Freight Advanced Traveler Information System (FRATIS) Impact Assessment

Final Report

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Cover photo of the Port of Los Angeles courtesy of Kenneth Troup, 2015.

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16. Abstract

This report is an independent assessment of three prototype Freight Advanced Traveler Information System (FRATIS) tests at Los Angeles, Dallas/Fort Worth, and South Florida. The FRATIS technologies deployed at one or two drayage companies in each test area included drayage truck fleet scheduling optimization, real-time information exchange with trading partners involving arrival, departure, and status information related to current or pending container movements. Considered part of USDOT's Dynamic Mobility Applications Program, FRATIS prototype systems were tested during 2014-2015. The report includes a series of findings and lessons learned to improve future prototype tests.

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Executive Summary

In 2012, the Federal Highway Administration and Joint Intelligent Transportation Program Office initiated the Freight Advanced Traveler Information System (FRATIS) project to test information technologies at three different U.S. locations involved with handling of intermodal containers. Considered part of USDOT's Dynamic Mobility Applications Program, prototype systems were tested during 2014-2015 at Los Angeles, Dallas/Fort Worth, and South Florida. An independent assessment of those prototypes was conducted, in part based on data collected before and during the test period. This report describes the findings of the independent assessment of FRATIS.

Each prototype deployed and tested software for drayage companies that would improve the operations of those companies in moving containers between intermodal terminals and various inland shipping points. Each test also involved terminal operations personnel and had the support of regional and state transportation agencies. In Los Angeles (LA), FRATIS was implemented at Port Logistics Group and included stakeholders at Yusen Terminal. In Dallas-Fort Worth (DFW), FRATIS was installed at two drayage companies, Associated Carriers and Southwest Freight. Both moved containers to and from Intermodal Cartage Group and for the Burlington Northern Santa Fe (BNSF) Railroad. In the Fort Lauderdale area of Florida (SFLA), the FRATIS test was conducted at Florida East Coast Railway Highway Services, which moved containers to and from the railway's intermodal ramp. State agencies were involved in the portion of FRATIS in South Florida that investigated the application of information technology to emergency response and recovery operations that would be conducted following a natural disaster, such as a hurricane.

The FRATIS technologies included real-time information exchange with trading partners involving arrival, departure, and status information related to current or pending container movements. The centerpiece of the FRATIS prototypes was software that included an optimization algorithm to analyze daily container movement orders, driver information, and traffic conditions and create optimal dispatching plans. Three of the FRATIS drayage prototypes used an optimization algorithm that had been tested in Memphis. The fourth dray used a different algorithm that had been tested in Kansas City. Three of the prototypes integrated the algorithm with the drays' order systems; the fourth worked on a similar integration, but did not complete it prior to the end of the test. Each prototype had webpages related to drayage operations through FRATIS; each investigated the use of real- time traffic data and of one or more data exchanges with terminals. Two prototypes addressed measurement of wait time at terminals and two had data sent from terminals to the drays about container availability or wait time outside the terminal.

To facilitate the assessment of the FRATIS prototypes, 50 trucks for each prototype site were equipped with TomTom 510 on-board devices. They recorded truck movements throughout the day, and the assessment team used analysis tools to analyze total mileage, operating time, trip time, and stop time for the equipped fleets. Data was collected throughout 2014 so that test data could be compared with data from the baseline period before FRATIS was operational. At each prototype site, the commercial Webfleet website which displays TomTom data was available to dispatchers and their managers through FRATIS. Webfleet was used daily by two of the four drayage companies. The other two did not use it on a regular basis, but found the information to be useful when they did. Uses included tracking individual drivers, monitoring the fleet, and sometimes using the geo-fencing provision to follow particular trucks.

Although there were technical advances in the software technology of drayage optimization, two problems common to all of the sites limited the usefulness of the optimization software and prevented measurement of quantitative benefits. Those two problems were that the algorithm was only run once or twice a day in most cases, and that dispatching policy at the drayage companies was not changed. More frequent runs, if not continuous updating, of optimization are needed to effectively employ optimization in drayage trucking. Optimization requires major changes in dispatching policy that must be advantageous to drivers and dispatchers if it is to succeed. All of the drays in the test thought economic equity among drivers was an important criterion, and this was not accounted for in the optimization software. This situation was exacerbated by the fact that most drivers in the tests were owner-operators who are paid by the trip, and who influence the assignments given to them. In the benefits analysis, the assessment team found that unless the number of trips was actually increased, the optimization technology impact could not be measured in monetary terms. Another aspect of optimization that had an important impact on the FRATIS tests was integration with the drayage companies' existing order management systems. Duplicate data entry in LA seriously impeded the progress and use of FRATIS. Integration of order input was reasonably successful in both DFW and SFLA, but caused delay which adversely affected stakeholders and also resulted in unanticipated resource uses.

As proof of concept tests within FRATIS, the automated exchange of information about the availability of containers at terminals or about estimated arrival of a container was shown to work in the FRATIS prototypes. All parties were cognizant of the small container volume between a single terminal and single drayage company in LA, but stakeholders like the idea of container availability information for more widespread use with more terminals and more drays. Of particular significance, advanced arrival emails that were sent from the dray companies to the intermodal terminal and railroad in DFW will continue to be provided. Terminal stakeholders believe the information will continue to be useful. As installed at one terminal each in LA and DFW, the concept of recording terminal wait time information and providing it to drays was viewed positively by potential users. A South Florida FRATIS-developed emergency response smartphone app that automates a manual reporting function was shown to be worthwhile. The Florida public agencies which manage reconnaissance and recovery activities were particularly interested in the functionality of the app, how it would serve their natural disaster recovery efforts, and how the app could assist them in collecting and disseminating data.

The assessment team as well as the development contractors observed that the emphasis on optimization in the three FRATIS prototypes consumed resources that could have been devoted to more robust technology testing related to information exchange about terminal wait time. The reality of the optimization portion of the test was that even with all of the prototype resources consumed on optimization, the use was limited at best and it was very difficult to quantitatively demonstrate improvement. Further complicating matters was the fact that the FRATIS users were overwhelmed with current operations within their regions, which often made it difficult for them to devote time to FRATIS testing. All of the prototype tests involved overlaying or integrating new technologies with existing systems and operations. The problem with users being unable to devote enough time increased pressure on development contractor resources to help users deal with the added responsibilities of testing. The sponsors of future pilot tests need to provide enough resources and flexibility in the development contracts so that adjustments can be made as the project proceeds.

On the other hand, the involvement of numerous public and private sector stakeholders in the FRATIS tests was important to what was achieved, and the relationships and cooperation established are likely to continue well beyond FRATIS to the benefit of each region. USDOT and the development contractors expended considerable effort at the beginning of the FRATIS program to bring together drayage companies, terminal operators, port officials, and various public sector agencies. In LA, there was significant cooperation involving port and carrier associations who had not necessarily worked together well in the past. The development of the emergency management mobile application in South Florida involved several public agencies that are involved in transportation and in emergency response. Future pilots should attempt to engage a wide range of stakeholders, and invest time at the beginning to involve the stakeholders and take their needs and desires into account.

Even though one of the FRATIS technologies to be deployed was for publicly-available traveler information for freight, none of the sites actually tested that technology. This was because in each case an existing commercial solution met or nearly met the requirements and was much easier for the drayage companies to use, and would not consume as many project resources. While FRATIS ended up using commercially-available traveler data, this took both planning and investigation time that could have been better devoted to analyzing drayage operations. The proponents of advanced technology pilots should concentrate development efforts on technologies that do not exist in the commercial marketplace. This will concentrate developer attention and resources on the new technologies rather than reinventing the wheel.

The FRATIS prototype tests were useful proofs of concepts that advanced the technologies, but they did not result in measurable improvements. FRATIS indeed improved the optimization algorithm as well as its place in the dispatching policy, but FRATIS was not able to quantitatively measure how drayage operations could be improved. Other container information that was tested in FRATIS may be able to reduce stop time, but drayage dispatching policy based on optimization in FRATIS, as observed by the assessment team, does not appear to affect stop time. In both cases, quantitative impacts could not be determined.

The prototype tests ended without any monetary incentive or facilitation resources that could be applied to assist in continued operational use or expansion beyond the tests. Each drayage company was left on its own to carry on. The problem after the test was the same as before the test: operations personnel within the dray company did not have time to do justice to the use of the test data during the test, and did not have resources to push system use forward. The FRATIS test had essentially been an “other duty as assigned” for the users. Post-testing they had additional time for their day-to-day jobs.

The prototype participants’ experiences and their lack of use of the system after the test were not new. Previous pilot tests from Electronic Freight Management in Columbus to Crosstown Improvement projects in Kansas City and Memphis also were not used after the pilots were completed. In those cases as well as in FRATIS, important lessons learned are being applied to two pilot projects beginning in 2015 and should be applied to future pilots. The FRATIS technology to be deployed in the LA follow-on will include dynamic planning with multiple optimization runs based on frequency of order input with involvement from multiple dray companies and multiple terminals. A second freight improvement pilot is a follow-on involving the I-35 corridor in Texas and trucks moving on that corridor. Plans are for two trucking companies that use I-35 to participate in testing an enhanced version of the optimization algorithm to make assignment of orders related to I-35 with real time road conditions taken into account. It is important that sponsors and developers apply the lessons learned from FRATIS to the two follow-on pilots, concentrating on the technologies that stand the best chance of helping the most stakeholders in the regions surrounding the two pilots. Advanced information exchange related to container availability, congestion, and anticipated arrival should be emphasized.

Although they do not necessarily use the kinds of software and data in FRATIS, there are efforts underway at various ports and terminal locations to address port congestion, efficiency, and air pollution issues. Many are private initiatives and some are funded by ports or by local or regional governments. All of these efforts should be supported wherever possible and should include benefits measurement capabilities when feasible. Progress has been made in FRATIS and the other initiatives, but there is much work that needs to be continued to solve freight problems associated with intermodal containers.

Section 1: Introduction and Background

1.1 Dynamic Mobility Applications

For more than a decade, the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Joint ITS Program Office has sponsored intelligent transportation system (ITS) demonstration projects that apply information technology, data exchange, and connected vehicle advancements to freight transportation. In an effort to address congestion problems at ports and intermodal terminals, in October 2011 FHWA contracted for a Concept of Operations for a Freight Advanced Traveler Information System (FRATIS). As a partner in the FRATIS prototype developments and impact assessment, the Joint ITS Program Office and its Dynamic Mobility Program included the proposed FRATIS bundles of applications in its Dynamic Mobility Applications (DMA) program with the additional objective of having applications developed in FRATIS be open source, and therefore available to others through the DMA program. The DMA website (http://www.its.dot.gov/dma/bundle/fratis_plan.htm, accessed on July 20, 2015) includes the following definitions of FRATIS and its two application bundles:

> The Freight Advanced Traveler Information Systems (FRATIS) bundle of applications seeks to improve the efficiency of freight operations by using several levels of real-time information to guide adaptive and effective decision making. While much data are already available, FRATIS seeks to integrate existing data sources in a manner and with a quality that is oriented toward freight's unique operational characteristics that require different data and methods/time frames for information delivery. Also, the applications will be developed in a manner that leverages connected vehicle data. Two applications comprise FRATIS. While envisioned as separate applications, both must be present and deployed in an integrated fashion. The applications are:
>
> **Freight Specific Dynamic Travel Planning and Performance**: This application bundle seeks to include all of the traveler information, dynamic routing, and performance monitoring elements that users need. It is expected that this application will leverage existing data in the public domain, as well as emerging private sector applications, to provide benefits to both sectors. Other data includes real-me freeway and key arterial speeds and volumes, incident information, road closure information, route restrictions, bridge heights, truck parking availability, cell phone and/or Bluetooth movement/speed data, weather data, and real-time speed data from fleet management systems.
>
> **Drayage Optimization**: This application bundle seeks to combine container load matching and freight information exchange systems to fully optimize drayage operations, thereby minimizing bobtails/ dry runs and wasted miles, as well as spreading out truck arrivals at intermodal terminals throughout the day. With this application, the US DOT and industry also have an opportunity to address some key industry gaps — to truly optimize a freight carrier's itinerary, extensive communication is required from a wide range of entities (including rail carriers, metropolitan planning organizations, traffic management centers, customers, and the freight carriers themselves) in a manner that assesses all of the variables and produces an optimized itinerary. This requires the development of a powerful set of algorithms that leverage data from multiple sources. In addition to optimization, these improvements are expected to lead to benefits in terms of air quality and traffic congestion.

