	926	1023	1	13	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, SH225-2
AV	No	928	1029	1	34	0			1	1	SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-2, SH146-1, SH146-2
AV	No	1253	1342	1	2	0			1		SH146-2, Ref-2, Ref-1, Entry-A, Exit-A
AV	No	1354	1359	1	5	0					Entry-A, Exit-A
AV	No	1403	1424	1	12	0					Entry-A, Exit-A, Ref-1
AV	No	1435	1500	1	9	0				1	Entry-A, Exit-A, Ref-1, Ref-2, SH146-2
AW	Truck	930	1017	1	15	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-1
AW	Truck	1104	1239	1	51	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
AW	Truck	1432	1527	1	24	1	1				SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AW	Truck	1557	1600	0		1		1			Barbours Cut, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
AX	Truck	929	1037	1	15	0			1	1	SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
AX	Truck	1217	1225	0		0			1		SH146-2, SH146-1, Choate
AX	Truck	1708	1725	0		0				1	Choate, SH146-1, SH146-2
AY	Truck	520	1026	1	27	1			1		IH10E, IH10E, SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
AY	Truck	1104	1524	0		1					Barbours Cut, SH146-1, SH146-2, SH225-1, SH225-2, Barbours Cut
AY	Truck	1547	1554	0		1				1	Barbours Cut, SH146-1, SH146-2
AZ	Truck	704	821	0		1		1			Barbours Cut, SH225-2, SH225-1
AZ	Truck	940	1121	1	63	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
AZ	Truck	1546	1627	1	20	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BA	Truck	942	1014	1	5	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
BA	Truck	1036	1041	0		1		1			Barbours Cut, SH225-2, SH225-1
BA	Truck	1300	1406	0		1		1			Barbours Cut, SH225-1
BB	Truck	952	1051	1	29	0	1			1	SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, SH146-1, SH146-2
BB	Truck	1341	1435	1	18	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
BC	Truck	1003	1215	1	18	1					Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
BC	Truck	1325	1338	0		1		1			Barbours Cut, SH225-1
BC	Truck	1404	1551	1	22	0	1				SH225-1, Ref-1, Entry-A, Exit-A, Ref-1,Ref-2
BC	Truck	1627	1627	0		0	1				SH225-2, SH225-1
BD	Truck	1000	1042	1	10	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
BD	Truck	1122	1126	0		1		1			Barbours Cut, SH225-1
BD	Truck	1242	1409	1	48	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
BE	Maybe	731	731	0		0					Spencer
BE	Maybe	918	918	0		1					Barbours Cut
BE	Maybe	1009	1047	1	23	0					Ref-2, Entry-A, Exit-A
BE	Maybe	1350	1350	0		0					Ref-2

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
BF	Truck	1003	1146	1	55	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
BF	Truck	1444	1527	1	15	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BF	Truck	1548	1559	0		1		1			Barbours Cut, SH225-2, SH225-1
BG	Truck	740	825	0		1			1	1	SH146-1, Barbours Cut, SH146-1
BG	Truck	1002	1053	1	25	0			1	1	SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
BG	Truck	1055	1345	0		1			1	1	SH146-2, SH146-1, Barbours Cut, SH146-1, SH146-2
BG	Truck	1512	1558	1	15	1			1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BG	Truck	1651	1658	0		1				1	Barbours Cut, SH146-1, SH146-2
BH	Truck	745	825	0		1				1	Barbours Cut, SH146-1
BH	Truck	1002	1053	1	16	0			1	1	SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-2, SH146-1, SH146-2
BH	Truck	1055	1345	0		1			1	1	SH146-2, SH146-1, Barbours Cut, SH146-1, SH146-2
BH	Truck	1512	1558	1	14	1			1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BH	Truck	1652	1658	0		1				1	Barbours Cut, SH146-1, SH146-2
BI	Truck	1005	1206	1	95	0			1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-2
BI	Truck	1358	1452	0		1	1	1			SH225-1, Barbours Cut, SH225-1
BJ	No	907	912	0		1	1				SH225-1, SH225-2, Barbours Cut
