Enhancement of Cross-Town Improvement Project (C-TIP) Drayage Optimization Proof of Concept - Los Angeles/Long Beach, California

Final Report

www.its.dot.gov/index.htm
Final Report – May 30, 2018
FHWA-JPO-18-676

U.S. Department of Transportation

Produced by Productivity Apex, Inc.
U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology
Federal Highway Administration (FHWA)
Intelligent Transportation Systems Joint Program Office (ITS JPO)
Cover photo source: Eric Shen, MARAD

Notice

Technical Report Documentation Page

1. Report No. **FHWA-JPO-18-676**	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Enhancement of Cross-Town improvement Project (C-TIP) Drayage Optimization Proof of Concept - Los Angeles/Long Beach, California		**5. Report Date** January 2018 **6. Performing Organization Code** FHWA-HOFM
7. Author(s) Mansooreh Mollaghasemi, Ph.D., Fabio Zavagnini		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Productivity Apex, Inc. 11301 Corporate Blvd. Suite 303 Orlando, FL 32817		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTFH61-14-F-00094
12. Sponsoring Agency Name and Address United States Department of Transportation ITS Joint Program Office 1200 New Jersey Ave., SE Washington, DC 20590		**13. Type of Report and Period Covered** **14. Sponsoring Agency Code** HVH-1
15. Supplementary Notes		

16. Abstract

This report summarizes the analysis methodology, results, and lessons learned from the deployment of the Enhanced Cross-Town Improvement Project (C-TIP) Drayage Optimization Proof of Concept Application. The system was deployed in the Los Angeles/Long Beach (California) area to five licensed motor carriers. The objective of the project was to provide solutions to help reduce the number of truck trips and improve the congestion problem over the Los Angeles and Long Beach transportation network. This document describes in detail the findings and the results from this project.

17. Keywords C-TIP, FRATIS, Route Optimization	**18. Distribution Statement**		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** **Unclassified**	**21. No. of Pages** **38**	**22. Price** **N/A**

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

Table of Contents

List of Tables

List of Figures

Executive Summary

The US Department of Transportation's (USDOT) Cross-Town Improvement Project (C-TIP) aims to develop and deploy information-sharing and -transfer capabilities that promote more effective and efficient coordination of freight moves. As part of this effort, USDOT developed a Freight Advanced Traveler Information System (FRATIS) in 2014 to improve truck operations in and around ports and other freight intermodal facilities. The centerpiece of FRATIS is an optimization algorithm that uses a variety of data to create optimal truck dispatching plans. Since initial FRATIS development, USDOT has deployed and tested several FRATIS prototypes in California, Tennessee, Texas, and Florida.

To enhance FRATIS data to better reflect trucking industry flows, USDOT also developed a Corridor Optimization for Freight (COfF) system, a framework and optimization application for integrating FRATIS data with data from trucks driving over a pre-determined portion of the highway network.

This report describes findings from a project to enhance FRATIS and test these enhancements in an urban location (Los Angeles/Long Beach), and improve the COfF for this location. This effort is also associated with the USDOT's C-TIP Drayage Optimization Proof of Concept Application, which was designed to develop and test drayage applications to help companies improve operations efficiencies.

This project completed FRATIS tests in coordination with drayage companies operating at the ports of Los Angeles and Long Beach. The project team gathered data and conducted analysis to compare drayage routing efficiency with and without the use of FRATIS. The team also developed operational metrics that allowed for robust assessment of the impacts of the enhanced FRATIS optimization algorithm.

This report provides an overview of the approach used to conduct the pilot test and analyze the results. It also discusses opportunities, challenges, and lessons learned associated with previous deployments of FRATIS as well as the Los Angeles/Long Beach deployment.

Overall the project demonstrated FRATIS' potential for substantial benefits in reduced drayage mileage and improved operational efficiencies. For example, analysis of live operational data showed that deployment of FRATIS led to a 14 percent reduction in average total miles driven. These and other benefits indicate promise for broader FRATIS deployment. However, successful deployment of FRATIS also needs to consider the highly dynamic nature of drayage operations, including the fact that companies use different methods to assign orders.

This project identifies how users interact with and experience new FRATIS functionalities, helping inform potential future enhancements to FRATIS and the COfF system. More broadly, this project helps develop a more robust understanding of the operational challenges and opportunities associated with the drayage industry. It provides an example of how drayage optimization tools deployed in coordination with drayage companies can potentially support improved industry operations, increased productivity, reduced mileage, and improved cost-efficiencies.

1 Project Overview

Freight movements via trucks represent only a small portion of total traffic volumes on the nation's highways; however, because of trucks' size, dimensions, and performance characteristics (e.g., idling, acceleration), truck movements generally have significantly greater effects on congestion, road wear, and air quality as compared to most passenger vehicles. Furthermore, truck movements in urban areas have a significant impact on regional congestion as well as air quality and fuel use. Reducing the number of truck trips can lead to congestion improvements. For these reasons, this project sought to test a tool that could reduce trucking mileage, ease congestion, and improve overall trucking efficiencies in the urban area surrounding the ports of Los Angeles and Long Beach (California).

This project is associated with the US Department of Transportation's (USDOT) Cross-Town Improvement Project (C-TIP). C-TIP aims to develop and deploy information-sharing and -transfer capabilities that promote more effective and efficient coordination of freight moves. In 2014, as part of C-TIP, USDOT developed a Freight Advanced Traveler Information System (FRATIS) for improving truck operations in and around ports and other freight intermodal facilities. The centerpiece of FRATIS is an optimization algorithm that uses a variety of data to create optimal truck dispatching plans.

To enhance FRATIS data to better reflect trucking industry flows, USDOT also developed a Corridor Optimization for Freight (COfF) system, a framework and optimization application for integrating FRATIS data with data from trucks driving over a pre-determined portion of the highway network. Specifically, the COfF system is used to create optimum routes that reduce the number of unproductive moves for trucks in drayage operations (defined here as short-haul freight movement involving pickup and delivery, such as movement from a port to a warehouse).

This effort is also associated with the USDOT's C-TIP Drayage Optimization Proof of Concept Application, which was designed to develop and test drayage applications to help companies improve operations efficiencies.

The primary objectives of the project described in this report were to develop enhancements to the optimization portion of FRATIS and then test these enhancements in order to: 1) identify potential improvements to the optimization algorithm; and 2) improve the Los Angeles/Long Beach COfF. The FRATIS enhancements developed included a Driver Mobile Application and a dynamic planning feature used to re-optimize drayage moves throughout the day using real-time data updates. The project team also sought to enhance Marine Terminal Operators (MTO) and Licensed Motor Carriers (LMC) communication protocols by developing a web-based portal to communicate data on transactions and truck arrivals to marine terminals.

It is important to note that many stakeholders use the terms C-TIP and FRATIS interchangeably; this is valid given that FRATIS evolved from C-TIP. This report uses the term FRATIS when referring to the base technology system being tested.

1.1 Understanding Drayage Operations

The Ports of Los Angeles and Long Beach currently move close to 8.8 million 20-foot equivalent units (TEU) and 6.8 million TEU, respectively. These are the first and second largest ports in the US and together represent the world's tenth busiest port complex by container volume. Many of the goods originating from these ports are destined for stores and factories in the Los Angeles metropolitan region, while other goods are distributed throughout the country. These regional and national freight movements rely on drayage routes to transport intermodal containers between pickup and drop-off locations.

Drayage routes consist primarily of local roads that connect shippers with receiver facilities. Drayage firms receive container requests for pickup at intermodal facilities and delivery at distribution centers; some of these deliveries may have appointments on the receiver side. Based on this information and other parameters discussed throughout this report, companies determine routing and schedules for assigning orders to drivers. Trucks are dispatched to distribution facilities where they proceed to a drop-off location and wait for yard cranes to load containers onto cargo ships, if they arrive with an export container. Trucks arriving with an empty chassis or as bobtail are first processed and then directed to a container pickup location. Bobtail trucks then proceed to a chassis pickup location before being loaded onto an import container. Drivers take the import containers to receivers where drivers wait for cargo to be unloaded from the truck. Alternatively, drivers perform what is known as "drop and pick" where they will drop their truck's trailer/container and pick it up at a later time. After dropping import containers, drivers usually pick up empty boxes from previous moves to be returned to specific locations determined by the steamship lines.

These operations are repeated constantly in a cycle. These ever-changing dynamics create a high degree of uncertainty for drayage operations.

1.2 System Evolution

The Los Angeles COfF prototype evolved from previously deployed C-TIP and FRATIS systems funded by the US Department of Transportation. The common purpose of these pilots was to provide a data tool and framework for improved freight operations that could work under many constraints and in different environments (e.g., congestion, insufficient communication among parties, etc.). A short description of previous C-TIP deployments is provided below.