1.2 FRATIS Impact Assessment RFP

In 2012 FHWA initiated prototype development and tests of FRATIS in three different intermodal metropolitan areas in the U.S. Coincident with the three separate prototype development contracts was a separate independent contract to perform an impact assessment of all three prototype developments. This report describes the results of that impact assessment.

The Request for Proposals (RFP) for the FRATIS impact assessment included the following objectives:

> Analyze the impacts of the FRATIS prototype bundle of applications and to extrapolate the observed findings from the prototype demonstration to estimate the effectiveness and impacts of a full FRATIS operational deployment in the region(s) where the small scale demonstrations occur. (page 1)
>
> Advance the FRATIS bundle from concept formulation (completed in Phase 1 of the DMA program) to prototype development and small-scale prototype testing (to be completed in Phase 2 of the DMA Program) to test if the FRATIS bundle can be successfully prototyped and works as envisioned. (page 2)
>
> Conduct a comprehensive independent evaluation of the FRATIS bundle of applications. The evaluation shall entail an impacts analysis of the FRATIS prototype, analytical activities necessary to estimate the effectiveness and impacts of a full FRATIS operational deployment in the region(s) where the small scale demonstration(s) occur, and obtaining feedback from demonstration stakeholders. (page 7)
>
> The activities will include analysis of the impacts of the prototype of the FRATIS bundle of applications and extrapolating the benefits from the prototype demonstration to estimate the effectiveness and impacts of a full FRATIS operational deployment in the region(s) where the small scale demonstration(s) occur. (page 7)

In commenting on the two FRATIS bundles in the RFP, USDOT included the following requirements:

> The Freight-Specific Dynamic Travel Planning and Performance application will include all of the traveler information, dynamic routing, and highway system performance monitoring elements identified in the development of user needs for this project. The FRATIS highway system performance monitoring capability will provide benefits to agencies in terms of system management and can also supplement FHWA's Freight Performance Measures Program. (page 3)
>
> The Intermodal Drayage Operations Optimization application will combine container load matching and freight information exchange systems to fully optimize drayage operations, thereby, minimizing bobtails/dry runs and wasted miles and spreading out truck arrivals at intermodal terminals throughout the day. (page 3)
>
> The PD Contractor(s) will develop a FRATIS prototype and incorporate drayage optimization software developed for FRATIS under a separate FHWA contract (page 4)

The separate FHWA contract mentioned above and in the RFP was with Productivity Apex Incorporated (PAI) and involved development and testing of optimization software at a Memphis trucking company. That effort is described in Section 5.1.2.

1.3 FRATIS Concept of Operations

As an outgrowth of several years of pilot demonstrations in freight technology information, and through efforts at the FHWA-sponsored Intermodal Freight Technology Working Group meetings, FHWA contracted for preparation of a FRATIS Concept of Operations (FRATIS ConOps), which resulted in several related volumes that defined requirements and documented an overview of current freight management practices as well as existing use of technology and freight data (*FRATIS Concept of Operations – Final Report* August 2012 FHWA-JPO 12-65; *Assessment of Relevant Prior and On-Going Research and Industry Practices* August 2012 FHWA-JPO 12-67; and *Assess Test Readiness of FRATIS (Task 4)* August 2012 FHWA-JPO 12-68). A highlight of the FRATIS ConOps was a survey of more than 300 trucking companies, mostly small drayage firms with fewer than 40 trucks. The results determined that 39 percent of the firms in the survey had no technology-based travel information system. Their reasons for not having technology included:

- Lack of accurate information
- Inconsistency among sources
- Poor coverage of freight terminals
- Lack of awareness of such tools

Technology users identified terminal information as the primary coverage gap, followed by freeway conditions and conditions on arterial streets. The users' issues were inconsistency of data sources, data accuracy, and timeliness of data, and those applied to non-technology users as well.

The contractor who developed the ConOps, Cambridge Systematics, conducted five public-private user needs workshops across the United States as part of the annual Intermodal Freight Technology Working Group series of meetings. The result was the series of critical needs shown in the table below as derived from the ConOps.

Table 1. Critical FRATIS User Needs

Designed for areas with significant freight congestion
Comprehensive coverage of land-based supply chain
Information coverage of most levels of roadway network types
Near real time information on terminal queues and roadway conditions
Provide roadway conditions information to dispatchers and drivers
Accurate data with robust error checking
Performance measures for public use in transportation planning

Source: Cambridge Systematics FRATIS ConOps Table 3-1

Then, based on further analysis of the user needs and the results of the aforementioned ConOps survey, the contractor defined the Essential Functions shown in the table below, which should be performed by the two FRATIS application bundles defined earlier:

Table 2. ConOps Essential Functions

Real-time information for freeways, port/terminal regions, major freight arterials
Preplanning regional truck trips
Congestion avoidance dynamic routing of trucks
Automated routing and permitting for oversize/overweight trucks
Real-time route-specific weather conditions and forecasting
Real-time information on length and wait times for truck queues at freight terminals
Real-time information on container status and appointments at intermodal terminals
Freight transportation performance measurement data for public sector
Container load-matching with trucks at intermodal terminals

Source: Cambridge Systematics FRATIS ConOps Table 4-1.

1.4 TRB Truck Drayage Productivity Guide

The Transportation Research Board's National Cooperative Freight Research Program sponsored research into drayage operations, the result of which was the *Truck Drayage Productivity Guide*. Published in 2011 as NCFRP Report 11, this guide provides a useful overview of drayage problems, potential solutions, and the types of benefits that can result from improvements in drayage operations. The Guide corroborates the deficiencies and gaps discussed earlier which FRATIS hoped to improve, and shows the context in which FRATIS was developed. In its Overview of Port Drayage, NCFRP Report 11 noted:

> The principal challenge for the dispatcher is to allocate resources (trucks) across orders in a way that keeps all trucks working productively while still meeting the delivery windows of the customers, which can vary based on the customer demands and commodity type. Truckers, who are paid per load, rely on dispatchers to ensure that their assigned daily schedule minimizes the number of miles they drive without a load and the time they spend waiting for a load to be ready. (page 2)
>
> Drayage companies and their drivers are remarkably adaptable, but the complexity of their task leads to inefficiencies, delays, excess costs, and unnecessary emissions. (page 2)

Against that resource allocation challenge the FRATIS prototypes were initiated at three sites in the U.S. Indeed, the principal FRATIS users were to be the dispatchers and drivers mentioned above. NCFRP Report 11 also extensively discussed drayage problems, which are shown in the following table.

Table 3. Drayage Problems

Long and unpredictable turn times
Long and unpredictable marine terminal gate queuing
Marine terminal gate processing delays
Marine terminal procedural exceptions and trouble tickets
Container chassis supply time and delays
Marine terminal container yard congestion delays
Marine terminal disruptions
Extra drayage trips ("dry runs")
Extra empty equipment moves
Congestion on streets and highways

Source: TRB NCFRP Report 11, Tioga Group et al, page 33

One additional aspect of the drayage problem, as described in NCFRP Report 11, is sub-optimization of the intermodal system. The following paragraphs from that report provide an excellent picture of the complexity of drayage operations and the context in which the three FRATIS prototype sites conducted their development and testing.

> A substantial portion of the delays and bottlenecks in port drayage are traceable to sub-optimization of the complex intermodal system. Drayage firms and marine terminals would both prefer an even, predictable, and uninterrupted workload over the day, week, month, and year. The context in which they operate, however, makes that unlikely to ever happen. A system optimized for the drayage customers (the importers and exporters) is unlikely to be optimal for the marine terminal customers (the ocean carriers). There is no one in charge of the entire process, so rational and well-informed actions by participants still do not optimize the whole.
>
> It is helpful to place drayage and terminal operations in context. Drayage of marine containers to and from port terminals is a complex process involving interactions between customers (importers, exporters, 3PLs), ocean carriers, terminal operators, and trucking firms. The fundamental transaction is between the ocean carrier and the customer, with the customer paying for waterborne transportation of the goods inside the container. Marine terminal operations and drayage are intermediate steps, and both must cope with the movement preferences, policies, and capabilities of the ocean carriers and their customers. This intermediate position requires both drayage firms and marine terminals to cope continually with unevenness of demand, inconsistent priorities, mismatched information flows, and cost pressure. (pages 42-43]

1.5 FMC Port Congestion Forums

Because of the port congestion crises occurring throughout the U.S. in 2013-2014, the Federal Maritime Commission (FMC) convened a series of Port Forums to discuss port problems with stakeholders. FMC documented the results of those meetings in an important July 2015 report, *U.S. Container Port Congestion and Related International Supply Chain Issues: Causes, Consequences, and Challenges.* One of the key issues investigated was port drayage. In introducing the drayage problem, FMC said:

> Although the underlying causes of this congestion usually have little or nothing to do with draymen, congestion costs are felt most immediately and acutely by them. This is because the predominant model for drayage trucking in the U.S. is the independent owner operator (IOO) who contracts his services to a licensed motor carrier (LMC) and gets paid by the trip. Port congestion severely impacts the number of trips per day the driver is able to achieve. Consequently, the most immediate cost of container terminal congestion is not borne by the terminal operators, longshore labor, steamship lines, shippers or the port authority, but by drayage drivers. (page 51)

Against the backdrop of the complex drayage environment in ports and intermodal terminals, the negative impacts of congestion on drayage, and the concepts developed in the 2012 *FRATIS Concept of Operations*, USDOT embarked on three simultaneous prototype developments aimed at improving drayage operation. The developments and tests are described in the remainder of this report.