BJ	No	1005	1048	1	24	1					Barbours Cut, Ref-2, Entry-A, Exit-A
BJ	No	1053	1205	1	11	1					Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BJ	No	1342	1349	0		1		1			Barbours Cut, SH146-1, SH146-2
BK	Truck	1012	1133	1	25	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
BL	Truck	939	944	0		1	1				SH225-1, SH225-2, Barbours Cut
BL	Truck	1010	1106	1	17	1		1			Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
BL	Truck	1409	1627	1	48	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
BM	Truck	1027	1118	1	27	0		1			Entry-A, Exit-A, SH225-1
BM	Truck	1227	1322	1	32	0		1			Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2
BM	Truck	1435	1549	1	28	0	1	1			SH225-1, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
BN	Truck	1019	1111	1	13	0		1	1		SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-2, SH225-2
BN	Truck	1118	1224	0		1				1	Barbours Cut, SH146-1, SH146-2
BN	Truck	1334	1407	0		0			1	1	SH146-2, SH146-1, SH146-1, SH146-2
BN	Truck	633	633	0		0					IH10E
BN	Truck	956	1128	1	24	1			1		IH10E, SH146-2, SH146-1, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BN	Truck	1155	1203	0		1				1	Barbours Cut, SH146-1, SH146-2
BO	Truck	1027	1103	1	12	0		1			Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
BO	Truck	1111	1118	0		1	1			1	SH225-1, Barbours Cut, SH146-2
BO	Truck	1405	1405	0		0			1		SH146-1
BP	Truck	1034	1133	1	25	0		1			Ref-2, Entry-A, Exit-A, Ref-2, SH225-1
BQ	Truck	912	920	0		0			1		SH146-2, SH146-1, Fairmont
BQ	Truck	1029	1134	1	17	0		1			Fairmont, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
BR	Truck	1035	1203	1	8	1					Fairmont, Ref-2, Entry-A, Exit-A, Ref-2, Fairmont, Barbours Cut
BS	Truck	1039	1135	1	20	1	1				SH225-1, SH225-2, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BS	Truck	1148	1232	0		1		1			Barbours Cut, SH225-2, SH225-1
BT	Truck	1039	1233	1	87	0			1	1	SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
BU	Truck	1051	1225	1	42	1		1	1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
BU	Truck	1229	1314	0		1	1			1	SH225-1, Barbours Cut, SH146-1, SH146-2
BU	Truck	1504	1507	0		0		1	1		SH146-2, SH146-1, SH225-2, SH225-1
BV	Truck	1004	1004	0		1					Barbours Cut
BV	Truck	1044	1208	1	17	1		1			Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
BV	Truck	1542	1551	0		0	1				SH225-1, Ref-2, Ref-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
BV	Truck	1625	1651	0		1		1			Ref-2, Barbours Cut, SH225-1
BW	Truck	945	949	0		1	1				SH225-1, SH225-2, Barbours Cut
BW	Truck	1101	1333	1	5	1		1			Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1, US59N
BW	Truck	1409	1624	0		1	1	1			US59N, SH225-1, SH225-2, Barbours Cut, SH225-2, SH225-1
BX	Truck	805	1213	1	16	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-2, Barbours Cut
BX	Truck	1331	1539	1	14	1					Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
BX	Truck	1658	1727	0		1					Barbours Cut, Spencer
BY	Truck	1100	1157	1	25	1			1		SH146-2, SH146-1, Ref-2, Entry-A, Exit-A Ref-2, Barbours Cut
BY	Truck	1547	1547	0		1					Barbours Cut
BZ	Truck	1110	1205	1	28	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-2, Barbours Cut
BZ	Truck	1239	1244	0		1		1			Barbours Cut, SH225-2, SH225-1
CA	Truck	1042	1048	0		1			1		SH146-2, SH146-1, Barbours Cut
CA	Truck	1107	1209	1	14	1		1			Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
CB	Truck	946	946	0		0					IH10_DewittRd
CB	Truck	1132	1202	1	29	0					Entry-A, Exit-A
CB	Truck	1332	1332	0		1					Barbours Cut
CB	Truck	1438	1527	1	28	0					Fairmont, Ref-2, Entry-A, Exit-A, Ref-1
CC	Truck	710	710	0		0	1				SH225-2
CC	Truck	1105	1222	1	29	0	1	1			SH225-1, Entry-A, Exit-A, Ref-2, SH225-1
CC	Truck	1346	1431	1	16	0					Ref-1, Entry-A, Exit-A, Ref-1, Ref-2
