



Caltrans Division of Research,
Innovation and System Information

Research



Results



Transportation
Safety and
Mobility

JUNE 2016

Project Title:

Truck Traveler Information,
Parking, and Operations

Task Number: 2815

Completion Date: October 31,
2015

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Tracking Truck Flows with Programmable Mobile Devices

Using current tablet and communication technologies, we developed a system for tracking and analysis of drayage activities so as to gain insights on drayage inefficiencies.

WHAT WAS THE NEED?

Inefficient use of drayage trucks results in negative externalities of pollution and congestion. A full measure of the current state of drayage efficiency and future changes as trade volume grows can only be obtained through detailed tracking of drayage activities.

Recent emergence of tablet computers provides an ideal platform for the design of an Electronic On-Board Recorder (EOBR) for such tracking. CSULB researchers (Browning, Lam & Monaco) have built a prototype of an EOBR that would perform GPS tracking of the truck locations periodically as well as during certain activities, with all logs timestamped. It would also provide easy entry by driver of their work activities where appropriate. The data collected on the device can then be transmitted to a server and maintained in a database. The prototype was tested on 18 drayage trips in the Southern California area.

This project is to adopt and enhance this prototype, conduct a large-scale deployment of this technology, build a database of the collected data, and develop a user interface and graphical display tools for the access and analysis of the collected data. With the rapid development of programmable mobile devices, it will be important for us to assess the latest technology in the current market for our enhancement and large-scale deployment of this technology. The collected data would enable a clear understanding of truck flow inefficiencies and their cause, as well as the freight flows pattern in a given area, which will not only provide useful data for the truck industry to devise strategies for productivity improvement, but also help stake holders in



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supply chain management, including the ports and terminal operators, to identify the sources of inefficiency in drayage, quantify the impacts of these inefficiencies and develop solutions.

WHAT WAS THE GOAL?

The anticipated outcome of this project included:

1. A GPS-enabled activity logging device based on the current tablet technology.
2. Logged data collected in a medium-term run with multiple drayage trucks.
3. A database for maintaining the collected data.
4. Software tools for data analysis and display and a website for accessing the database.

WHAT DID WE DO?

The project consisted of the following tasks:

1. Surveyed the latest programmable mobile devices, compare and evaluate them against the prototype in terms of capability, usability, ease of development, and future enhancement. A final selection of a mobile device was a 10.1" LG G Pad LTE (for wireless communication).
2. Produce detailed specifications of the EOBR based on our development and field experimentation experience of the prototype as well as feedbacks from the truck drivers involved in test runs.
3. Developed software for data logging.
4. Identified and negotiated with truck drivers for the device deployment and data collection.
5. Trained drivers to use the device and deployed the device to contracted truck drivers for data collection and managed the data collection activities.
6. Collected data on a fleet of five trucks for a total duration of 9 weeks.
7. Enhanced the software required for the mapping of the GPS logged data and the display.
8. Developed/enhanced the database for storing the collected data.
9. Collected geofencing data of all terminals

in the twin ports and distribution locations that the drayage company uses. Mapped collected GPS data and driver input to events, examine and clean up data. Developed software tools for accessing the database for data analysis and display and a Website for accessing the database.

WHAT WAS THE OUTCOME?

The development of the truck tracking device was developed and deployed on a fleet of five trucks for a total duration of 9 weeks of data gathering. The collected data has been analyzed and the research findings are summarized below:

- The GPS-tracked location data is very useful in producing a fairly clear picture of every trip that a driver makes, from origin to destination. From the 9 weeks of tracking by five drivers, we extracted a total of 2,405 transactions covering 12 port terminals at the San Pedro Bay port complex with arriving times at the terminals from 7:00 am to 8:30 pm. The transactions are grouped into three categories: terminal transactions, travel between two locations, and others.
- Terminal transactions record what task a driver enters a terminal for and for how long. The time a driver spent in a terminal can be extracted from the GPS data, and is broken down into two components: queue time and flow time, the sum of which would be the turn time. Based on these transactions we have found an average turn time of 88 minutes, a result that appears to be much longer than findings in several previous studies based on monitoring at single terminals.
- The distribution of our turn time data shows a very long tail, indicating that there are a few extremely long turn times that have obscured the average. Indeed, the median turn time was substantially lower at 68 minutes. One-quarter of the transactions in the port terminals took more than 2 hours, and 10% took more than 3 hours. These exceptionally long turn times are likely the results of trouble tickets in completing the transactions.
- The job performed in each terminal transaction

relies on driver inputs using the touch screen on the device. The accuracy of this information is less than satisfactory due to human errors. However, by matching our records and the database of the drayage company where the five drivers work, we were able to clean up and correct many of the questionable entries. At the end, 41 terminal transactions out of a total of 533 had to be excluded, resulting in a 7.7% error rate.