Section 2: Prototype Site Descriptions

This section provides an overview of the three sites at which FRATIS prototypes were implemented: Dallas-Fort Worth, Los Angeles, and South Florida. Each prototype test has been documented by the appropriate development contractor and the reports are listed below. The final reports contain lessons learned, some of which are drawn upon or summarized in this report. The summary for each prototype site below describes the site, including its geography, transportation network, principal drayage companies and intermodal terminals involved, and other stakeholders as appropriate. The three FRATIS prototype reports listed below were principal sources of descriptive information about the prototype sites:

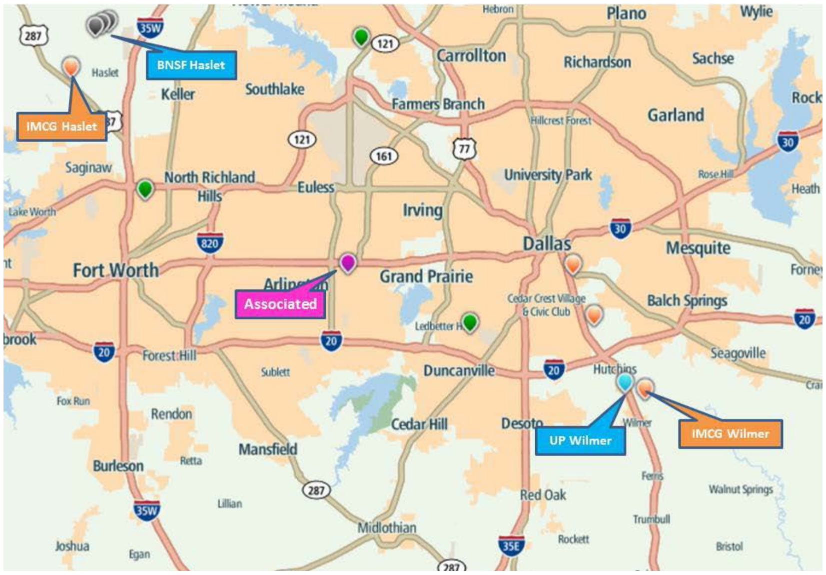
- Freight Advanced Traveler Information System – Dallas-Fort Worth (DFW) Prototype Final Report FHWA-JPO-15-220, May 22, 2015
- Los Angeles-Gateway Freight Advanced Traveler Information System: Demonstration Team Final Report FHWA-JPO-14-197, Feb. 2, 2015
- South Florida Freight Advanced Traveler Information System: Demonstration Team Final Report FHWA-JPO-15-216, May 2015

2.1 Dallas-Fort Worth

Dallas-Fort Worth is the fourth largest and one of the fastest growing metropolitan areas in the United States. DFW is a prime gateway for the movement by truck of imports and exports to and from Mexico and the lower 48 states, anchored by two large Class I rail terminals, numerous dray companies which support them, and the many distribution and warehouse centers in the region. DFW has some of the busiest and most congested stretches of interstate highways in the U.S. The FRATIS DFW prototype sought to improve the efficiency of operations in two participating drayage companies that move ocean containers and other intermodal shipments to and from the railroads. Associated Carriers (Associated) and Southwest Freight International (Southwest) were the drayage stakeholders in FRATIS, along with the Intermodal Cartage Group in Wilmer, Texas (IMCG-Wilmer), a container facility that primarily handles empty containers for the ocean carriers.

Associated is a Metro area container pickup and delivery carrier based in Arlington, Texas, and their operations include local cartage, two intermodal divisions, a regional and long haul dry van division, a freight brokerage division, and a warehousing division. Their Arlington facility is located between the Union Pacific Dallas Intermodal Terminal and BNSF's Haslet facility near Fort Worth. The figure below presents a TomTom WebFleet map highlighting the location of Associated and the two key rail terminals. The green icons represent customer locations (without names). Associated's fleet includes over 60 vehicles; approximately 35 percent use company drivers and the remainder are owner-operators.

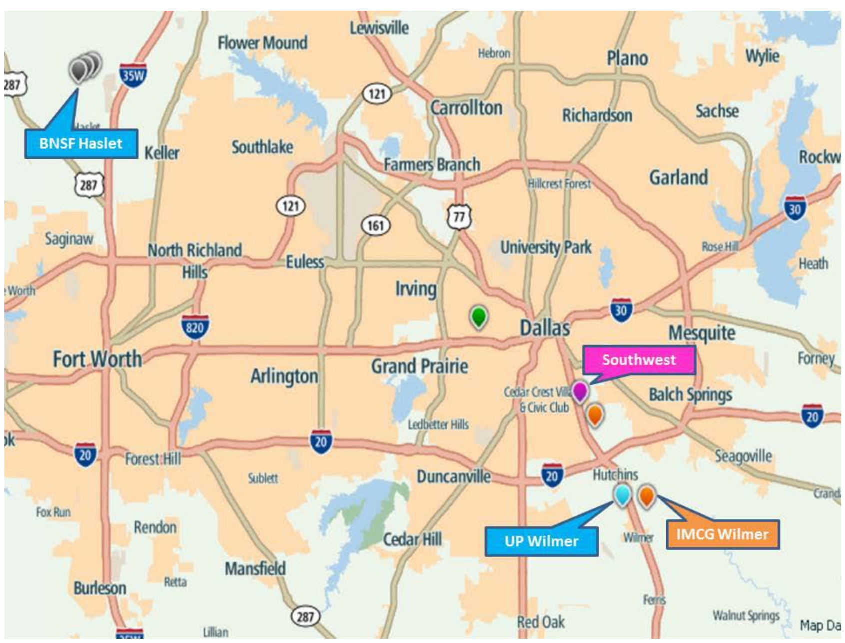
Figure 1. Associated Carriers DFW Map



Source: Leidos FRATIS DFW Final Report

Southwest is a local and regional container pick-up and delivery carrier located in South Dallas near the Union Pacific Dallas Intermodal Terminal noted above (see Figure 2 below) and provides ocean container drayage services from DFW rail terminals with pick-up and delivery throughout the south including Texas, Oklahoma, Arkansas, and Louisiana. Their operations include local and interstate intermodal drayage as well as local and regional less than truckload (LTL) and full truckload (FTL) delivery. Their Dallas facility is a bonded U.S. Customs Centralized Exam Station. Southwest employs 120 drivers, with a mix of owner-operator and company-employed staff.

Figure 2. Southwest Freight DFW Map



Source: Leidos FRATIS DFW Final Report

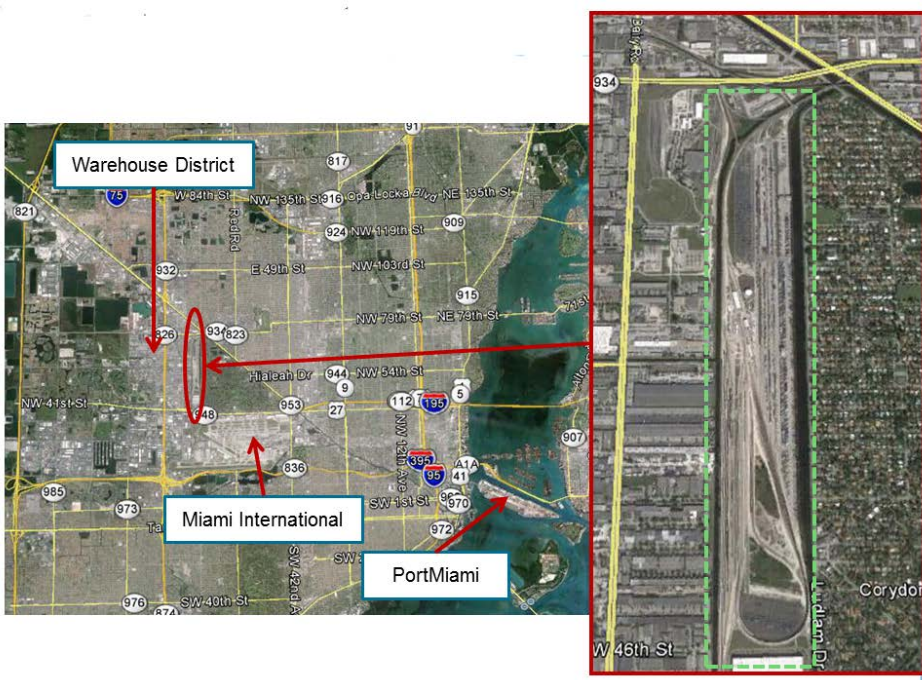
IMCG-Wilmer is an intermodal container facility that handles empty containers for ocean carriers. It was a stakeholder in FRATIS as the recipient of advanced arrival information and as a provider of terminal wait time information for the dray companies.

2.2 South Florida

According to the FRATIS South Florida Final Report, South Florida is considered the international trade gateway to the Americas. It has a large and growing population and hosts many tourists. The greater Miami area is said to be the leading U.S. port of entry for perishables, including flowers and produce. The region has two of the state's largest seaports and has an established network of roadways that provide the freight industry with access to and from key trade gateways, warehouse and distribution centers, and regional and hinterland markets. These roadways have become more and more congested as the region has continued to grow. Congestion could be even worse in the future because of an anticipated surge in international trade driven by significant investments at Port Miami, Port Everglades, and Miami International Airport. South Florida, given its susceptibility to major storm events and its comprehensive emergency response program, provided an opportunity to test the use of technologies to streamline post-event recovery activities involving the freight industry.

Florida East Coast Railway (FEC) Highway Services was the dray company chosen for the FRATIS prototype. Its offices and terminal in Miami's warehouse district are shown in the figure below.

Figure 3. FEC Highway Services Location



Source: Cambridge Systematics South Florida FRATIS Final Report

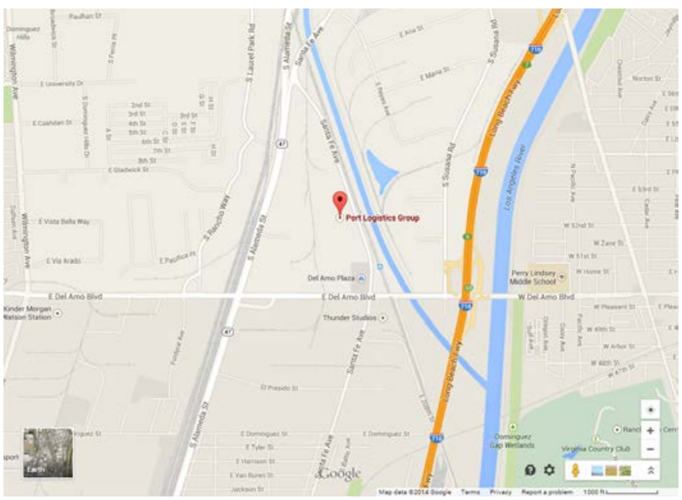
FEC's primary operating function is rail intermodal pick-up and delivery from its parent railroad, Florida East Coast, to customers throughout South Florida. FEC Highway Services operates a fleet of more than 100 trucks with operations in Miami, Ft. Lauderdale, Jacksonville, and Atlanta. There are about 80 trucks, all owner-operated, in the Miami area and FEC performs about 90,000 moves per year, mostly as part of a larger rail move. FEC uses customer appointments to schedule loads when a train arrives. The FRATIS prototype test of the emergency management application involved public sector agencies in the Miami area including regional and state emergency management organizations.

2.3 Los Angeles

The area of Southern California south of Los Angeles contains the two largest ports in the United States and a large array of freeways and interstates. The Ports of Los Angeles and Long Beach and the freight-centric communities, warehousing and distribution centers, and transportation infrastructure that serve them (collectively termed the L.A.-Gateway Region) handle more than 40 percent of the nation’s import traffic and about 25 percent of its exports. Port congestion and the impacts of port-related transportation on the surrounding communities and roadways have been of concern for some years. The two ports implemented a fee-based program intended to move some port traffic to evening hours. The FRATIS prototype was intended to help drayage companies operate more efficiently.