The first FRATIS prototype was deployed in Memphis, Tennessee, in 2013 with the participation of one motor carrier. The main objective of this pilot project was to develop and deploy a solution to minimize unproductive freight moves. An optimization algorithm was developed that allowed for the assignment and sequencing of freight orders in a way that minimized driven miles, given several operational constraints. These constraints related to the order appointment times, the driving and duty hour limits for the drivers, the starting location and earliest start time for the drivers, and the overall configuration of each order. The algorithm was deployed via a web interface where dispatchers entered the orders manually and ran the optimization on the day before execution. After the completion of the optimization run, the user was provided with the capability to manually modify any order assignments and sequencing based on their preferences. The optimized orders were then sent to drivers through an on-board device. Drivers could then see their itinerary and update the status of the order in real time using the on-board device. This system was implemented successfully and generated significant operational improvements with a 13 percent reduction in bobtail miles and a 21 percent reduction in required fleet miles for executing the same number of orders.[1]

After the success of this pilot project, other FRATIS pilot projects were initiated and completed in three locations: Los Angeles/Long Beach, Dallas, and South Florida. The Los Angeles/Long Beach project had participation from one licensed motor carrier (LMC) and a single marine terminal, while the South Florida project had one LMC participate and the Dallas project had two LMCs participate. As part of each pilot, FRATIS was modified and enhanced to take into consideration each location's constraints and characteristics. For example, at the Port of Los Angeles, FRATIS was adapted to coordinate with a marine terminal's existing information-exchange systems to obtain real-time updates on order and container status. Traffic information, marine terminal waiting times, and turn times were also integrated into the FRATIS optimization algorithm, in order to account for heavy traffic congestion in the area. The user was required to manually enter orders into the system.[2]

The major accomplishment of both the South Florida and Dallas projects was identifying an approach that enabled FRATIS to integrate with existing LMC transportation management systems (TMSs) in order to eliminate double data entry. Each project took a different approach. In South Florida, data migration was scheduled to automatically populate into the system multiple times a day, so that the participating LMC always had the latest order status available on their interface.[3] In Dallas, integration was accomplished by manually uploading a flat file, which is a file without any internal hierarchy.[4] These two approaches help illuminate the pros and cons of mechanisms available to integrate FRATIS with third-party systems. However, the integration approaches in both projects were specific to the LMCs' TMSs; these approaches might not with work with other systems.

The three previous pilot deployments in Los Angeles/Long Beach, Dallas, and South Florida led to lessons learned that informed the project team's enhancement of FRATIS for Los Angeles/Long Beach. The following section describes major enhancements that the team implemented based on the experiences associated with prior deployments.

---

[1] Development of a Cross-Town Improvement Project (C-TIP) Drayage Optimization Application (USDOT; September, 2013)

[2] Los Angeles-Gateway Freight Advance Traveler Information System. Demonstration Team Final Report (USDOT; February, 2015)

[3] South Florida Freight Advance Traveler Information System. Demonstration Team Final Report (USDOT; May, 2015)

[4] Freight Advanced Traveler Information System (FRATIS) - Dallas-Fort Worth (DFW) prototype: final report (USDOT; May, 2015)

1.3 System Enhancements

1.3.1 Integration with LMC Dispatching Systems and TMSs

During the development phase of this pilot project, several efforts were made to integrate FRATIS with participating LMCs' order management and dispatching systems. However, the software companies responsible for creating and managing these systems did not grant the project team the access needed to permit seamless integration. The companies expressed concern that providing the team with access would conflict with current development of similar functionalities on company applications. Furthermore, the companies stated that they had limited technical resources to assist with the integration. Given these constraints, the project team developed a standard approach that would satisfy data migration from any TMS using a comma-separated value (csv) or Excel-formatted file report. Following this approach, the team developed a feature for FRATIS users to upload a csv or Excel file in order to import orders. Nevertheless, challenges persisted in using this approach. Not every user was able to generate the same formatted report, and each of these reports differed in file structure and data format. To mitigate this problem, the team developed a customized data-mapping module for each of the project participants called the Pre-FRATIS Module. This module standardized users' files, permitting FRATIS to read these files.

In addition to developing data import capability in FRATIS, the team developed a data export functionality feature. This new feature allowed system users to generate a report after running the optimization algorithm, which contained the resulting order assignment and schedule plan. With this capability, users could print a file containing all assignments and sequences; they could also upload these assignments to a dispatching system to expedite status update and order assignments in their systems.

The development of the data export feature in FRATIS eliminated the possibility of data double entry that was experienced in prior deployments. The feature also provided FRATIS users with a more streamlined experience.

1.3.2 Development of a Driver Mobile Application

During the development phase of the project, the team developed a mobile application along with a web dashboard tool to provide truck drivers with an on-board system to receive their assignments and itineraries in real time. This application also allowed each driver to access his or her assigned orders in an optimized sequence for execution. Additionally, using the mobile application, drivers were able to more easily update order status and location information for their assigned orders. Figures 1 and 2 show screenshots of the mobile application.

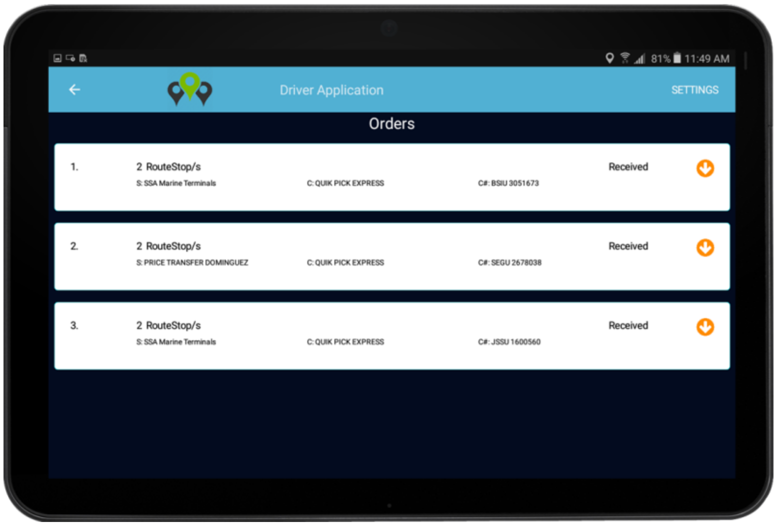


Figure 1. FRATIS Mobile App Screenshot with List of Assigned Orders
Source: Productivity Apex, Inc.

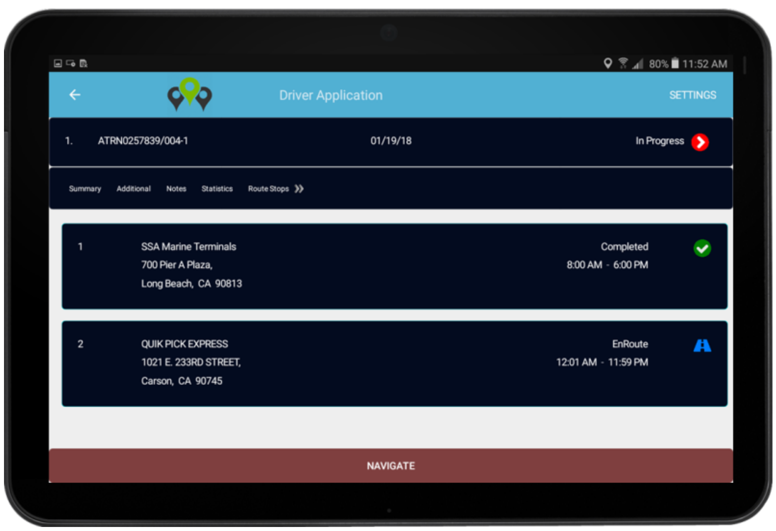


Figure 2. FRATIS Mobile App Screenshot with List of Stops in an Order
Source: Productivity Apex, Inc.

The list of features and requirements developed in the mobile application follows below:

- The mobile application was developed for both Apple operating system (iOS) and Android operating systems. Drivers from participating companies accessed the mobile application using Apple and Android tablets and/or cellphones.

- The mobile application requires that devices have data plan or internet connectivity through Wi-Fi in order to send and receive order data from FRATIS. The application can also operate without a data signal; however without a signal it cannot send or receive data. Once a data signal is available, the mobile application synchronizes with the web dashboard in order to update order status and driver information.

- The mobile application allows drivers to access their assigned orders as well as the optimal sequence in which they should be executed.

- The mobile application allows drivers to update the status of their orders by indicating—when they are en route to an order—when an order is in progress and when the order has been completed. All updates are synchronized with the web dashboard, informing dispatchers of the order status.

- The mobile application captures global positioning system coordinates from the mobile device in order to locate the drivers and use the resulting data for dynamic planning (i.e., route re-optimization) throughout the day, as well as to provide real-time driver information.

1.3.3 Integration with Traffic Services for Algorithm Travel Time Calculations

The project team integrated FRATIS with historic traffic information to enhance estimated travel time between locations. For this purpose, the team was granted access to the Regional Integration of Intelligent Transportation Systems (RIITS) database. The RIITS network is sponsored by the Los Angeles County Metropolitan Transportation Agency (Metro), and agencies including Caltrans, the City of Los Angeles Department of Transportation, the California Highway Patrol, Long Beach Transit, and Foothill Transit. The partnering agencies contribute information collected through their own Intelligent Transportation Systems (ITS) to RIITS using the Los Angeles County Regional ITS Architecture and National ITS Standards. The network supports information exchange in real-time between and among freeway, traffic, transit and emergency service agencies to improve management of the Los Angeles County transportation system and better serve the traveling public (https://www.riits.net/).

RIITS traffic data was selected for integration with FRATIS, because RIITS contains thousands of data points throughout the region that are classified by date and time of day. This information was key for use in FRATIS, given that historical data was needed in order to predict the travel time between two locations on a specific day of the week and during each hour of the day. For the purpose of this project, the tool used historical data from the previous four weeks in order to estimate travel times between locations for a given day and hour.