CC	Truck	1605	1656	1	**	0					Ref-1, Entry-A, Ref-1
CD	Truck	1129	1244	1	27	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
CD	Truck	1405	1637	0		1					Barbours Cut, SH225-2, SH225-1, SH225-1, SH225-2, Barbours Cut
CD	Truck	1724	1735	0		1		1			Barbours Cut, SH225-2, SH225-1
CE	Truck	1129	1244	1	26	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
CE	Truck	1405	1637	0		1					Barbours Cut, SH225-1, SH225-1, Barbours Cut
CE	Truck	1721	1735	0		1		1			Barbours Cut, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
CF	Truck	656	910	0		1	1	1			SH225-1, Barbours Cut, SH225-2, SH225-1
CF	Truck	1139	1232	1	34	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
CG	Truck	940	945	0		1	1				SH225-1, SH225-2, Fairmont
CG	Truck	1038	1112	0		1	1				Fairmont, SH225-1, Barbours Cut
CG	Truck	1146	1235	1	11	1		1			Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
CG	Truck	1536	1559	0		1	1	1			SH225-1, Barbours Cut, SH225-1
CG	Truck	1605	1608	0		0	1			1	SH225-1, SH225-2, SH146-1, SH146-2
CH	Truck	1024	1214	1	18	0					IH-45_FM-1488, Entry-A, Exit-A
CH	Truck	1308	1357	1	26	0		1			Entry-A, Exit-A, SH225-1
CI	Truck	559	559	0		0					IH10W_BrazosRiver
CI	Truck	1055	1055	0		0					US-290_Mueschke
CI	Truck	1148	1312	1	46	0	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2
CI	Truck	1405	1454	1	9	0		1			Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
CJ	Truck	1040	1046	0		1	1				SH225-1, Barbours Cut
CJ	Truck	1147	1303	1	27	1		1			Barbours Cut, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
CK	Truck	1150	1305	1	35	0	1	1			SH225-1, SH225-2, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
CL	Truck	1151	1304	1	25	0		1			Fairmont, Choate, Ref-2, Entry-A, Exit-A, Ref-1, SH225-1
CM	Truck	1152	1324	1	57	0	1	1			SH225-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
CN	Truck	741	743	0		0	1			1	SH225-1, SH146-1
CN	Truck	853	856	0		0		1	1		SH146-2, SH146-1, SH225-2, SH225-1
CN	Truck	1050	1053	0		0		1	1		SH225-1, SH146-1, SH146-2
CN	Truck	1201	1329	1	17	0		1	1		SH146-2, SH146-1, Ref-2, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1, SH225-2
CO	Truck	734	734	0		0					IH10E
CO	Truck	1135	1353	1	79	0			1	1	IH10E, SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
CO	Truck	1505	1637	0		1			1	1	SH146-2, SH146-1, Fairmont, Barbours Cut, SH146-1, SH146-2
CP	Truck	309	309	0		0					US-290_Mueschke

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
CP	Truck	1117	1311	1	28	0	1	1			US-290_Mueschke, SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
CR	Truck	1208	1331	1	41	0			1	1	SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
CS	Truck	1219	1252	1	27	0					Entry-A, Exit-A, Ref-1
CT	Truck	1214	1334	1	54	1			1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
CT	Truck	1416	1420	0		1		1			Barbours Cut, SH225-2, SH225-1
CT	Truck	1911	1914	0		0	1			1	SH225-1, SH225-2, SH146-1, SH146-2
CU	Truck	237	237	0		0					IH10W_BrazosRiver
CU	Truck	1116	1127	0		1	1				SH225-1, SH225-2, Barbours Cut
CU	Truck	1213	1324	1	41	1		1			Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
CV	Truck	719	832	0		1	1	1			SH225-1, SH225-2, Barbours Cut, SH225-2, SH225-1
CV	Truck	1220	1328	1	43	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
CV	Truck	1418	1423	0		1		1			Barbours Cut, SH225-2, SH225-1
CW	Truck	1230	1309	1	22	0					Ref-2, Ref-1, Entry-A, Exit-A, Ref-1
CW	Truck	1344	1416	0		1		1			Barbours Cut, SH225-1
CX	Truck	440	558	0		0			1		Fairmont, SH146-1, IH10E, IH10_DewittRd
CX	Truck	1235	1319	1	30	1					Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
CX	Truck	1422	1541	0		1		1			Barbours Cut, Fairmont, SH225-1