Port Logistics Group (PLG) was chosen as the drayage company for the FRATIS LA prototype. PLG is a seaport terminal container pick-up and delivery drayage company with an all-owner-operated fleet of 46 in Rancho Dominguez serving the ports of Los Angeles and Long Beach, as shown in the figure below. PLG moves about 25,000 containers annually and has eight facilities in the Los Angeles region, with three million square feet of space and a complete range of services including drayage, trans-loading, cross-docking, warehousing, distribution, and 3PL services.

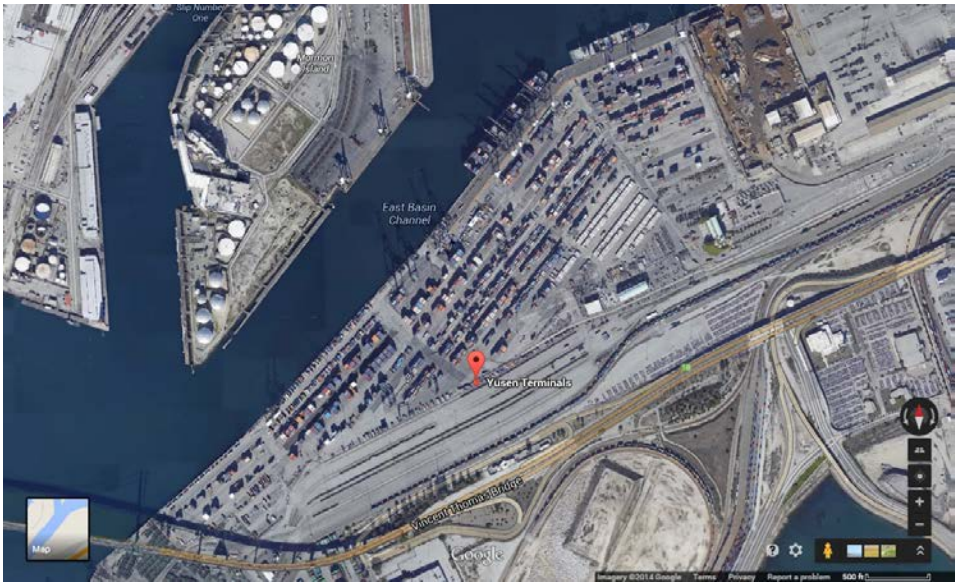
Figure 4. Port Logistics Group LA Location



Source: Cambridge Systematics FRATIS LA Final Report

Another stakeholder in FRATIS LA was Yusen Terminals Inc. (YTI), one of the marine terminal operators at the Port of Los Angeles. YTI operates a state-of-the-art 185-acre terminal on Terminal Island which handles 1,400 containers per week (see the figure below). The intermodal container facilities include 16 entry lanes with 6 scales, 7 exit lanes, 1,200 wheeled slots, and a near-dock rail facility. YTI agreed to work with PLG on two-way communications of container operations-related issues during the FRATIS prototype test.

Figure 5. Yusen Terminal LA



Source: Cambridge Systematics FRATIS LA Final Report

According to the FRATIS LA Final Report, principals at PLG and at YTI have been leaders in working with local and regional public-private groups including LA Metro and the Gateway Cities Council of Governments in advancing port improvements, the FRATIS prototype, and related ITS efforts. It should also be noted that throughout the 2013-2015 period of the FRATIS prototype development and test, the Los Angeles port area experienced almost continual and nearly unprecedented port congestion. While this gave the project participants further incentive to make needed improvements in drayage operations, the need to deal with the congestion issues diverted attention and resources to complete current drayage business.

Section 3: FRATIS Transformative Benefits and Requirements

The FRATIS Concept of Operations (ConOps) included discussion of the anticipated benefits of widespread implementation of FRATIS. The table below was derived from a list of potential benefits included in the ConOps.

Table 4. ConOps Anticipated Benefits

Improved drayage productivity
Congestion avoidance
Reduced idling at terminal gates
Fuel savings and reduced emissions
Better asset utilization
Improved customer service/adherence to delivery windows
Improved trip planning
Improved data for freight planning

Source: Cambridge Systematics, FRATIS ConOps, Table 5-1.

Anticipated benefits were further discussed in a related companion document, *FRATIS Concept of Operations: Assessment of Prior and Ongoing Research* (August 2012) (referred to below as the *Prior Research* report), that looked at other advancements being pursued in the logistics technology industry. That document explored in more detail some of the anticipated benefits and introduced what became the transformative benefits that were included in the FRATIS assessment RFP. According to the *Prior Research* document:

> These goals and performance measures are based on the results of this state-of-the-practice scan, additional Internet research, and the collective experience of the consultant team. (page 96)

FRATIS transformative benefits from the *Prior Research* report and the FRATIS assessment RFP are described below. The definitions were taken from the approved FRATIS Impact Assessment Plan. Measures are likely to be applied to the number of trips and trucks during a particular time period, whether daily, weekly, monthly, or for a testing period, and represent averages over the time period.

- **Number of bobtails** – This is a count of the number of trips in which a truck is not carrying a chassis, trailer, or container. Typically drivers are not paid for bobtails, so they represent unproductive, albeit sometimes necessary, moves. A key objective of FRATIS is to reduce the number of bobtail trips in the test period compared with the baseline.
- **Travel time** – This represents the time from an origin (typically a customer with a loaded container) to a destination (a rail or ocean terminal, or the reverse trip of a load from the line haul carrier to a consignee site). Travel time can obviously vary by time of day and is affected by traffic conditions. The premise is that with better information and optimal routings based on FRATIS, the average travel time for a drayage fleet will decrease.
- **Fuel consumption** – This is directly related to travel time, but is also affected by unexpected or long delays. The presumption is that fuel consumption will decrease because optimal routings

- **Fuel consumption** – This is directly related to travel time, but is also affected by unexpected or long delays. The presumption is that fuel consumption will decrease because optimal routings and the ability to find alternate routes in real time may allow a truck to keep moving and avoid incidents or areas of major congestion. Because of the devices in use in the FRATIS test, fuel consumption will be calculated from total miles traveled by a truck or fleet.
- **Emissions** – If fuel consumption is lower, the related emissions from trucks will be lower. In addition, reducing idling time or avoiding sitting in traffic will help reduce emissions. The assessment team planned to calculate emissions based on miles traveled and fuel consumed using the EPA Smartways DrayFLEET model. NCFRP Report 11, *Truck Drayage Productivity Guide* contains an excellent discussion of the use of the model and the required inputs and results.
- **Terminal queue time** – This is the amount of time a truck spends waiting to get into the intermodal terminal. FRATIS is intended to help both the drayage company and the intermodal terminal operator by providing advanced and real time information about traffic conditions in and around terminals. With the optimization based on historic trends of terminal congestion, the combination of the optimal routings, and the ability to use real time information to alter arrival schedules at terminals, terminal queue time should be reduced.

The *Prior Research* report also provided performance targets in three timeframes: near term, corresponding to the next 5 years; midterm, which is 5-10 years out; and long-term, which is more than 10 years. These near, midterm, and long-term targets were made part of the FRATIS assessment RFP. Primarily derived from previous work by USDOT on the Cross-Town Improvement Project (C-TIP) in Kansas City, the transformative targets described in the *Prior Research* report included the following caveats or assumptions:

> For improvements in travel time, reduced fuel consumption, and reduced emissions, the increasing benefit over time is assumed to result from incremental improvements in technology and user interfaces within fleets that adopt FRATIS, regardless of overall market penetration (i.e., the improvements are expected for the adopting fleet irrespective of the level of FRATIS usage in the wider population of trucks). Bobtail reduction metrics are predicated on full coordination between participating truck fleets and terminal operators, since without such coordination it becomes much harder to reduce unproductive truck trips. For reductions in terminal queue times, the incremental improvements over time assume improvements in queue detection systems as well as growing adoption of new methods of information delivery such as smartphones.
> (page 96)

Section 4: FRATIS Assessment Methodology

4.1 Assessment Plan

The assumption in the three FRATIS prototypes was that the drayage operations would change during the test and these changes could be measured. The measurement would compare test data with baseline data (before and after or with and without), both collected by the developers and provided to the assessment team. In 2013, the FRATIS Assessment Plan prepared by the Impact Assessment Team was approved by USDOT. The Assessment Plan dated August 15, 2013 included a series of hypotheses to be tested and outlined, the data that needed to be collected, and the analyses that the assessment team would conduct. The hypotheses are discussed in Section 9. The test data noted above for each of the three sites was to consist of:

- Actual data for trips during a six-month period prior to the test, between a defined origin and a defined destination where a change in equipment status occurs
- Trip data for the test trucks as developed by the FRATIS optimization algorithm for a prototype test period
- Actual trip data for test trucks during the test period

USDOT mandated that the development contractors purchase TomTom 510 devices for 50 trucks at each site to capture the actual trip data. Included were accounts for each dray carrier with Webfleet, the supplier of the TomTom devices, whose website allowed tracking of individual trucks and daily reports of the movements of each truck.

USDOT also arranged to have Productivity Apex Inc. (PAI) develop and provide to the assessment team Excel-based tools that could be used to evaluate the daily TomTom data. With these tools, the assessment team was able to calculate origin-destination travel time and overall miles traveled, total time, and stop time for the equipped fleet of each drayage company and for each truck. The tools included a Plan Comparison Module that was to allow manual entry of optimization plans for examination of movements using the optimization algorithm versus plans before the algorithm was implemented; an Execution Module that calculated miles traveled, total time, and stop time for each fleet; and a Trip Identification Module that identified individual trips with origin, destination, trip distance, and trip time. The latter two Excel tools were the primary ones used by the assessment team.

4.2 Bin Analysis (Cluster Analysis)

The basis of the FRATIS assessment was to compare daily results with FRATIS technologies being used against daily results during the baseline period, which was to be at least six months prior to the test. The dray companies began collecting the daily TomTom data during the latter portion of 2013. The assessment was planned to compare days when the operating characteristics were the same so that changes in the performance measures could, in fact, be attributed to the FRATIS technologies. A Bin Analysis or Pairwise Matching Enhanced by Cluster Analysis was selected and documented in the assessment plan.

In using the binning analysis, the IA Team expected that all days in the baseline and test periods would be assigned to a bin, or the team would identify a different way to test the extremes of the distribution. In addition, the team examined daily operating data for fleet size, types of routes covered, and hours of fleet operation to help explain the distributions of the data. The hope was that the binning approach would make the test versus baseline comparisons as quantitative as possible to allow an apples-to-apples comparison. The operating conditions to be included in the bin analysis were traffic volume (low-medium-high), shipment order volume (low-medium-high), weather (no impact, moderate impact, high impact), and incidents (no effect, medium delay, significant delay). The agreed-upon plan for the assessment was that when days assigned to the same bin were compared, the resulting improvement in travel time or the other measures could be quantified to determine the benefits of FRATIS. The binning analysis is discussed further in Section 6, which presents the data analysis.