To accomplish this, the project team developed special queries for the traffic database so the required data could be obtained within the needed timeframe. This data was processed and mapped to the FRATIS route engine in order to match road waypoints from the two systems. Finally, a file was generated containing all the average delays categorized per day and time of day; this file was used by the FRATIS optimization algorithm to calculate the proper travel distances between locations when generating optimized plan solutions.

1.3.4 Provision of Truck Navigation with Real-Time Traffic Capability

Additional functionality developed in the enhanced version of FRATIS consisted of using real-time traffic information to support navigation between stops. The project team used the third-party application Copilot® Mobile Navigation by ALK Technologies to provide this capability. This third-party application was integrated into the FRATIS mobile application so that drivers could easily navigate to different locations along their itinerary with the click of a button. When drivers click on the navigation button for the corresponding location, the Copilot® application opens and provides step-by-step directions that consider real-time traffic, road closures, and accident information in order to minimize travel time. Figure 3 shows how the Copilot® and FRATIS applications were integrated:

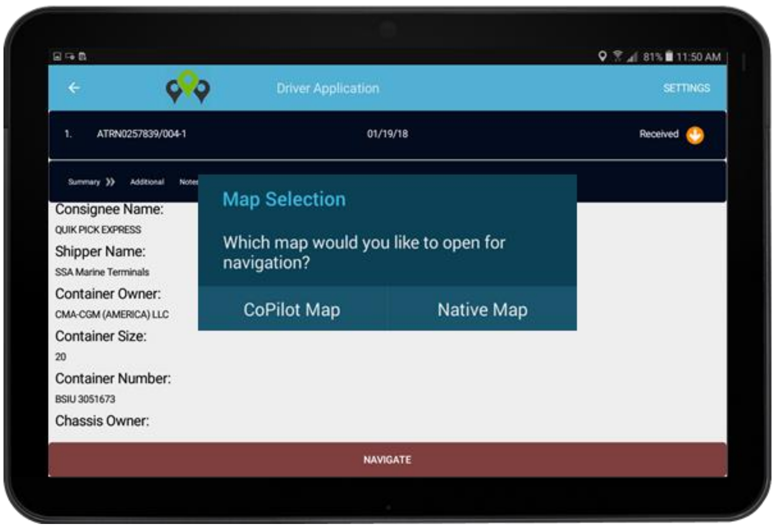


Figure 3. FRATIS Mobile App Screenshot with Copilot® Integration
Source: Productivity Apex, Inc.

1.3.5 Development of Dynamic Planning Feature for Optimization

The FRATIS dynamic planning feature was one of the most requested functionalities from previous pilot projects. This feature allows users to re-optimize their plans at any time during the day to consider the last location of drivers, the updated status of each assigned order, and the remaining duty and driving time for each of the drivers in the plan.

Additionally, users can add and remove orders as well as drivers on a particular plan. This capability allows for the incorporation of same-day or emergency orders on a day's plan, removal of drivers who cannot complete their assignment for any reason, and the reassignment of those orders to new drivers to permit efficient deliveries. Figure 4 below shows a plan itinerary containing completed orders updated through the Driver Mobile Application.

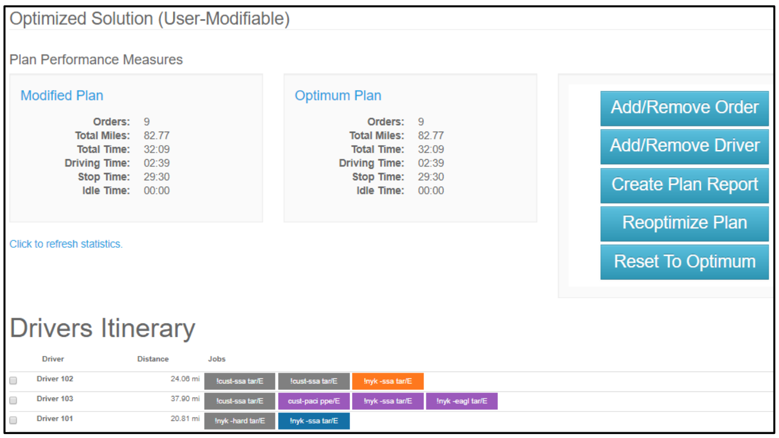
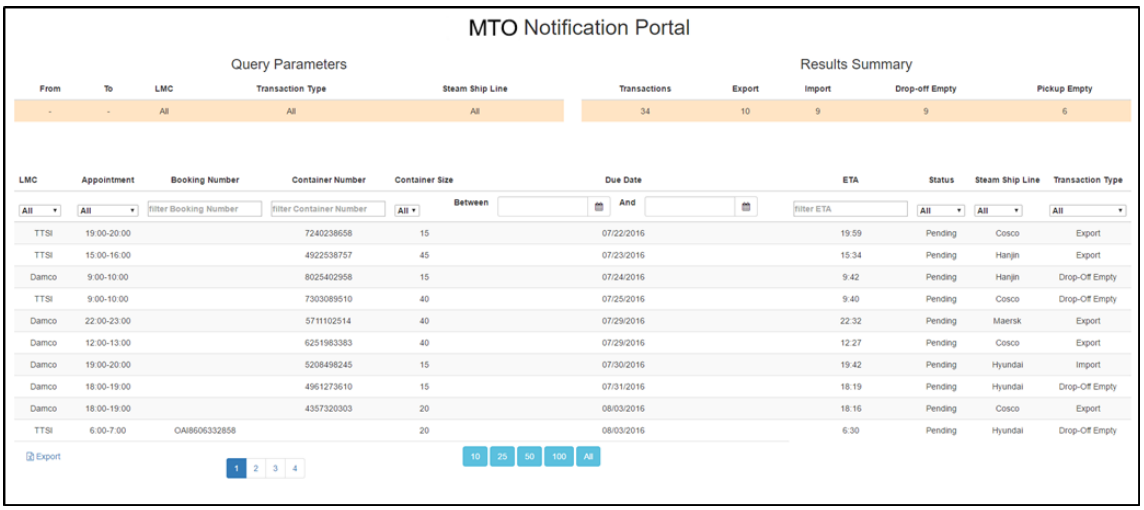


Figure 4. FRATIS Application Route Planning Screenshot
Source: Productivity Apex, Inc.

1.3.6 Development of an Online Marine Terminal Notification Portal and Open Application Programming Interface (API)

As part of this project, the team tried to obtain participation from at least three MTOs; however, MTOs in the Ports of Los Angeles and Long Beach were not able to participate. Some of the reasons that operators cited for not wanting to participate included lack of resources to dedicate to the project, and security concerns for integrating FRATIS with their systems. In consultation with FHWA staff, the project team devised an alternative solution to reach potential marine terminal participants. The alternative solution involved the development of an Online Marine Terminal Notification Portal, as shown in Figure 5, and an Open API as part of this project's system enhancement. Terminals can be granted access to the portal, which provides detailed information including estimated arrival time of upcoming orders to their facilities. The portal also provides access to an open API that operators can use to integrate with their own systems and access the same information provided through the portal. This solution allows marine terminals to estimate the number of potential transactions at their facilities in advance and categorize these transactions by type, carrier, shift, and steamship line. The information in the online portal is updated once trucks start navigating towards the terminal; current traffic conditions are taken into consideration as long as drivers are using the FRATIS mobile application. Using this system, MTOs can also identify LMC transaction cancellations or no-shows in advance.


MTO Notification Portal

Query Parameters

From	To	LMC	Transaction Type	Steam Ship Line
-	-	All	All	All

Results Summary

Transactions	Export	Import	Drop-off Empty	Pickup Empty
34	10	9	9	6

LMC	Appointment	Booking Number	Container Number	Container Size	Due Date	ETA	Status	Steam Ship Line	Transaction Type
All	All	filter Booking Number	filter Container Number	All	Between And	filter ETA	All	All	All
TTSI	19:00-20:00		7240238658	15	07/22/2016	19:59	Pending	Cosco	Export
TTSI	15:00-16:00		4922538757	45	07/23/2016	15:34	Pending	Hanjin	Export
Damco	9:00-10:00		8025402958	15	07/24/2016	9:42	Pending	Hanjin	Drop-Off Empty
TTSI	9:00-10:00		7303089510	40	07/25/2016	9:40	Pending	Cosco	Drop-Off Empty
Damco	22:00-23:00		5711102514	40	07/29/2016	22:32	Pending	Maersk	Export
Damco	12:00-13:00		6251983383	40	07/29/2016	12:27	Pending	Cosco	Export
Damco	19:00-20:00		5208498245	15	07/30/2016	19:42	Pending	Hyundai	Import
Damco	18:00-19:00		4961273610	15	07/31/2016	18:19	Pending	Hyundai	Drop-Off Empty
Damco	18:00-19:00		4357320303	20	08/03/2016	18:16	Pending	Cosco	Export
TTSI	6:00-7:00	OAI8606332858		20	08/03/2016	6:30	Pending	Hyundai	Drop-Off Empty

Export

1 2 3 4

10 25 50 100 All

Figure 5. Marine Terminal Notification Online Portal
Source: Productivity Apex, Inc.