- The time it takes to complete a terminal transaction varies by the time that a truck arrives at a terminal. The best times in terms of fast turnaround appears to be mid-afternoon, 3:30-4:30 pm, and the evening after 7:00 pm.
- Different types of transactions take different amounts of time to perform. Our data confirm that the dual-move transactions take longer than the single-move transactions, as expected. Our data also show that picking up load is the dominant type of work that drivers go to port terminals for. All the three transaction types that include this work account for 64% of all transactions, and these transactions tend to take the longest time, 100 minutes or more. Average turn times for all other transaction types are much lower when compared to these top three. Delivering empty container also had a substantial count, a phenomenon that reflects the trade imbalance between the Pacific Rim countries and the U.S.
- Besides terminal transactions, our data also allow us to find the travel conditions that drayage drivers are enduring. A careful examination of the data produced a total of 1,045 trips that the drivers made during the monitoring period. From these trips we identified the 20 most frequently used paths that account for 34.5% of all travel. Due to the specific nature of the work types that 4 out of the 5 drivers are assigned to perform, these paths mostly covered an area within 10 miles from the ports. The fifth driver that runs general store delivery has the longest distance to travel. His most frequently traveled path has a distance of 55 miles that takes him an average of 72 minutes to complete at an average speed of 46 mph. The average speeds on all other frequently traveled paths that surround the ports range from 17 mph to 30 mph, giving a solid confirmation that the

roads in the vicinity of the port area are indeed congested.

- The travel speeds vary by work type, as shown in our findings. The averages from low to high are 19 mph for the heavy tags, 22 mph for rail delivery, 23 mph for the Target delivery, and 35 mph for the general store delivery. Compared to the Google estimated speed without traffic on these travel transactions, these averages are 26-39% below the speeds under ideal conditions.
- A drayage truck's travel is productive if it carries a container, otherwise the travel is considered non-productive. Our findings show that the percentage of non-productive travel vary by work type, ranging from the highest for the Target delivery (46%) to the lowest for the general store delivery (12%). While the non-productive travel is mostly needed for truck repositioning, a high percentage of its occurrence increases the cost of drayage, reduces driver productivity, and adds to road congestion and potential pollution. Cutting down this type of inefficiency requires proper scheduling of job orders, which would be a challenging proposition in light of the fact that visit times at port terminals are highly unpredictable.
- Our data also provided us some potentially useful information about the amount of travel that trucks made within each terminal. The average amount of travel per visit to 28 individual terminals ranges from a high 4.85 miles at APM to a low 1.13 miles at Pier C Berth C60-C62. APM is the largest terminal in terms of land area in the Twin Port Complex and Pier C Berth C60-C62 is the smallest. Our results, which show trucks tend to drive a long distance within a large terminal and a short distance within a small terminal are logical. However, there are exceptions to this rule. For example, Yusen Terminal has the second-longest average travel, even though it is the fourth-smallest among the twelve covered in our collected data. An unusually long travel length within terminal grounds may be an indication of suboptimal terminal layouts and/or terminal operation procedures.
- GPS location data are prone to inaccuracy in urban centers with a concentration of tall buildings and in the interior of buildings. Therefore, our data



on the entry and exit of a warehouse location may be subject to errors. A technology that combines the capabilities of inertial sensors and GPS is expected to reduce the degree of error.

- While GPS tracking, with or without inertial sensors, provides a wealth of data on truck movements, does not solve the challenging problem of determining the task performed on each trip and the time at which the task is executed. Our experience illustrates that accurate and timely driver inputs cannot be relied on in large scale tracking. We believe that some forms of weight sensing could be of potential use to eliminate the need for driver involvement in logging what task is performed and when it is done in a drayage trip. With such complete automation, the touch screen UI will no longer be needed and a much more compact and special purpose device can be built at a lower cost, and will have a much greater chance of acceptance by the drayage operators and drivers. We should note that the change or recharge of batteries on such device still require driver involvement and hence may still be a potential issue, and the special circumstances that cause exceptionally long delays in terminals may still be difficult to know without driver inputs.

WHAT IS THE BENEFIT?

The goal was to enable the collection of drayage truck flow data and use them for measuring inefficiency in the current system. By analyzing detailed information on driving tasks during drayage and time spent per task we can evaluate "best practices" within port drayage to make recommendations to firms and drivers. Furthermore, the data will help improve understanding of freight flows and pinpoint specific stops freight makes within the Southern California region, and would potentially be a rich and important source of data for those who model freight flows.

IMAGE

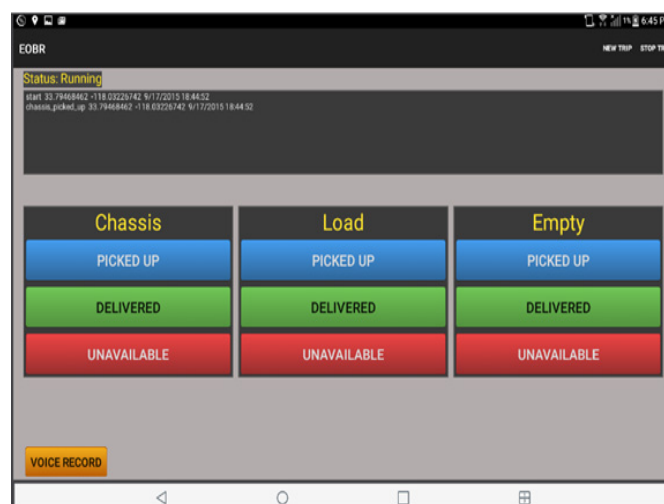


Image 1: User Interface for the Mobile Application.