CY	Truck	1227	1352	1	58	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
CY	Truck	1523	1613	0		1	1	1			SH225-1, SH225-2, Barbours Cut, SH225-2, SH225-1
CZ	Truck	1256	1333	1	12	0	1				SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2
CZ	Truck	1439	1534	1	29	0		1			Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
DA	Truck	1118	1118	0		0					Fairmont
DA	Truck	1301	1349	1	7	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
DA	Truck	1441	1615	0		1		1			Port Road, Barbours Cut, SH225-1, Barbours Cut
DB	Truck	950	1039	0		1	1			1	SH225-1, Barbours Cut, SH146-1
DB	Truck	1241	1348	1	23	0		1	1		SH146-2, SH146-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
DB	Truck	1646	1730	1	9	0		1			Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, SH225-1
DC	Truck	725	856	0		1	1	1			SH225-1, Barbours Cut, SH225-1
DC	Truck	1309	1403	1	20	1	1				SH225-1, Ref-2, Entry-A, Exit-A, Ref-1, Barbours Cut
DC	Truck	1504	1504	0		0		1			SH225-1
DD	Truck	924	924	0		0					IH10E
DD	Truck	1245	1410	1	20	1			1		IH10E, SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DD	Truck	1438	1616	0		1					Barbours Cut, SH146-1, SH146-2, SH146-2, SH146-1, Barbours Cut
DD	Truck	1634	1641	0		1				1	Barbours Cut, SH146-1, SH146-2
DE	Truck	1311	1404	1	17	1			1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DE	Truck	1701	1703	0		0				1	SH146-1, SH146-2
DF	Truck	750	822	0		1					Fairmont, Spencer, Barbours Cut
DF	Truck	1133	1409	1	7	1			1		SH146-2, SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DF	Truck	1545	1634	0		1					Barbours Cut, Spencer, Fairmont
DG	Truck	1214	1419	1	24	0	1	1			IH-45_FM-1488, SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1
DH	Truck	1324	1349	1	9	0					Ref-1, Entry-A, Exit-A
DH	Truck	1716	1716	0		0					US59N
DI	Truck	1323	1428	1	42	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-1, SH225-2
DJ	Truck	836	929	0		1	1	1			SH225-1, SH225-2, Barbours Cut, SH146-1[1], SH225-1, SH225-2
DJ	Truck	1330	1419	1	25	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DJ	Truck	1450	1454	0		1		1			Barbours Cut, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
DK	Truck	650	927	0		1	1	1			SH225-1, Barbours Cut, SH225-1
DK	Truck	1337	1519	1	22	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
DL	Truck	650	927	0		1	1	1			SH225-1, Barbours Cut, SH225-1
DL	Truck	1337	1519	1	59	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
DM	Truck	759	804	0		1	1				SH225-1, SH225-2, Barbours Cut
DM	Truck	821	1015	0		1					Barbours Cut, SH225-2, SH225-1, SH225-1, SH225-2, Barbours Cut
DM	Truck	1158	1158	0		0		1			SH225-2, SH225-1
DM	Truck	1344	1443	1	24	1					Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DM	Truck	1511	1511	0		0		1			SH225-2, SH225-1
DN	Truck	1037	1037	0		1					Barbours Cut
DN	Truck	1138	1138	0		0		1			SH225-1
DN	Truck	1348	1452	1	8	0	1	1			SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
DN	Truck	1640	1640	0		1					Barbours Cut
DO	Truck	617	717	0		1	1				Fairmont, Spencer, SH225-1, Barbours Cut
DO	Truck	924	933	0		1		1			Barbours Cut, SH225-1
DO	Truck	1356	1529	1	20	1	1				SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DO	Truck	1600	1713	0		1		1			Barbours Cut, SH225-1, Spencer
DP	Truck	1257	1459	1	22	1	1				IH-45_FM-1488, SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DP	Truck	1536	1551	0		1		1			Barbours Cut, SH225-1
DP	Truck	1906	1906	0		0					IH-45_FM-1488
DQ	Truck	604	604	0		0					US59N
DQ	Truck	915	1026	0		1	1	1			SH225-1, Barbours Cut, SH225-1
DQ	Truck	1400	1504	1	27	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DQ	Truck	1545	1624	1	29	0					Ref-2, Ref-1, Entry-A, Exit-A
DQ	Truck	1649	1717	1	10	0		1			Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