2 Data Analysis

To better understand the impacts and user experience of the enhanced FRATIS, the project team collected order plans and execution data from one participating drayage company over four months of FRATIS deployment. The team then developed a series of modules that allowed a comparison of the company's manually generated plans with FRATIS-generated ones. The team performed statistical analysis on the results to determine what efficiencies were gained through using the FRATIS optimization tool. The resulting analysis helps illustrate the impact that FRATIS can have to reduce unproductive freight movements.

2.1 Data Analysis Methodology

The project team received and reviewed Excel files from one participating drayage company for the months of July, August, September, and October 2017. The received files contained information that included pickup and delivery time windows, order numbers, driver names and numbers, city codes, delivery dates, as well as pickup and delivery street addresses. In total, 101 days of data were provided by the participating company, with 85 days used for final analysis. Some days were discarded for reasons that included insufficient data and data affected by holidays.

As part of the analysis, the project team developed several modules to rearrange and condition the raw data for use by FRATIS. Some of these modules were Excel-based programs while others were more complex tools that used APIs like Google Maps. The modules developed are described below:

- Distance Calculation Module: This tool was used to calculate the distance traveled by drivers when provided with a list of addresses and scheduled times. This module calculated the distances driven on the executed plans.
- Analysis Formatting Module: This module prepared raw data from participating companies for entry into the Distance Calculation Module. This was accomplished by reformatting part of the data into a format recognized by the Distance Calculation Module.
- File Reconfiguration Module: This module prepared raw data for use in a later step. This was accomplished by rearranging Excel columns into a format readable by the Pre-FRATIS Module.
- Pre-FRATIS Module: This module took data generated from the File Reconfiguration Module and restructured the format to permit consumption by the FRATIS optimization algorithm. The Pre-FRATIS Module's main task is to break orders into their constituent parts, separating the pickup and delivery stop locations into individual records associated with the original order.

To calculate FRATIS mileage, the project team performed the following steps:

1. The raw data provided by participating companies was trimmed to eliminate shipments that took place outside of day shift hours (5:00am to 5:00pm) and then split into daily files.
2. Daily files were fed through the File Reconfiguration Module to re-order and format the data as required by the Pre-FRATIS Module.
3. The data was run through the Pre-FRATIS Module to separate the "drop off" and "pickup" data within the orders and to complete necessary reformatting of the data.
4. Following these two modules, the data were examined one final time for entries that might interfere with FRATIS. These included: deliveries taking place outside of the day shift, deliveries

taking place when the delivery time window was scheduled after the pickup time window, and addresses were not in standard postal format.

5. Once the correct formatting was verified, the data were uploaded to FRATIS where the optimization algorithm was run to determine the optimal route for each day's set of orders.

In addition to the process outlined above, the team undertook parallel work using the Distance Calculation Module to show the actual mileage that the driver executed while completing each day's set of deliveries. The Distance Calculation Module was developed to calculate the distance that trucks would have driven between locations using a configuration that prioritized highways and fastest truck routes. To show the actual mileage executed, raw shipment data were trimmed in an identical manner as described in step one (above) to eliminate those shipments that took place outside the day shift hours. The data were then separated into weekly files instead of the previously used daily files. The information was then fed through the Analysis Formatting Module to rearrange Excel columns into a format that could be understood by the Distance Calculation Module. This processed data could then be run through the software for actual execution mileage.

2.2 Data Analysis Results

FRATIS was designed to reduce unproductive freight moves and minimize the travel distance for drayage trucking operations by using an optimization algorithm that considers operational constraints such as appointment times, driver duty time allocations, driver starting locations and starting time, as well historical traffic conditions, among others. The following tables shows the improved efficiency that could have been achieved with use of FRATIS.

Table 1 shows results for the month of July.

Table 1. Data Analysis for July

Data Analysis Results for July	
Average Percent Distance Reduction	14%
Average Company Generated Plan Miles	1,763.15 mi
Standard Deviation for Company Generated Plan Miles	537.76 mi
Average FRATIS Generated Plan Miles	1,514.07 mi
Standard Deviation for FRATIS Generated Plan Miles	483.83 mi
Potential Miles Reduction with FRATIS	4,483.46 mi
Number of Data Points Collected	23
Number of Data Points Discarded	5

Table 2 shows the results for the month of August.

Table 2. Data Analysis for August

Data Analysis Results for August	
Average Percent Distance Reduction	15%
Average Company Generated Plan Miles	2,006.54 mi
Standard Deviation for Company Generated Plan Miles	431.39 mi
Average FRATIS Generated Plan Miles	1,700.83 mi
Standard Deviation for FRATIS Generated Plan Miles	412.45 mi
Potential Miles Reduction with FRATIS	7642.75 mi
Number of Data Points Collected	27
Number of Data Points Discarded	2

Table 3 shows the results for the month of September.

Table 3. Data Analysis for September

Data Analysis Results for September	
Average Percent Distance Reduction	11%
Average Company Generated Plan Miles	1,879.46 mi
Standard Deviation for Company Generated Plan Miles	491.10 mi
Average FRATIS Generated Plan Miles	1,674.65 mi
Standard Deviation for FRATIS Generated Plan Miles	461.54 mi
Potential Miles Reduction with FRATIS	4,300.88 mi
Number of Data Points Collected	25
Number of Data Points Discarded	4

Table 4 shows the results for the month of October.

Table 4. Data Analysis for October

Data Analysis Results for October	
Average Percent Distance Reduction	16%
Average Company Generated Plan Miles	2,066.64 mi
Standard Deviation for Company Generated Plan Miles	510.49 mi
Average FRATIS Generated Plan Miles	1,759.61 mi
Standard Deviation for FRATIS Generated Plan Miles	465.45 mi
Potential Miles Reduction with FRATIS	6,447.74 mi
Number of Data Points Collected	26
Number of Data Points Discarded	5

Table 5 shows the overall results found in the study.

Table 5. Overall Data Analysis Results

Overall Data Analysis Results	
Average Overall Distance Reduction	14%
Average Company Generated Plan Miles	1,928.95 mi
Standard Deviation for Company Generated Plan Miles	502.73 mi
Average FRATIS Generated Plan Miles	1,662.29 mi
Standard Deviation for FRATIS Generated Plan Miles	461.71 mi
Largest Improvement	30% (October 21)
Smallest Improvement	2% (August 22)
Total Data Points Collected	101
Data Points Discarded	16
Potential Miles Reduction with FRATIS	22,874.83 mi

2.2.1 *Monthly Distance Reduction Comparison*

The following figures show a comparison of the study results per month:

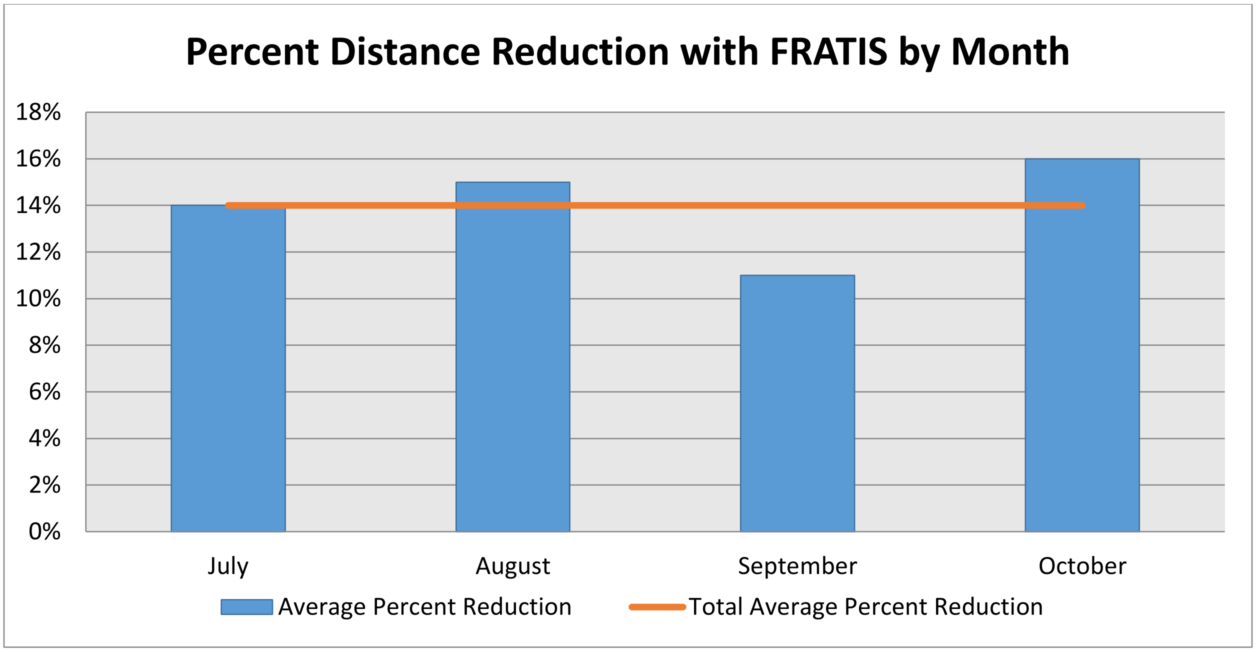


Figure 6. Percent Distance Reductions with FRATIS by Month
Source: Productivity Apex, Inc.