4.3 Terminal Queue Time

Because the FRATIS prototypes involved operations at intermodal terminals, the project included objectives to improve terminal delays through the use of better information about terminal operations. The development contractors in LA and DFW worked with their terminal stakeholders to install vehicle detection devices at key points at gates and in terminals. The data would then be used to calculate terminal queue time at terminals, which could be provided to drayage managers or dispatchers.

4.4 Qualitative and Quantitative Benefits Analysis

During and just after completion of the prototype test at each site, the assessment team visited stakeholders to view the operations and interview the dispatchers and their managers as well as the terminal operators. Essential at both LA and DFW were the development contractors' stakeholder coordinators, Susan DeSantis in LA and Tiffany Melvin in DFW. They scheduled all of the interviews and facilitated the visits, providing transportation and either answering or providing contacts for many questions from the assessment team. At LA, the team interviewed Mike Johnson and Alice Rivera of Port Logistics Group and Doug Hansen and Dan Blackburn of Yusen Terminal, in addition to Mark Jensen of Cambridge Systematics. Fabio Zavagnini of Productivity Apex Inc. provided useful information by phone and email about the optimization software. At DFW, the team interviewed Robert Hooks of Southwest Freight, Lon Lloyd and Jerome Zeffer from Associated Carriers, James White from the Intermodal Cartage Group, and Kevin Feldt from the North Texas Council of Governments. For South Florida, the team conducted telephone interviews that were facilitated by Mike Williamson and Erin Kersh of Cambridge Systematics and interviewed Merissa Palacios, Willie Garcia, and Bertha Orta of Florida East Coast Railway Highway Services and Arlene Davis from the Florida Department of Transportation. Their explanations of what was done during the test and their perception of how FRATIS worked and how it contributed to completion of their mission were critical elements of the assessment team's findings and lessons learned.

The assessment team worked through the development contractor at each site to coordinate schedules of visits to the various stakeholders. This was extremely valuable to the assessment team and also was important in limiting the time burden placed on the stakeholders. The development contractor, particularly their designated local stakeholder coordinator noted above, was in the best position to identify the right people to talk with and "greased the skids" in ways that were invaluable to the success of the interviews.

A key objective of the assessment team was to estimate the benefits of improvements from FRATIS applications at each of the three sites. The benefits analysis, which is discussed in detail later in this report, was intended to involve:

- Qualitative benefits based on stakeholder feedback
- Quantitative benefits related to trip distance and fleet mileage and operating time based on daily measurements of truck operations throughout the duration of the FRATIS project (2013-early 2015)
- Estimates of fuel consumption and emissions savings based on fleet averages and the EPA DrayFLEET model, using mileage and time savings quantified above

Section 5: FRATIS Applications Testing at Prototype Sites

Before describing the results of the testing, this section will summarize how the FRATIS tests were conducted at each of the three prototype sites.

South Florida – Florida East Coast Railway Highway Services is a rail intermodal container pick-up and delivery carrier, as described in Section 2.2. Fifty of its trucks were equipped with TomTom 510 data gathering devices for testing. FEC uses a rolling list for assigning moves to drivers and continued with that dispatching policy throughout the test period. From their back office order processing system, FEC and its system provider created an automated input of a comma-separated value (CSV) file of orders three times a day to a dedicated FRATIS server that housed the optimization software. They then ran the optimization algorithm and output the resulting list, which was stored on the PAI website developed for the FRATIS optimization. The dispatcher reviewed the optimization plan on the website and then, after making changes, created assignments in the existing system using the rolling list with deviations based on the optimization proposal. Generally speaking, the dispatcher stayed with the rolling list and did not try to force on the drivers significant changes to the rolling list. In addition, the South Florida developer worked with regional emergency preparedness agencies and developed a smart phone app which was used in emergency response simulations related to hurricanes of varying intensities.

Dallas-Fort Worth - In Dallas-Fort Worth two drays participated in the test; both are described in Section 2.1. Associated Carriers had 40 of its approximately 60 trucks outfitted with TomTom 510 data gathering devices, and used the PAI algorithm with pre- and post-processing to get orders into the system. A CSV file of orders was sent twice a day from the back office transportation management systems to the development contractor. Because the dray did not have the resources to actually run the algorithm, that task was performed during the test by the development contractor, who ran the algorithm twice a day and emailed the results to the dispatch supervisor for review. Assignments of moves were made by phone based on the dispatcher's knowledge of drivers. During the test, the Associated dispatcher used optimization results for first and second assignments.

Southwest Freight provided ten of its company drivers with TomTom 510 data gathering devices. A CSV file of orders was sent once a day from the back office transportation management system to the development contractor, who ran the algorithm and emailed results from the Leidos algorithm to the supervisor for review. After reviewing early test runs using the PAI algorithm, Southwest did not find the results appropriate for its operation. Leidos, the development contractor, provided an alternative algorithm it had used in a previous project. Shipment assignments are made by the dispatcher by phone, based on the dispatcher's knowledge of drivers. During the test the supervisor provided the optimization results to the dispatcher, who used optimization results for first and second assignments.

As noted in Section 2.1, the Dallas Fort Worth prototype development also involved implementation and testing of wait time measurement equipment at an intermodal terminal that handles empty ocean containers. They also implemented and tested advanced notification of expected arrivals at that terminal and at railroad intermodal terminals serving Dallas-Fort Worth. To assist the dray companies with using this information and other FRATIS data, the prototype development contractor developed a web portal the dray companies could use to access freight data on the website including wait time at the intermodal terminal.

Los Angeles - Port Logistics Group, described in Section 2.3, is a seaport terminal container pick-up and delivery drayage company that provided all of its 46 owner-operators with TomTom 510 data gathering devices. Drivers come to the PLG depot for assignments, which are made by the PLG dispatcher based on dispatcher knowledge, Pier Pass restrictions such as night shift selection by the shippers, and driver preferences. The FRATIS project team implemented and tested the PAI optimization algorithm at PLG using manual data entry of orders and a website for user review of optimization results. Throughout the FRATIS test period, the developer team manually input orders twice a day because the dray company did not have time to do so. This came about because PLG's customer service department had negative views regarding duplicate data entry. As a result of this experience, the project team began developing an automated interface for orders from the existing system but it was not finished in time for testing. For each of the two sets of orders each day, the developer ran the PAI optimization algorithm and the optimization list was displayed on the PAI website, where it was available for review by the dispatcher. Driver assignments were made in the existing transportation management system. Generally speaking, PLG was overburdened by the huge container volume and overall traffic congestion problems in the LA area throughout the period of the FRATIS prototype. Its dispatchers could not spend time on changing assignments as suggested by the optimization algorithm. The intensity of the operations generally forced the dispatchers to assign moves to drivers one at a time using existing methods.

The LA project team also implemented the ability to send assignments and other information to drivers, and those drivers could then accept orders via a TomTom 7150 device in the 46 PLG truck cabs. LA also implemented terminal wait time measurement at the Yusen terminal in the port of LA and provided the drayage company with user access to the Yusen terminal website and wait time data. The PAI website noted above included a page that displayed the wait time data for use by the dispatcher. The contractor also developed the ability to provide advanced notification of expected arrivals at the terminal by the PLG dispatcher to Yusen's terminal operations personnel.

5.1 Drayage Optimization

5.1.1 Optimization Objectives

The objective of the FRATIS optimization, as originally defined in the DMA program, was to use an application to create an optimized load plan for the entire drayage fleet. The objective is that if the optimized plan is used fewer miles will be wasted on bobtails or empty moves, resulting in reductions in fuel usage and related air pollution.

In defining intermodal drayage operations optimization, USDOT's goal was to integrate load-matching and freight information exchange systems in an application that could fully optimize drayage information, including reducing bobtails, balancing chassis, and spreading out the traffic arriving at terminals throughout the day. This would result in reduced trips, reduced miles, and corresponding improvements in air quality. While web-based container load-matching systems such as Loadmatch.com were described as being in use in 2012, USDOT noted in the RFP for this FRATIS project that what was missing was the connection to the container and chassis availability information maintained by railroad terminals and steamship line terminals.

The user interface for the FRATIS container load-matching function was to be provided in a visual information format for dispatchers (and for stationary truck drivers); an audible solution for drivers was preferred because of potential distracted driving. It is important to note here that, according to the FRATIS Concept of Operations, load-matching was expected to be accomplished partly through connections with existing private sector electronic load-matching systems.

The functional FRATIS grouping within DMA focused on providing these linkages, and was intended to facilitate automated information availability among all intermodal parties, including current drayage truck load matching and container availability and appointment scheduling at railroad and steamship line terminals. Two projects grew out of these objectives: a small scale pilot of optimization in Memphis in 2011 and conceptual design work on FRATIS in 2012. These efforts led to the three FRATIS prototypes that included optimization.

5.1.2 Memphis Optimization Pilot

The predecessor pilot test that drove the optimization requirements for FRATIS was conducted in Memphis, Tennessee. It is important to note that a small trucking company was selected with a manageable number of orders that could be manually entered in the systems. This was, in part, workable because the company did not have a sophisticated transportation management system. In addition, the company's orders were fairly stable from one day to the next, allowing an optimization plan to be applied to the next day's orders. The company was small enough and invested enough in the project that it was willing to work with the developer on manual entry of orders, and it changed its operations to incorporate the optimization results created in the plans. The overall freight system in Memphis had lower volumes and was less congested than larger terminal areas.

The Memphis effort grew out of the Cross-town Transportation Improvement Project (C-TIP), in which the FHWA Office of Freight Management had sponsored pilots of

> ...promising technological solutions to urban freight management…The main objective of the Memphis C-TIP is developing, testing, and deploying a drayage application that utilizes powerful and intelligent optimization heuristics to improve drayage operations while considering all operational constraints and restrictions associated with drayage moves. The main concern of the projected drayage application is to maximize the loaded moves and minimize the unproductive ones (e.g., bobtail moves), which improves drayage companies' efficiencies, reduces congestion on the roads, and will positively impact the environment by decreasing the carbon footprint. (*Development of a Cross-Town Improvement Project Drayage Optimization Application*, Sept. 13, 2013, page 5)

The developer created an Excel-based tool for the Memphis testing site to collect data on the details of the daily orders and the plan for executing the orders. The detailed elements collected from the orders, as listed in the aforementioned report, were:

- Order number
- Order stops
- Location of each stop
- Freight action (e.g., pick up loaded with chassis) at each stop
- Expected wait and service time at each stop
- Time window of each stop
- Required equipment for the order
- Equipment owner

Manual plans created by the drayage company during a pre-deployment period were then compared with plans generated by the optimization algorithm. The plans included both the assignment of orders to trucks and the sequence for executing orders by each truck.

Using TomTom 510 data collection devices installed in the trucks participating in the test, the Memphis pilot recorded daily data on performance measures including total fleet miles driven, average miles per truck, the total operating time, and stop time for the fleet and for each truck. Together the developer and the drayage company looked carefully at these fleet performance data for the several-month 2013 test, comparing days when manual plans were used with days when the results of the optimization algorithm were applied.

While the results documented in the Memphis final report showed reductions in the miles driven and the average miles per truck, the report did not attempt to explain the benefits of those reductions to the drayage company or its drivers. Nevertheless, the improvements in the performance measures became the basis for the FRATIS Statement of Work and the Transformative Benefits described in Section 3.