DR	Truck	916	920	0		1	1				SH225-1, Barbours Cut
DR	Truck	1006	1207	0		1					Barbours Cut, SH225-2, SH225-1, SH225-1, Barbours Cut

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
DR	Truck	1245	1249	0		0		1			Barbours Cut, SH225-2, SH225-1
DR	Truck	1401	1441	1	14	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2 Barbours Cut
DR	Truck	1535	1541	0		1		1			Barbours Cut, SH225-2, SH225-1
DR	Truck	1744	1744	0		0					US59S
DS	Truck	728	728	0		0					US59S
DS	Truck	1122	1122	0		0					US59S
DS	Truck	1359	1543	1	32	1			1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DS	Truck	1606	1612	0		1				1	Barbours Cut, SH146-1, SH146-2
DT	Truck	105	105	0		0					IH-45_FM-1488
DT	Truck	1257	1504	1	31	0	1	1			IH-45_FM-1488, SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
DU	Truck	1310	1548	1	54	0	1				IH-45_FM-1488, SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1
DV	Truck	1404	1513	1	10	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DV	Truck	1545	1552	0		1				1	Barbours Cut, SH146-1, SH146-2
DV	Truck	949	954	0		1			1		SH146-2, SH146-1, Barbours Cut
DV	Truck	1020	1125	0		1		1			Barbours Cut, SH225-2, SH225-1
DV	Truck	1313	1319	0		1			1		SH146-2, SH146-1, Barbours Cut
DV	Truck	1350	1558	1	72	1				1	Barbours Cut, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH146-1, SH146-2
DW	Truck	920	926	0		1	1				SH225-1, Barbours Cut
DW	Truck	1122	1554	1	65	0	1	1			SH225-2, SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
DW	Truck	1612	1704	0		0	1				SH225-1, Fairmont
DX	Truck	1323	1509	1	20	1	1				IH-45_FM-1488, SH225-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DX	Truck	1548	1553	0		1		1			Barbours Cut, SH225-2, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
DY	Truck	554	1002	0		0			1	1	SH146-1, Fairmont, SH146-1, IH10E
DY	Truck	1405	1541	1	41	1			1		IH10E, SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DY	Truck	1615	1621	0		1				1	Barbours Cut, SH146-1, SH146-2
DZ	Truck	1256	1328	0		1	1	1			SH225-1, SH225-2, Barbours Cut, SH225-1, SH225-2
DZ	Truck	1435	1547	1	48	1	1				SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
DZ	Truck	1603	1603	0		0		1			SH225-2, SH225-1
EA	No	749	754	0		0					SH146South, Choate
EA	No	1144	1144	0		0					Fairmont
EA	No	1220	1227	0		0				1	Fairmont, SH146-1
EA	No	1454	1520	1	26	0					Entry-A, Exit-A
EA	No	1601	1737	?	**	0					Exit-A, Ref-1
EB	Truck	740	825	0		1			1	1	SH146-1, Barbours Cut, SH146-1
EB	Truck	957	1344	0		1			1	1	SH146-2, SH146-1, Barbours Cut, SH146-1, SH146-2
EB	Truck	1516	1605	1	19	1			1		SH146-2, SH146-1, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, Barbours Cut
EB	Truck	1641	1647	0		1				1	Barbours Cut, SH146-1, SH146-2
EC	Truck	1204	1228	0		0	1	1			SH225-1, SH225-2, SH225-1
EC	Truck	1533	1657	1	65	0	1	1			SH225-1, SH225-2, Ref-2, Ref-1, Entry-A, Exit-A, Ref-1, Ref-2, SH225-2, SH225-1
ED	Maybe	910	957	1	**	0	1			1	SH225-1, Entry-A, SH146-1
ED	Maybe	1220	1346	1	**					1	Ref-1, Entry-A, Ref-1, SH146-1
EE	Maybe	921	926			1	1				SH225-1, Barbours Cut
EE	Maybe	1217	1256	1	**	1					Exit-A, Ref-1, Barbours Cut
EF	Maybe	1155	1440	1	**			1			IH45_FM1488, Exit-A, Ref-1, SH225-1
EG	Maybe	421	539					1			Fairmont, SH225-1, US-290_Mueschke
EG	Maybe	902	1135			1					US-290_Mueschke, Barbours Cut
EG	Maybe	1509	1809	1	**			1			Ref-2, Ref-1, Entry-A, Ref-1, Fairmont, SH225-1

Device ID†	Type	Start Time	End Time	Bayport	BP Turn Time (min)	BC*	SH 225		SH 146		Loop
							O	D	O	D	
EH	Maybe	1427	1616	1	**						IH-45_FM1488, Ref-2, Ref-1, Entry-A, Ref-1, Ref-2

† Actual Device ID is Masked

* Barbours Cut

** Time not able to be calculated

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