Figure 6 shows the average percent reduction in miles for plans generated by FRATIS for the months of July to October 2017. During this period, the month with the smallest reduction was September (11 percent) and the largest reduction was October (16 percent). The study found that overall average miles were reduced by 14 percent.

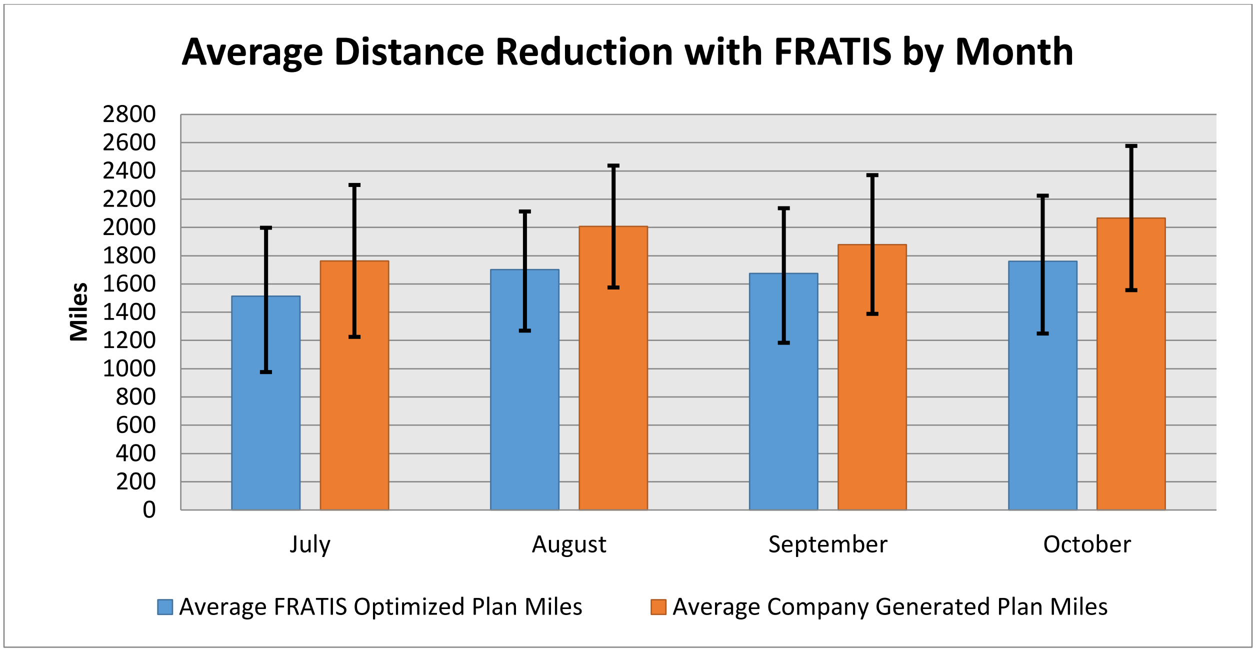


Figure 7. Average Distance Reduction with FRATIS by Month
Source: Productivity Apex, Inc.

Figure 7 compares the average number of FRATIS optimized plan miles with average company-generated plan miles for the months of July to October 2017.

2.2.2 *Daily Distance Reduction Comparison*

The following figures show a comparison of daily optimized plan miles with company-generated plan miles for each month in the analysis. Several days do not have corresponding data for the reasons discussed above in Section 2.1 (Data Analysis Methodology).

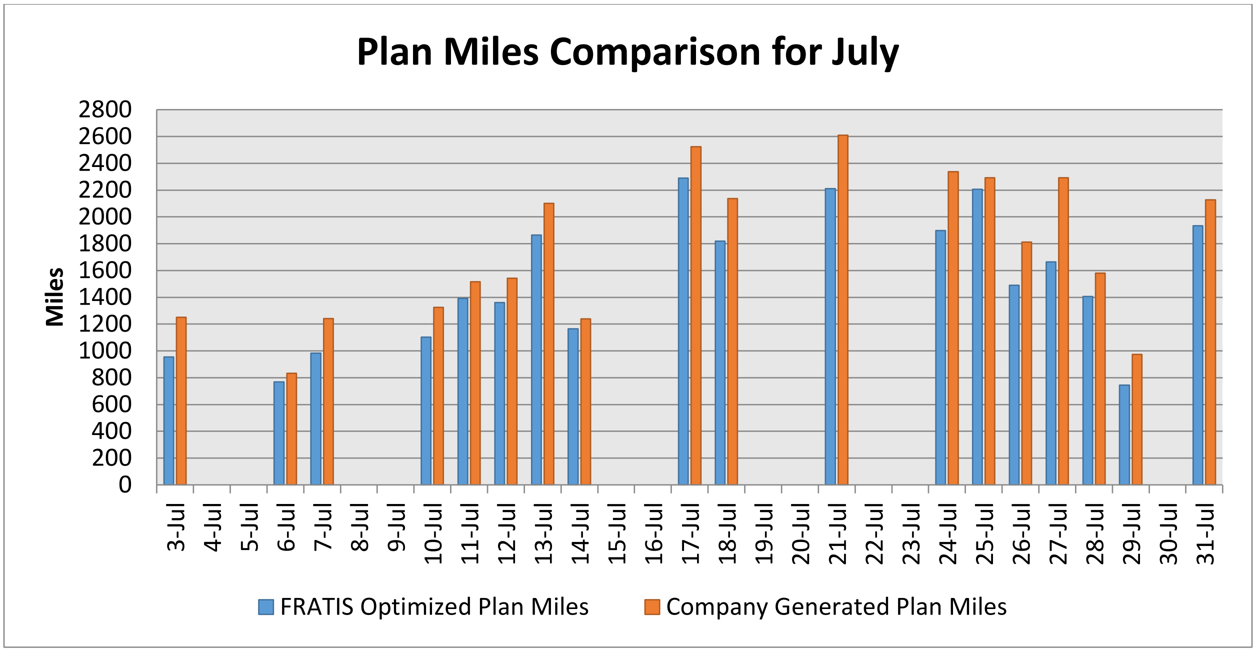


Figure 8. Plan Miles Comparison for July
Source: Productivity Apex, Inc.

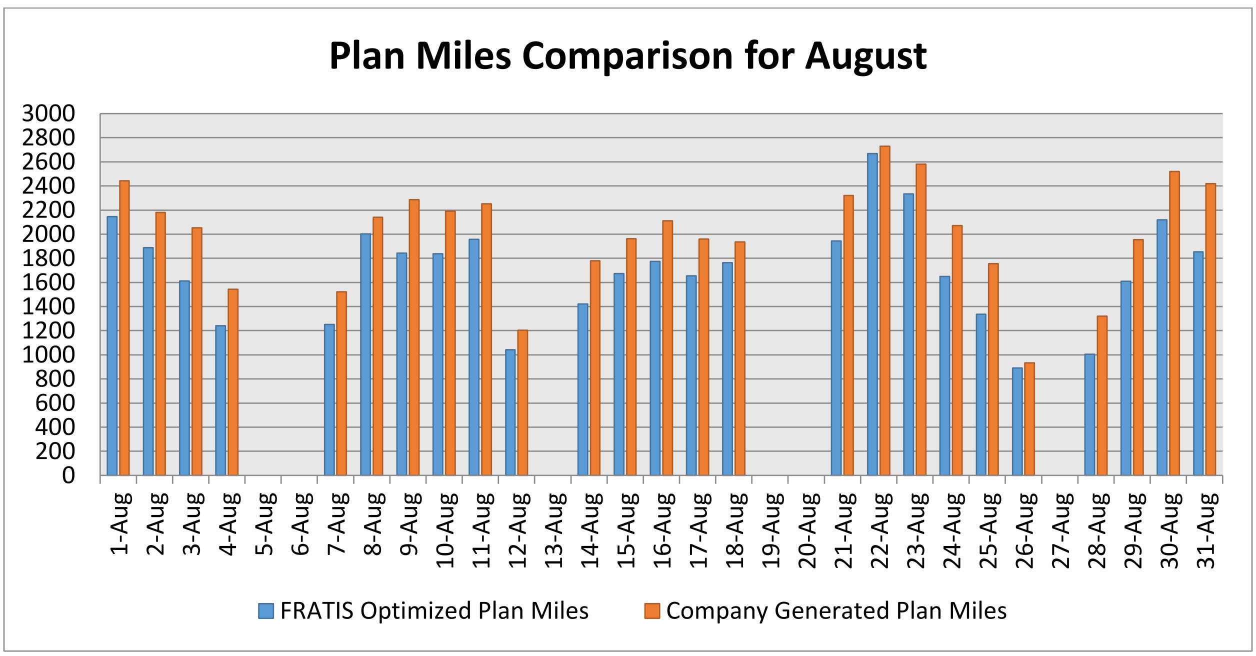


Figure 9. Plan Miles Comparison for August
Source: Productivity Apex, Inc.