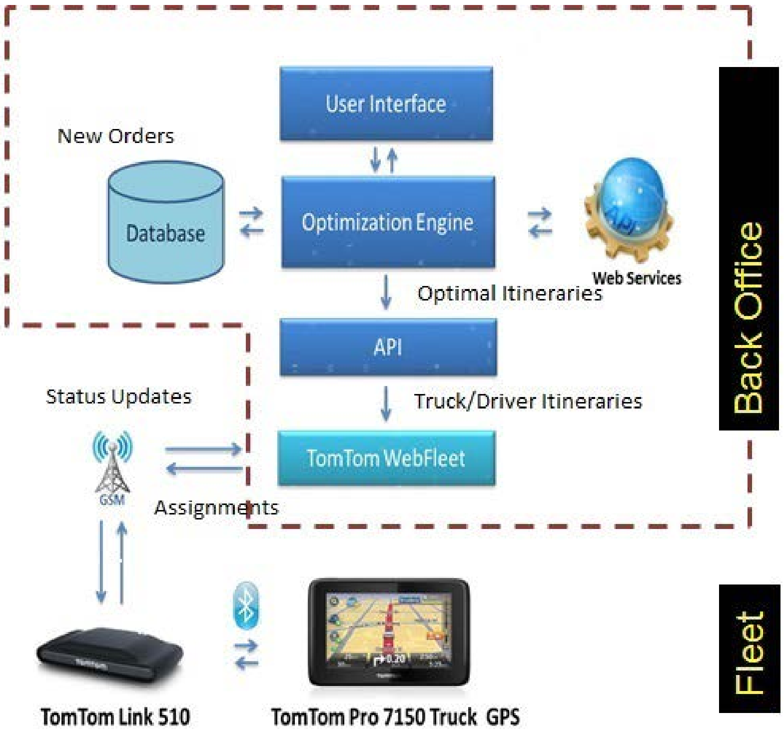
These results and performance measures were incorporated in the USDOT requirements for the FRATIS project, and the PAI optimization algorithm that came out of the Memphis project became part of the prototype development at each of the three FRATIS sites.

5.1.3 FRATIS Optimization System Features

As the Memphis pilot test was being completed, USDOT contracted for the aforementioned FRATIS Concept of Operations. In FRATIS, the objective was to integrate optimization in existing freight systems and to provide a visual format that could be used by dispatchers in reviewing and approving optimization plans. Where Memphis had been a small and constrained drayage operation, the FRATIS prototypes were to be more broadly-based and target drayage companies that worked with intermodal containers, either inland with railroads or at ports with steamship lines.

According to the FRATIS ConOps, the optimization application aimed to optimize drayage operations so that loaded and unloaded movements would be coordinated between freight facilities. Individual trucks were to be assigned time windows to arrive at a pickup or drop-off location. Early or late arrivals to the facility were intended to be dynamically balanced. The concept called for a web-based forum for load matching to reduce empty or unproductive moves. The drayage optimization application defined was to be applicable to short-haul, primarily local freight movement.

Figure 6. Optimization Algorithm Functionality



Source: Productivity Apex Inc.

The above diagram from Productivity Apex Inc. (PAI), the Memphis developer who also was the software contractor on two of the three FRATIS prototype sites, shows how the optimization algorithm was to be incorporated into existing drayage operations. An important aspect of the Back Office portion of the diagram is automated order entry shown at the top and from the database on the left. The web services provide some of the traffic and weather constraints that are included in the algorithm.

The Fleet portion of the diagram was intended to provide the driver with automated information about the assignment. In LA, the TomTom 7150 devices were part of the test to allow the driver to receive an assignment automatically and accept the assignment via the device. As discussed later, each dray company's prototype implementation of optimization was customized to its operations, so each was slightly different.

The computer algorithm for optimization balances a series of constraints and definitions about the orders being moved by the drays, characteristics of the drivers, and equipment in the fleet. In addition to order-specific information such as an appointment time window, the algorithm uses historical traffic information to adjust its recommendations.

Table 5. Optimization Algorithm Primary Constraints

Distance and travel time between stops
Appointment time window at each stop
Traffic delays by time of day/day of week
Weather condition and expected delays
Construction schedules on routes
Waiting time at each stop by time of day
Drivers hours of service/duty
Equipment-related constraints
Special hours of operation (e.g., PierPass)
Special requirements (e.g., Hazmat)

Source: Cambridge Systematics

As a user interface to the optimization algorithm, PAI developed a web-based application hosted on its server, which drayage personnel could access to input orders as well as review optimization results. Depending on the extent of integration of the order entry and how the dray company used the optimization results, drayage personnel were intended to use the results page shown and discussed below.

Figure 7. Algorithm Plan

Source: PAI Website using LA test data

The above view from the optimization website has some overall statistics about the optimization plan to fulfill 67 orders, including the total mileage and time that would be required to move the orders in the optimal way. A similar box is displayed to show the statistics after the dispatcher has made changes to the plan. The intent was to provide a positive feedback mechanism to the dispatcher as he or she considered changes to the plan.

The drivers are listed below the boxes on the webpage, as shown in the figure below, with color-coded rectangles containing order numbers assigned to that driver. The intent was that the boxes shown for each driver cover the entire shift. The total number of miles that should be driven to complete the orders is shown to the left of the boxes.

Figure 8. Optimization Driver Assignments

Source: PAI Website using LA test data

The bottom of the webpage shows a step-by-step plan for assignments for each driver recommended by the optimization algorithm. These lines show the starting point, time and mileage to the first destination, and the freight action (such as unloading) the order assignment involves. The assignments run throughout the day, ending back at the home base. In Dallas-Fort Worth, rather than using the PAI website and displaying the assignment table or the step-by-step assignment plans, the supervisor printed out a step-by-step plan that could be handed to the dispatcher. It is worth noting, however, that none of the prototype drays had ever functioned with full day driver assignments such as this; all of the drays assigned one order at a time. This will be discussed in more detail in subsequent sub-sections.

Figure 9. Driver Routing Plan

Next stop @ FEC MIAMI RAIL (Drop Off Empty With Chassis) departing prev stop @ 10:00, arriving @ 10:33 - (waited 0 hrs 0 mi) travelling 16.63 miles in 0 hrs 33 mi | queue 0 hrs 0 mi
Next stop @ FEC MIAMI RAIL (Pickup Loaded With Chassis) departing prev stop @ 11:03, arriving @ 11:03 - (waited 0 hrs 0 mi) travelling 0 miles in 0 hrs 0 mi | queue 0 hrs 0 mi
Next stop @ GENMARIE (Live Unloading) departing prev stop @ 11:33, arriving @ 11:40 - (waited 0 hrs 19 mi) travelling 3.74 miles in 0 hrs 7 mi | queue 0 hrs 0 mi
Next stop @ FEC MIAMI RAIL (Drop Off Empty With Chassis) departing prev stop @ 14:00, arriving @ 14:07 - (waited 0 hrs 0 mi) travelling 3.74 miles in 0 hrs 7 mi | queue 0 hrs 0 mi
Next stop @ FEC MIAMI RAIL (Pickup Loaded With Chassis) departing prev stop @ 14:37, arriving @ 14:37 - (waited 0 hrs 0 mi) travelling 0 miles in 0 hrs 0 mi | queue 0 hrs 0 mi

Source: PAI Website using SFLA test data

It is worth noting that at the DFW prototype site, the DFW developer built pre- and post-processors that took orders from the Trinium dispatch system and provided outputs tailored to the needs of each dray company. The output data presented to the user included the above information on total mileage and the individual route solutions for each driver. The output also included some Trinium-specific information normally used by the dispatcher.

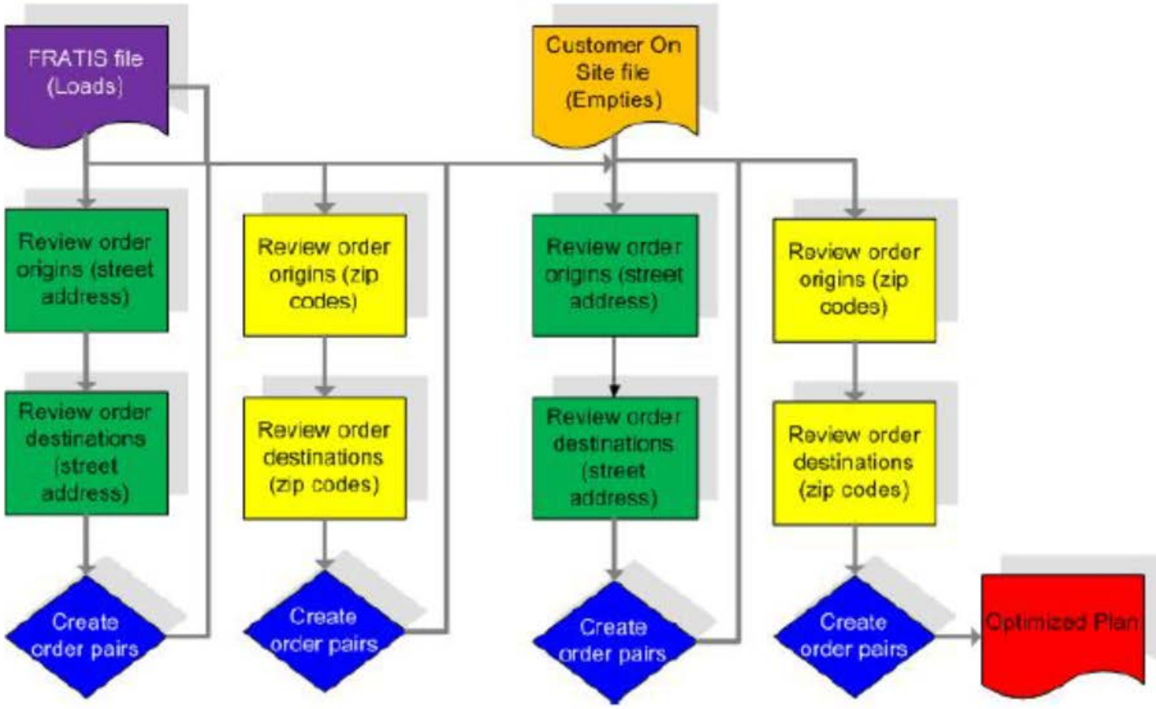
At the DFW FRATIS prototype site, Southwest Freight started using the PAI algorithm but did not like the early results, especially if the first move in the plan was a bobtail. Neither the carrier nor its drivers wanted to start a day with a bobtail move. As noted in the FRATIS DFW Architecture and Design (page 12), Southwest had three specific issues with the PAI algorithm:

- It did not prioritize loaded moves over empty moves.
- It contained too many bobtails.
- It did not evenly distribute the day's moves among available drivers.

Partway through the test, the carrier switched to an alternative optimization algorithm that had been used by Leidos in Kansas City on C-TIP. The Leidos development team rewrote and customized the C-TIP code for Southwest. The objective function of the alternative algorithm was described by Leidos in its Architecture and Design document as minimizing bobtails, as opposed to the PAI algorithm's objective function of minimizing total fleet mileage, but it provided the FRATIS developer and impact assessment team with a different algorithm to compare, which was beneficial.

The Alternative Optimization Program was written in Java and included some simplifying conditions tailored to Southwest Freight. The diagram below in Figure 10 shows the process flow in the alternative program.

Figure 10. DFW Alternative Optimization Program Process



Source: Leidos DFW FRATIS Architecture and Design, page 23

5.1.4 FRATIS Optimization Prototype Tests

To allow comparisons among the four dray companies and their uses of the algorithms, the series of three tables below contains characteristics of the companies and their experience with the system. A more detailed narrative follows each table.

5.1.4.1 Dray Descriptions

Table 6. FRATIS Optimization Pilot Testing

Characteristic/ Functionality	SFLA	DFW-Associated	DFW-Southwest	LA
Drayage Business	RR Intermodal container pick-up and delivery	Metro area container pick-up and delivery	Local/regional container pick-up and delivery	Port terminal container pick-up and delivery
Driver Affiliation	80 owner-operators	60 trucks, mix of owner-operators and company owned	120 trucks, mix of owner-operators and company owned	46 owner-operators
Order entry	FTP file transfer to development team contractor	CSV file transfer to development team contractor	CSV file transfer to development team contractor	Manual by development team contractor

Characteristic/ Functionality	SFLA	DFW-Associated	DFW-Southwest	LA
Dispatching Policy	Rolling list of drivers with assignment to balance workload and account for special circumstances. Assignments by phone or at dispatch window.	Dispatcher knowledge of drivers and routes. Assignments by phone.	Dispatcher knowledge of drivers and routes. Assignments by phone.	Dispatcher knowledge of drivers and routes. Drivers come to dispatch for assignments.

Source: CDM Smith

All of the drayage companies in this FRATIS testing had larger and more sophisticated operations than those in the Memphis pilot. While this was the intention of the FRATIS requirement, the sophisticated operations made it more difficult to achieve results through optimization.

In DFW, the two drays had slightly different operations, although both served rail intermodal customers. In SFLA, the dray company which originally intended to participate handled intermodal containers at the ports of Miami and Everglades. The dray that participated had more limited operations, handling rail intermodal container pick-up and delivery, resulting in limited potential for optimization. Most of the drivers for the drayage companies in the test were owner-operators. One DFW dray had a mix of owner-operator and company employee drivers. (Actually, both DFW drays had a mix, but Southwest Freight gave TomTom 510 devices only to company drivers.) Generally speaking, dray managers felt that the ability of owner-operators to influence the assignments they received was detrimental to the use of optimization, although the DFW dray with the mixed fleet did not see any difference. That said, that dray installed TomTom devices only on company trucks because of concerns that owner-operators might have issues with the requirement to install such devices. Perhaps more significant was the dispatching policy at each dray. Three of the drays provide assignments to their drivers by phone, while one has drivers come to the depot to receive their assignments. Each dray has some customers with long-standing arrangements or preferences for certain drivers.

The SFLA dray company uses a rolling list for assigning moves; the next driver on the list would receive the assignment, with an overall eye toward equitable freight distribution among drivers. To fully use the optimization would require changing the operating philosophy from the rolling list, which the dray was unwilling to do.

An initial condition for optimization in FRATIS was that the dispatcher be able to review and make changes to the optimization plans. While this was understandable and in many cases necessary, changes to the plan reduced the effectiveness and presumably the potential benefit of the optimization plan and resulted in more work for the dispatchers. In effect, the operating philosophy at each dray was that the dispatcher knows best, based on past experience and a desire to keep the fleet of drivers happy and productive.

Associated Carriers used the PAI algorithm with pre- and post-processing to enter orders in the system. As noted earlier, in Memphis order entry was manual. For the South Florida and DFW dray companies, the volume of orders and the preferences of the dispatchers required an interface be built in which an automated file of orders was created by the existing order management system of the dray company and provided to the optimization algorithm. Since both DFW drays used the same back office system from Trinium, the DFW FRATIS developer set up a server to which CSV files were sent. In South Florida, the developer also set up a server to which orders were sent from the back office system via file transfer protocol.

The LA prototype attempted to implement duplicate manual data entry of orders. This was almost immediately rejected by the dray company's customer service personnel responsible for entering orders. Later, a contract was awarded to integrate the order input process from the TMW back office system. Although progress was made, the integration effort was not completed by the end of the test. Orders were instead entered manually twice a day by the development team and results were reviewed, modified, and used on a limited basis by the night shift dispatcher.

5.1.4.2 Optimization Testing

Since the PAI algorithm developed in Memphis was included in the FRATIS prototype statement of work, the two DFW drays started with the version of the PAI algorithm available on the DMA portal. Associated Carriers used the PAI algorithm with pre- and post-processing created by the development contractor Leidos to get orders into the system. Southwest Freight, after initially working with the PAI algorithm, settled for an alternative optimization algorithm discussed previously. Both LA and South Florida had the same software developer, so used the PAI algorithm customized to each dray's operation.

Table 7. FRATIS Optimization Algorithm Pilot Testing 2

Characteristic/ Functionality	SFLA	DFW-Associated	DFW-Southwest	LA
Algorithm Vendor	PAI	PAI	Leidos	PAI
Extent of Integration	Partial integration. Back office system produces file that is run by optimization algorithm. Dispatchers use FRATIS website to review assignments.	Partial integration. Trinium produces file that is run by optimization algorithm. The output of optimization is not integrated with Trinium.	Partial integration. Trinium produces file that is run by optimization algorithm. The output of optimization is not integrated with Trinium.	Not integrated; duplicated data entry through most of test. Attempted mapping at end of test, but did not actually test.
Frequency of Running Algorithm	Load updates 3 times a day via FTP	Twice daily	Once daily	Twice daily
Party that Ran Algorithm	FEC with Cambridge Systematics assistance	Leidos	Leidos	Subcontractor to Cambridge Systematics.
How Results were Given to Dispatcher	FRATIS website available to dispatcher	Results emailed to dray supervisor.	Results emailed to dray supervisor.	FRATIS website available to dispatcher.

Source: CDM Smith

The South Florida dray and both the DFW drays' optimizations were partially integrated so that duplicate data entry of orders was not required. The South Florida algorithm was run three times a day for review by the dispatchers. The data entry by the developers' staff was updated twice a day. The dispatcher reviewed the optimization plan on the website and then, after making changes, created assignments in the existing system using the rolling list with deviations based on the optimization proposal. The dray found that twice a day was not enough to cover all the new and changed orders. As a result, the optimization results were used for the first and sometimes the second assignment to each driver.

Because none of the drays at any of the prototype sites had the resources to run the algorithm, that task was performed during the test by the development contractors. At both LA and South Florida, the PAI-developed webpage discussed earlier was used to present the results of the optimization runs to the dispatchers. At Associated Carriers in DFW, the developer emailed the results to the dispatch supervisor twice a day (3:00 pm for the next day with an update at 9:00 am) for review and changes as necessary. A hardcopy print-out was then used in making assignments to drivers.

At Southwest Freight in DFW, the developer ran the algorithm once daily and sent results by email to the supervisor who reviewed the results. After making changes as appropriate, revised plans were shared in hardcopy form with one dispatcher who occasionally used the recommendations for the first assignment.

None of the dray companies wanted to fully integrate until after testing, so this did not occur. In a full implementation, it would be important to automatically import optimization results in the dispatch system so the results appear on the screen with the other dispatch information.

5.1.4.3 Uses of Optimization Results

The table below summarizes the ways in which the optimization results were used at the three pilot testing locations. Following the table is a more detailed discussion of the factors that influenced the use of optimization by the drayage companies involved in the pilot testing.

Table 8. FRATIS Optimization Pilot Testing-3

Characteristic/ Functionality	SFLA	DFW-Associated	DFW-Southwest	LA
Use of assignment by dispatcher	After dispatcher review, used for first and perhaps second assignment.	After dispatcher review, sometimes used for first and second assignments.	After dispatcher review, sometimes used for first and second assignments.	For the most part, plans were reviewed but not used. Occasionally used with a small number of drivers to test order acceptance process with TomTom 7150 in trucks.
Reaction of Drivers	Drivers objected to plans that resulted in inequitable number of assignments. Drivers were used to rolling list and did not like change.	Drivers did not like idea of starting with a bobtail or empty run. Dispatchers made assignments they thought drivers would like.	Didn't assign beyond first trip, so drivers weren't affected. Objection of dray on behalf of drivers led to alternative algorithm without starting with a bobtail or empty run.	Never really received assignments, except for a small number of drivers. 1 or 2 drivers were ok with the idea; most drivers did not like the idea.
Feedback from Dray Company	Somewhat indifferent because optimization didn't fit origin-destination pairs. Many changes had to be made in algorithm assignments.	Thought it would be useful for first or second assignments, if fully integrated. Many changes had to be made in algorithm assignments.	Thought it would be useful to new or inexperienced dispatchers, if fully integrated. Many changes had to be made in algorithm assignments.	Duplicate data entry was rejected. Liked the concept, if it were fully integrated, but never really used it to assign trips. Changes would have been needed in algorithm assignments.
Primary Lessons Learned	Either optimization must adapt to dray operations or the dray must be willing to change their operations. Change is hard because it involves many drivers and long-standing practices.	Optimization needs to be near real time (if not continuous) in order to be effective and capture new orders as changes occur.	Whatever algorithm is used, customization to dray operations is essential, as is integration with back office system.	Duplicate data entry is a non-starter. Investment in integration with back office system is essential.

Source: CDM Smith

Generally speaking, the LA dray company was overburdened by the huge container volume and overall traffic congestion problems in the LA area throughout the FRATIS prototype period. They felt overwhelmed with port traffic conditions during the test and could not deal with the potential change in operations. The dispatchers were significantly overworked just dealing with the drivers, and could not spend additional time to review optimization results and make required changes. For a few weeks in December 2014 and January 2015 LA optimization runs were done for import containers only, but the results were not used by dispatchers. The limitation to imports was intended to help dispatchers get used to the system using more complicated orders. According to feedback provided to the assessment team by some stakeholders, during the test five drivers actually used FRATIS for 155 import container jobs, although it was virtually impossible to identify and pull out performance data for those 155 jobs. The assessment team found that, with only anecdotal exceptions, the optimization results were not used in LA.

The very limited use of the TomTom 7150 to accept an order uncovered a problem: the order received by the driver on the device did not include detailed information about the order, so the driver was asked to accept the assignment without knowing its details. The driver initially declined the assignment, reviewed the details, and then accepted. This was more time-consuming than necessary and therefore frustrating for the drivers involved. The dispatcher had to spend time on the phone explaining the orders to the driver. As a result, the drivers and dispatchers continued to use the text capability of their cell phones to exchange information about orders. One driver told the assessment team he found the 7150 was not easy to work with. A perhaps unanticipated complication was that the 7150 had a single ID for each truck. But at PLG some trucks are used by two different drivers, one in the day and one at night. Use of the 7150 device is discussed further in Section 5.2.