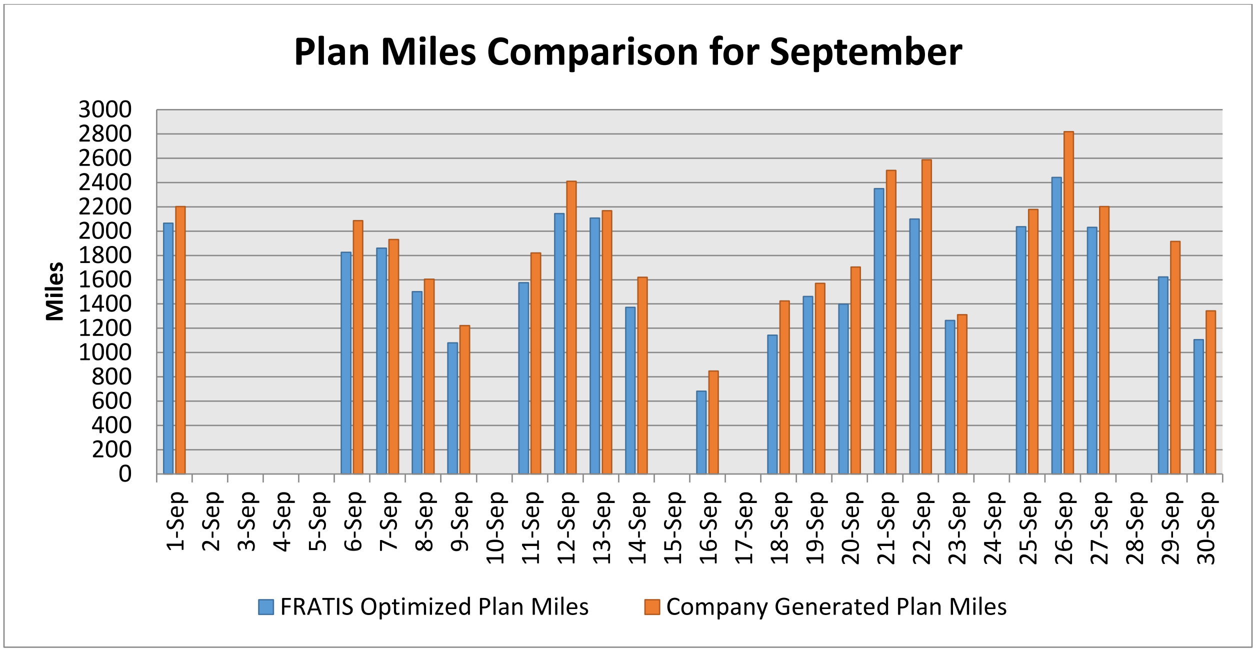


Figure 10. Plan Miles Comparison for September
Source: Productivity Apex, Inc.

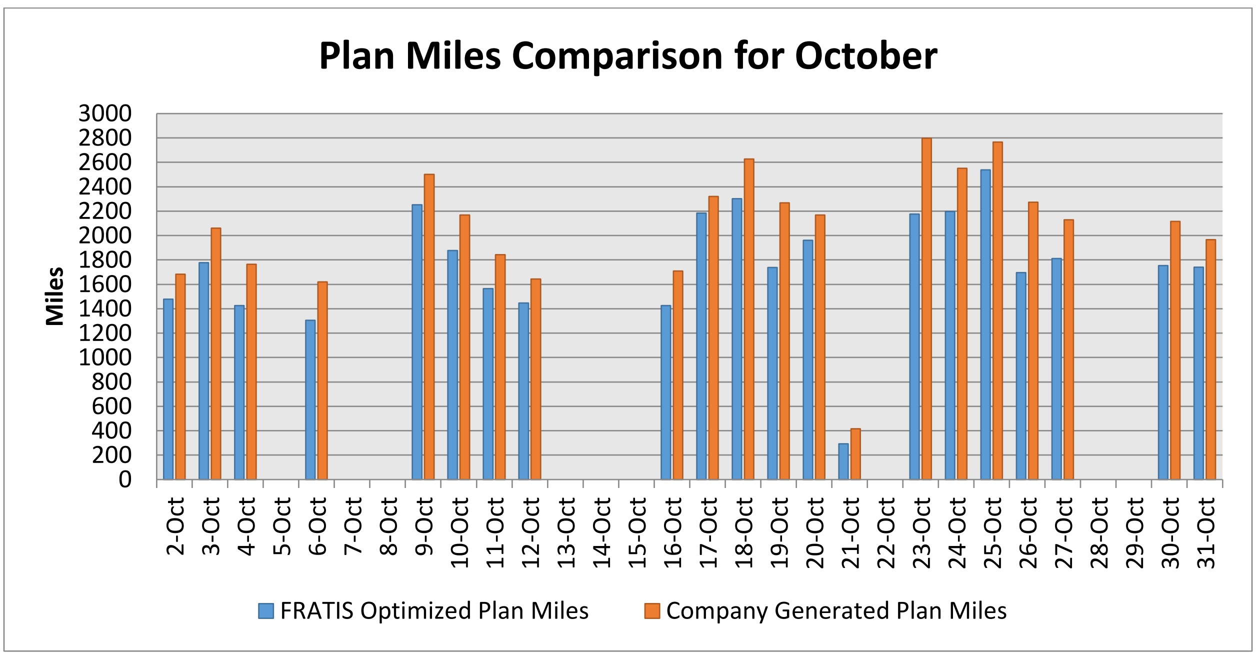


Figure 11. Plan Miles Comparison for October
Source: Productivity Apex, Inc.

The following figures compare the percentage in mileage reduction between the FRATIS optimized plans and the company-generated plans on a daily basis per month.

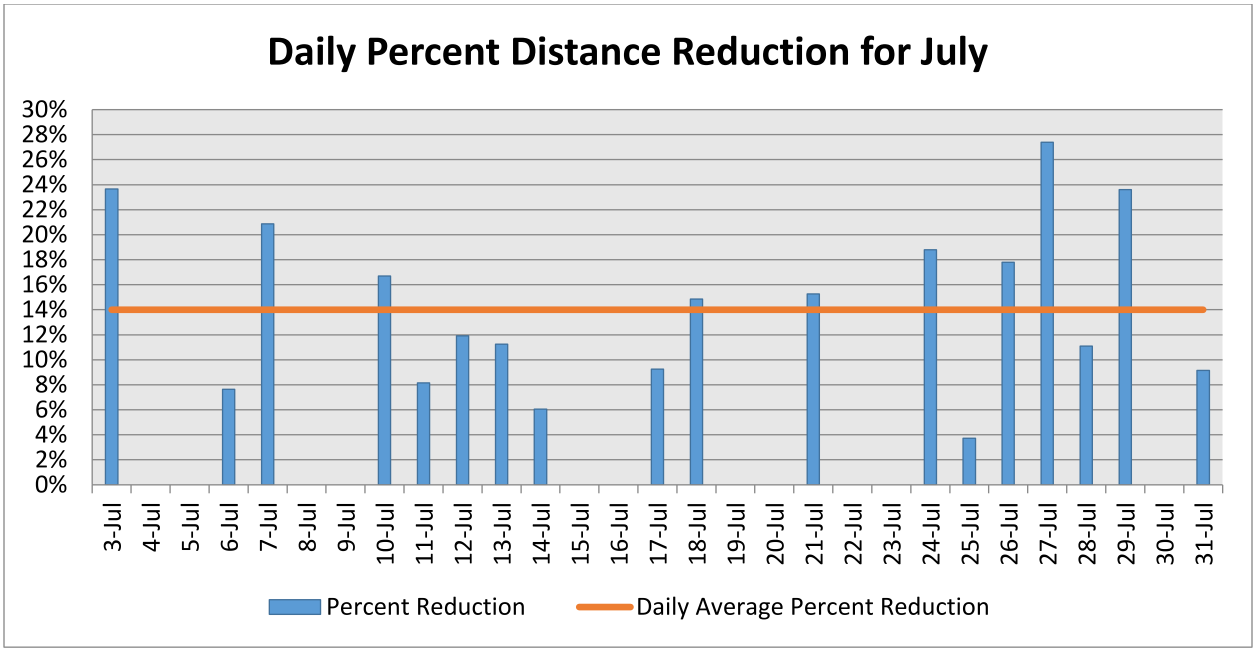


Figure 12. Daily Percentage Distance Reduction for July
Source: Productivity Apex, Inc.

Figure 12 shows the percentage reduction of daily mileage after running the FRATIS optimization algorithm for the month of July 2017. The smallest reduction was 4 percent (July 25) and the maximum reduction was 27 percent (July 27). The monthly average distance reduction was 14 percent.

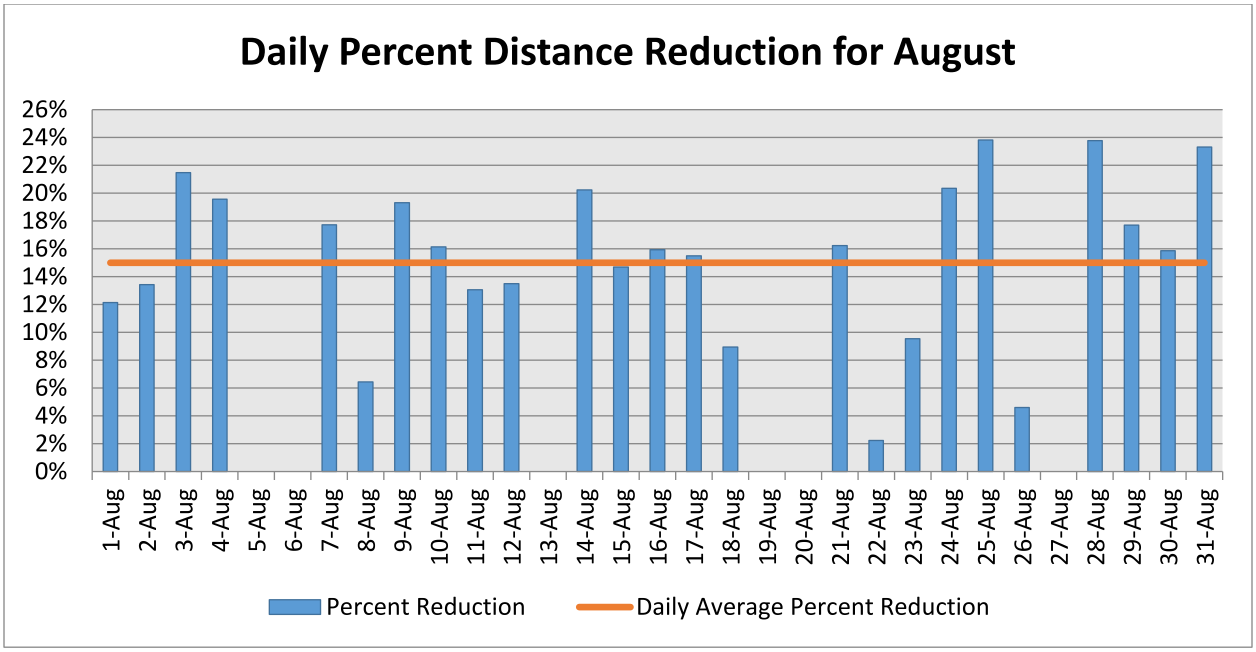


Figure 13. Daily percent distance reduction for August
Source: Productivity Apex, Inc.

Figure 13 shows the daily percentage for miles reduced after running the FRATIS optimization algorithm for the month of August 2017. The minimum value was 2 percent (July 22) and the maximum value was 24 percent (August 25 and 28). The monthly average distance reduction was 15 percent.

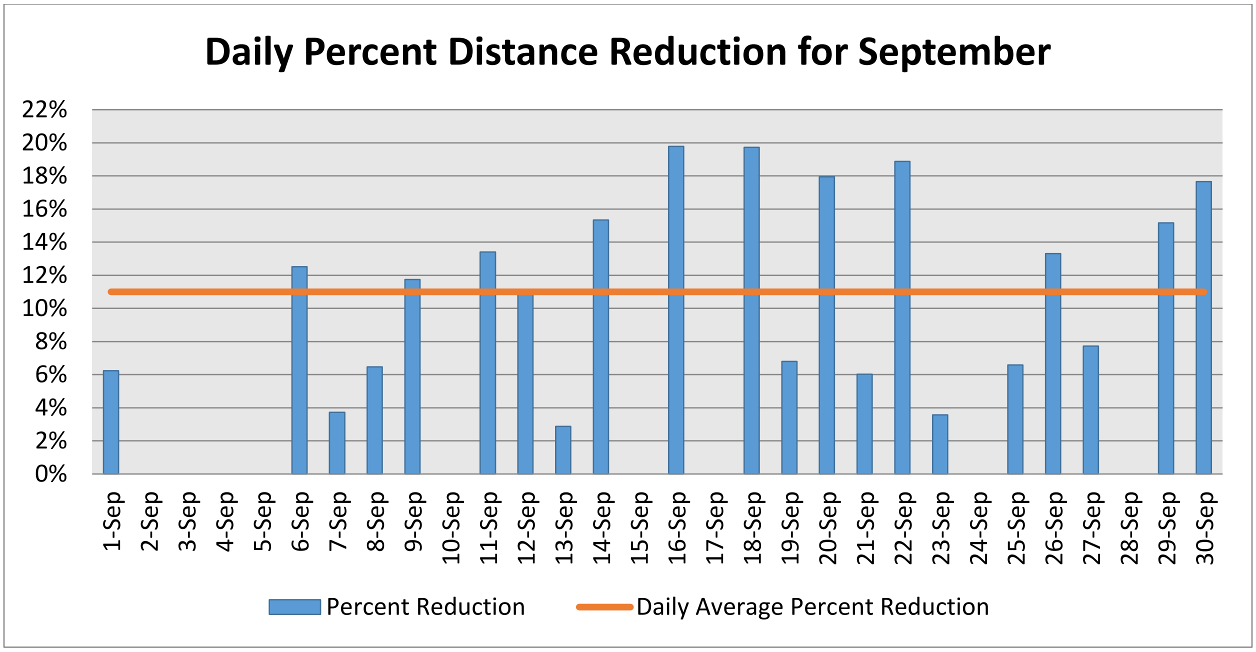


Figure 14. Daily Percentage Distance Reduction for September
Source: Productivity Apex, Inc.

Figure 14 shows the daily percentage for miles reduced after running the FRATIS optimization algorithm for the month of September 2017. The minimum value was 3 percent (September 13), and the maximum value was 20 percent (September 16 and 18). The monthly average distance reduction was 11 percent.

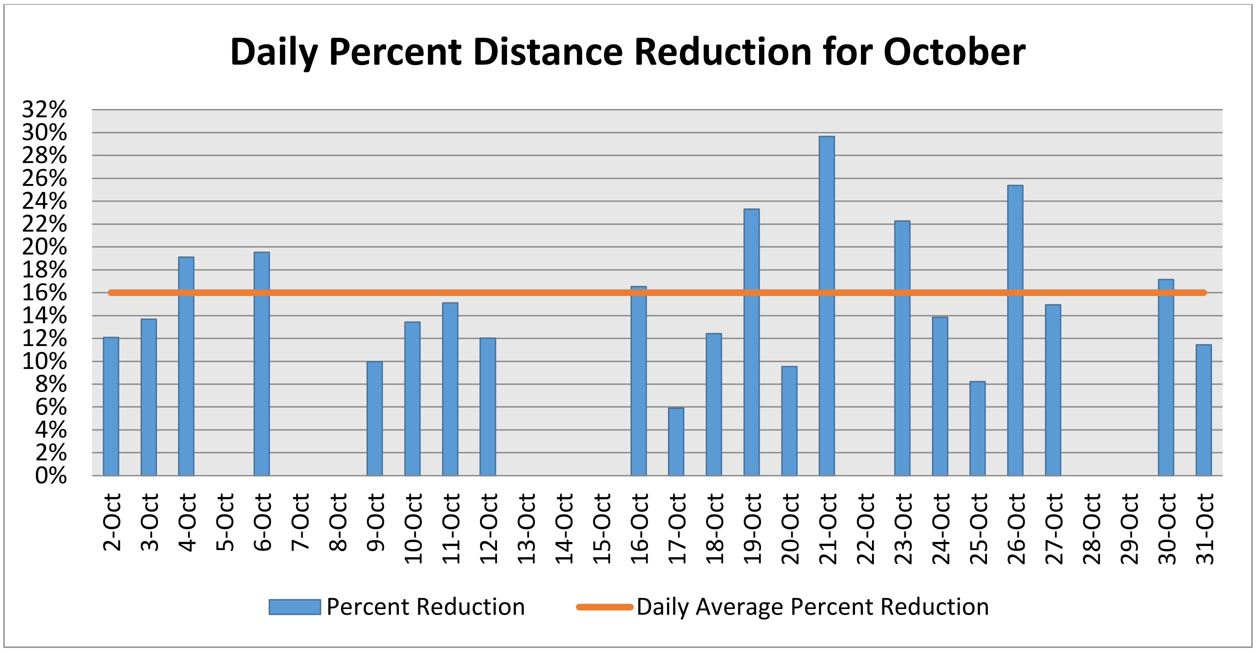


Figure 15. Daily percentage distance reduction for October
Source: Productivity Apex, Inc.

Figure 15 shows the daily percentage for miles reduced after running the FRATIS optimization algorithm for the month of October 2017. The minimum value was 6 percent (October 17) and the maximum 30 percent (October 21). The monthly average distance reduction was 16 percent.

3 Lessons Learned

One of the most critical aspects of any project is identifying and documenting its key lessons learned. This project's lessons learned convey important findings resulting from the deployment of FRATIS to support freight operations. Together with the quantitative data analysis performed for this project, these lessons learned provide valuable guidance to enhance potential benefits derived from future FRATIS deployments.

3.1.1 Integrating FRATIS with existing order management systems encouraged participants to use FRATIS and considerably reduced data entry human errors.

In previous deployments of FRATIS, participants suggested that integration with their order management systems would be key to improving the adoption of the technology. The final report of FRATIS phase one deployment in California included this as a lesson learned. For this C-TIP project, the team successfully integrated FRATIS with the participating company's order management system. This facilitated the interaction between the order management system and FRATIS. Uploading multiple orders to FRATIS took a few minutes for an entire set of daily orders (this was close to the same amount of time it previously took to enter a single order into the company's order management system). This high level of functionality played a critical role in supporting participants' increased use of the tool and also served to greatly reduce the potential for data entry human errors.

3.1.2 Different implementations of the same TMS can create challenges for integrating data solutions.

During the integration of FRATIS with each participating company's TMS, the project team found that although some participants were using the same TMS, its implementation was different at each company. This created data formatting inconsistencies that affected FRATIS' consumption of input data. The team addressed these challenges and achieved successful integration by creating a middleware customized to read and translate data configurations specific to each TMS.

Differences in data format and TMS implementation represent a challenge for integrating with solutions like FRATIS. In general, routing algorithms require certain degree of consistency in data type and format. Additional tailored integrations will need to be completed if potential users each have a custom implementation of a TMS.

3.1.3 Having accurate order data is critical to perform successful route optimization.

One of the observations made during this pilot deployment was the lack of quality control in the order data for most users. For example, in the order appointment time windows, many orders had the same appointment time for container pickup and drop-off. This made it impossible or impractical to meet the appointment times for at least one of the locations. FRATIS categorizes these types of orders as invalid; the tool will not allow these orders into the optimization algorithm, thereby reducing potential disruptions in the process and streamlining the entire flow.

When implementing systems that are highly dependent on quality and accuracy of input data, it is important to account for cases where data records may be invalid or impractical for processing. The team addressed these types of issues by identifying all potential data issues before and during deployment and subsequently updating data assumptions and data mapping each time a case occurred. The downside of this approach is that it may disrupt the ability of FRATIS to communicate or integrate with an existing TMS.

3.1.4 Methods for assigning orders to drivers are highly dynamic and are customized to the individual needs and requirements of different companies, leading to different user expectations of FRATIS.

Throughout the deployment phase of this project, differences between companies in assignment methodology were evident. Typically, trucking companies assign jobs to drivers based on multiple variables such as:

- Number of imports available for pickup at terminals.
- Number of empty containers ready to be returned.
- Length of the trip, such as a short- or long-haul move.
- Type of cargo, such as dry or refrigerated cargo.
- Chassis ownership, such as whether the trucking company owns the chassis or if it belongs to a chassis pool.
- Driver's preferences.
- Customer requests and priorities.

These variables play key roles in shaping companies' operations. They can pose challenges to developing a tool that will account for each user outcome expectation in a single routing algorithm. Addressing all of the required variables may require custom implementations or configurations of the algorithm for each user, which is difficult to accomplish in a pilot project focused on one particular deployment. Although measures were taken to find a middle ground and develop features that were common among participants, this issue represented a considerable challenge for the project.

3.1.5 Offering multimedia trainings through a range of different delivery approaches yielded significant benefits.

Previous FRATIS deployments indicated the value in providing dispatchers and drivers with more interactive training materials and increased "on-demand" support materials to address questions and concerns. During the training phase of this project, several training sessions were scheduled and delivered with each of the project's participants. Before conducting any onsite training visits, the project team developed and sent agendas to all participants and obtained early access to the participating companies' systems to ensure that all users could become familiar with the FRATIS interface and formulate questions to ask during training. In addition to conducting onsite trainings, the project team also performed live web video conferences with screen sharing to help address critical issues raised by users.

The project team developed an online help and support page containing a series of frequently asked questions (FAQs), which was made accessible to all users. Finally, the project team developed multiple videos showing in a step-by-step fashion how a user could access all of the functionalities available on both the dispatcher dashboard and the driver's mobile application.

Providing live training sessions and training materials using a range of delivery approaches had positive impacts on users' experience with using FRATIS.

3.1.6 It is challenging to effectively optimize empty returns given there are many uncertainties characterizing this particular drayage activity.

One of the primary objectives of using the FRATIS route optimization is to allow the participating trucking companies an improved ability to plan more efficient execution of daily itineraries. Earlier stages of C-TIP deployments and FRATIS pilots led to determinations that advance itinerary planning was key to realize operational improvements. However, in order to plan, it is necessary to have a degree of certainty that not found in some operational scenarios of drayage business.

For example, one issue faced by many drayage companies is determining where to return empty containers. This creates a series of costly problems, such as where and how to find storage for empty containers and paying per diem charges if empty containers are not returned on time.

Shipping lines and equipment owners determine the location where empties must be returned based on several factors, including: vessel departures, chassis availability, and storage capacity, among others. However, although empties can often be returned to multiple locations, the availability of these locations can change multiple times a day depending on the size and type of the equipment needing storage.

Dispatchers often encounter challenges in determining where an empty container should be returned (e.g., a marine terminal, a depot) in order for drivers to maximize productivity. Additionally, after dropping loaded or empty containers at a terminal, truckers are frequently asked not to leave the chassis at the terminal once containers are removed. However, current industry practice is that drivers are not paid to reposition bare chassis to other designated drop-off facilities. Some terminals prohibit drivers from entering the facilities with bare chassis and request that drivers use a bobtail when picking up containers. Failure to comply with these requirements may result in drivers’ inability to access certain terminals.

All these factors can create a highly dynamic environment that makes advance planning very challenging. During the deployment phase of this project, the project team identified that uncertainty related to drop-off locations for empty containers was a factor preventing users from adopting the plan provided by the optimization algorithm.

3.1.7 Driver preferences play a critical role in a route optimization system.

As previously mentioned, the dynamic nature of the drayage environment makes solving drayage routing problems particularly challenging. Human factors also contribute to the complexity of the environment. For example, over 80 percent of the drivers in the Los Angeles/Long Beach region are owner operators and serve as independent contractors. Therefore, when assigning orders, dispatchers must consider drivers’ preferences for specific routes. This adds more complexity to solving the routing problem as numerous other constraints such as appointment times, hours of service, and type of loads must be considered. To address this problem, dispatchers often present drivers with alternative assignments to choose from once the optimization is run.

3.1.8 Real-time dynamic planning requires real-time data updates.

Throughout the deployment phase of the project, the project team found that there is constant change in daily drayage operational conditions. Among the many ever-changing factors are stop time at pickup and drop-off locations, equipment availability at intermodal facilities and marine terminals, waiting times and turn times at marine terminals, traffic conditions, road closures, and others.

This nature of drayage operations means that feeds of real-time information are crucial to mitigate and navigate the constant change in conditions. Advance planning can therefore be challenging for the drayage industry, yet it is beneficial because it creates a clear path to follow and a sense of responsibility among all parties to commit to paths that are mutually beneficial.

3.1.9 Drivers currently use many mobile applications; adding an additional one can create challenges.

The number of mobile applications used by drivers had significant impact on their use of FRATIS. For example, drivers in this pilot used a mobile application associated with their company's TMS through which they received orders assigned by dispatchers. Additionally, many drivers used a mobile application to track and report their hours of service. In the Los Angeles/Long Beach port area, drivers also accessed mobile applications to check on waiting times at different port terminals. This information helps them (particular owner operators) decide whether or not to accept orders destined to a specific terminal. Finally, some drivers used their own mobile phones to receive calls and text messages regarding orders.

Companies that volunteered to participate in this project were made aware of the FRATIS Driver Mobile Application but expressed concern about it given the multitude of other applications in regular use. Furthermore, both trucking managers and dispatchers expressed concerns about how use of the Driver Mobile Application might affect drivers' safety and productivity (although the application was designed to lock when the driver is in motion).

4 Conclusion

The Los Angeles FRATIS/COfF pilot project described in this report evolved from previously deployed USDOT initiatives including C-TIP. As part of C-TIP, several FRATIS prototypes have been developed and deployed with the common purpose of improving freight operations across many different environments. These deployments have constituted the base for the COfF system.

The project described here developed key enhancements to the previous FRATIS prototypes, addressing gaps identified in previous deployments. These included:

1. Integration with LMCs' dispatching and order management systems.
2. Development of a Driver Mobile Application.
3. Integration with traffic services for algorithm travel time calculations.
4. Integration between the Driver Mobile Application and a third-party software (Copilot® Mobile Navigation by ALK Technologies) to make use of real-time traffic information to better support navigation between stops.
5. Development of a dynamic planning feature for the optimization algorithm.
6. Development of an Online Marine Terminal Notification Portal and Open API.

To analyze the enhanced FRATIS, the team evaluated a total of 101 days of operational data generated using drayage company legacy routing methodologies. This comparative analysis showed a consistent reduction in distance traveled (on average, a 14 percent reduction) attributed to use of FRATIS.

Key lessons learned from this project are described below:

- Integrating FRATIS with company order management systems improved FRATIS usability and considerably reduced data entry human errors.
- Significant differences exist in how different participants implement the same TMS, making it challenging to develop a FRATIS that addresses all users' needs.
- Companies have varied, legacy processes for assigning driver orders, which can make it difficult to develop a consistent modeling approach for an automated system like FRATIS.
- Certain types of orders such as empty returns contain numerous additional operating parameters that add complexities to the route planning process.
- Order data issues and inaccuracies require data cleansing efforts that need to occur before information can feed the optimization algorithm. In some cases, data quality issues can preclude their use within the algorithm or in FRATIS overall.
- Dynamic planning drives a need for real-time data updates to support the planning and optimization process.
- Driver preferences and use of existing mobile applications can pose a challenge to adoption of additional, similar technologies.
- Multimedia trainings can yield significant benefits such as improving users' perception of FRATIS. Trainings should use a variety of delivery approaches such as videos, onsite and instructor-led training, and written materials such as FAQs.

The project described in this report demonstrates the potential for important operational benefits resulting from use of FRATIS. Additional experience working with multiple trucking companies to test FRATIS will support potential further enhancements, while helping establish a more robust COfF framework.

U.S. Department of Transportation
ITS Joint Program Office – HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free “Help Line” 866-367-7487

www.its.dot.gov

[FHWA Document Number]

U.S. Department of Transportation