Generally, both DFW drays felt the supervisor or the dispatcher knew as much or more about assignments than the algorithm. Dispatchers often changed assignments to even them out among drivers. For Southwest Freight, that used the alternative optimization, the supervisor reviewed daily optimization runs for realism, but dispatchers assigned jobs based on their knowledge of drivers and customers. Further, the alternative optimization algorithm provided suggested assignment sequences but did not assign a driver; that was left to the dispatcher. In both cases, the dispatchers said the optimization results occasionally provided them with assignment ideas they had not considered. But because new orders or movement opportunities arise throughout the day, dispatchers found that after one or two assignments, there were too many changes or additions to continue to use the current optimization list. Southwest thought the optimization plan might be useful to a newly-hired dispatcher.

In Florida, the dispatcher reviewed the optimization plan on the website and then, after making changes, created assignments in the existing system using the rolling list with minor deviations. The changes included some customers working with specific drivers or some driver situations that might not be included in the optimization constraints. There was a perception among users that the algorithm recommendations were “too random.” The dispatchers also found that many orders were not processed by the optimization because of data errors. These needed to be corrected and either reprocessed or dealt with as changes and additions to the optimization plans. The net result was that it required more work to use optimization than not.

Because of the way the optimization results were used by the four drays, the dispatchers made the decisions and drivers were not significantly affected. That said, where there was interaction between dispatchers and drivers about “new” assignments based on optimization, the drivers were usually against change. Here the experience of the dispatcher base was important because they felt the need to protect the drivers and equitably distribute the assignments, even if the optimization suggested favoring one driver over another because of more favorable economics for the company. At most of the drays, there was a long standing practice to avoid starting a day with an empty move or a bobtail and the drivers objected to any suggestions, whether based on the optimization software or not, to change this policy.

What about quantitative analysis? The baseline and test data collected in FRATIS and the defined assessment methodology were to generate before and after results that would show the extent to which operations improved as a result of the optimization algorithm. Daily data was analyzed, but because drayage operations did not change and, at best, only one or two assignments were made by dispatchers using the optimization on a very limited basis, it was not possible to identify any change, much less attribute that change to FRATIS. In LA, there was an effort in January 2015 to run the algorithm on daily shipments so the assessment team would be able to compare actual movements during the period as recorded on the TomTom devices with optimization results to see what the result might have been if the dispatchers had actually used the results.

The various screens and reports on the PAI website were used by the assessment team to examine the optimization results. Unfortunately, the optimization results were essentially manual data that could only be visually studied one day at a time. Spot checks of data by the assessment team found it extremely difficult, if not impossible, to match a truck in the optimization plan with a truck in the actual 510 data for that date, which was a surprise to the assessment team. One reason for this was that the identifier on the PAI website was either driver initials or a code, while the primary identifier in the TomTom data was a different numerical code. Even more surprising, though, was the finding that some trucks in the optimization run were not even in the inventory of TomTom-equipped trucks. Thus, the assessment team could not analyze the “what if” data, much less come up with a way to compare overall results. The bottom line was that the data gaps were much too large and the data was not in a form that lent itself to comparative analysis.

5.1.5 FRATIS Optimization Test Findings

NCFRP Report 11 *Truck Drayage Productivity Guide* (2011) contained an important comment about drayage operations:

> Most drivers are owner-operators who receive a percentage of the revenue from each move rather than being paid by the hour or the mile. Drivers therefore have an incentive to make as many revenue moves as possible and minimize non-revenue time and miles, accounting for much of the practices observed in the industry. The fragmentation of the system, however, limits the ability of any one firm to optimize operations, manage peaking, reuse empty containers, or otherwise rationalize the system as a whole. (page 2)

That limitation was evident at all of the FRATIS sites and in the set-up of the prototype testing with the various stakeholders. None of the drays was willing or able to change operations to the extent that would have been required to use optimization results. According to the developers, at least one dray said they would be willing to change operations, but in the end they would not.

The bottom line was that most of the dispatchers and supervisors at the drays in the FRATIS test thought the idea of optimization was good, and the plans provided some assignment ideas they hadn’t thought of but they believed they knew more than the algorithm about what assignments were needed and what could not change. Thus the original hope that optimization would have a dramatic effect on operations, as it appeared to in Memphis, did not materialize in the FRATIS tests. Progress was definitely made and a lot was learned that should help the next optimization effort.

The findings of the Assessment Team, based on observations and interviews at the sites and the narrative above, are summarized below. Some of the findings are corroborated by the final reports of each of the three prototype site contractors. Page references in these reports are included as appropriate.

1. **Drayage operations are very dynamic and cannot be efficiently conducted using assignments from a once-per-day or even twice-per-day optimization run.** Dray operators thought that continually-updated optimization would be more likely to capture the dynamic nature of the drayage business. According to a DFW dray, Trinium (the back office

system provider) believes there are too many variables to continuously re-optimize, but both Trinium and the dray believe there would be a big market for continuous updating. PAI said that it is working on dynamic planning in the LA follow-on, with the constraint being the availability of order data.

Trinium representatives told the assessment team that what was attractive about FRATIS was the sequencing of driver assignments provided; however, their customers find drivers are not willing to follow the sequence as given. This forces dispatchers to assign moves one or two at a time. Trinium said they are working on a sequencing module, which they felt could be used in conjunction with optimization.

2. **The drays thought economic equity among drivers was an important criterion, especially if there isn't enough freight for everyone, but this was not a key parameter in the algorithm.** All of the drays had long standing relationships with their drivers. Most drivers were owner-operators and, since there was a driver shortage, close working relationships had been developed between the dispatchers and drivers with the objective of getting the work done. Because there was so much work to be done, the dray companies needed drivers as much as the drivers needed the work. The experienced dispatchers at all of the sites knew the drivers' preferences and customer relationships. They found it difficult to justify not giving assignments to a willing driver with the available hours and equipment, even if those assignments (or lack thereof) were based on the best economics for the company. Equitability among drivers was a problem in both SFLA and DFW. Intuitively, the dispatcher realized from the FRATIS training that optimization plans were company-wide. But as a group, they found themselves unable to ignore the circumstances of individual drivers, who may or may not have understood that the proposed assignments were in the best interests of the company. One of the DFW drays noted that because of driver shortages, management may have to be more accepting of an individual driver's quirks and operating habits. While the optimization algorithm did take into account an individual driver's hours of service requirements, it did not attempt to distribute assignments equitably. From the feedback the assessment team received, it is clear that future iterations of such technology should include clear benefits for drivers and dispatchers as well as the drayage company.

3. **Integration of order input was crucial to use of optimization, but was not easy to achieve.** Although partial integration occurred to provide an electronic file for optimization in SFLA and DFW, data quality issues adversely affected the optimization results. In both cases, this resulted in dispatchers spending more time dealing with optimization results than with normal operations. In attempting to achieve integration, the mapping of the data needed was complex and required significant interaction between the optimization developers and the existing system developer (e.g., Trinium in DFW). The latter was cooperative, but on its own schedule and priorities. The effort needed to customize optimization and build an automated order interface should not be underestimated. In LA, mapping issues between the existing order management system and the FRATIS optimization system could not be resolved in time to adequately test the algorithm. In SFLA, orders were integrated at the beginning of the process and updated order files were received three times a day. Integration is crucial to the success of any optimization system; LA clearly showed that the lack of integration has major negative impacts on progress.

4. **Fully using the optimization would require changing the dispatching philosophy at a dray company, which no dray was willing to do.** Drivers in general, and especially owner-operators, did not like assignments based on optimization results. These drivers sometimes resisted because they were not accustomed to executing certain types of orders (e.g., new

customers, different locations). Many of the dispatchers were not inclined to move away from the status quo to an overall company planning approach using the optimization algorithm to plan and dispatch the day's jobs. There was some skepticism among the dispatchers on the value of generating plans the day prior to or even the day of operations, knowing that the plan will need to change to react to the inevitable uncertainty. The FRATIS ConOps stated that the FRATIS software would help the dray companies without them having to change their dispatching policy (page 56), but the assessment team found at all sites that was not true: dispatching policy would have to change, and no one was ready for it.

5. **Dispatchers and other operations personnel at the dray companies had generally positive attitudes toward optimization, but tended to think it might work better in other trucking applications.** For example, they thought optimization might work better in LTL or TL operations that are less dynamic. Although the two DFW companies handled regional traffic, it was not included in the test. Because those involved in the test were experienced dispatchers, they thought optimization might be useful for new or inexperienced dispatchers who did not understand customer needs and driver behavior.

6. **The dray companies at the three sites were all very busy with current operations and did not have the resources in-house to run the optimization algorithm.** This meant the FRATIS developer had to devote extra resources to running the algorithm on a daily basis and providing the results to the appropriate parties at the dray company. Originally it had been assumed that the system would be operated by drayage company personnel. One of the DFW drays said they did not have time to put in all of the constraints, and thought a more limited number might be better.

7. **Some complexities of dray operations either were not covered by the algorithm or helped increase the amount of change in assignments by the dispatcher.** PAI said the key to success in optimization is that the dray have a mix of the freight actions described for the algorithm. The SFLA dray did not have many freight actions, but did have a number of live unloads. These caused problems because of uncontrolled stop time. Thus, the use of an optimization plan in the FRATIS test in SLFA stopped with live unloads. The optimization algorithms require the equivalent of appointment time windows for each order; not only does this inhibit the inclusion of live unloads, but there are also significant operational changes that are not necessarily compatible with drayage operations. One constraint not included in the algorithm that users in LA said would be helpful in the future was Last Free Day, the end of the 4-day period for which there is no container demurrage charge. Users thought orders with the Last Free Day should have higher priority in the system. They necessitated changes to the algorithm plan which might not have been necessary if Last Free Day were included as a constraint.

   Another complexity dray operations managers noted is that contractual arrangements between some beneficial cargo owners and certain drays were important determinants of dispatcher assignments, but these were not in the algorithm and had to be adjusted after the optimization run. Beneficial cargo owners were not involved in FRATIS, but are planned to be part of the LA follow-on. The assessment team found in its interviews and observations at dray companies that, despite the efforts of the development contractor, not enough of the current complex operations were or could be captured in the optimization algorithm's constraints.

8. **Many changes and tweaks in the optimization software were needed after initial implementation, which in some cases was negative for stakeholder participants.** The developer thought such tweaks were generally not a good idea because they reduced the

effectiveness of the optimization results and therefore the potential benefit. However, early problems adversely affected user views of the potential benefit and usability of optimization. What had worked at Memphis because of smaller volumes could not work at any of the larger and more complex prototype sites. Particularly important was integrating order input to avoid duplicate data entry.

9. **Adequate resources, including training, need to be available at the drayage companies in order to conduct a successful test.** LA stakeholders thought additional training of dispatchers would have been helpful. Project personnel in LA observed that the relatively long time between initial design and implementation discussions and the actual test required additional training. One dispatcher in LA was favorably disposed toward FRATIS optimization, while the others had not taken time to examine the recommended assignments. Spending time examining optimization recommendations took away from already busy dispatching duties.

10. **Drayage company relationships with their drivers affected the way the companies viewed optimization technology.** Some of the trucking companies blame their inability to move forward on optimization or other FRATIS capabilities on their driver relationships, particularly with owner-operators. For example, the manager at the LA dray believed the results would have been better with company drivers, since their pay scheme is different. Each of the development contractors noted in their final reports that owner-operators could refuse assignments. The assessment team found that drivers frequently, if not usually, influence the loads they receive, but the assessment team did not perceive much difference in the way the assignments were made at the DFW drays that had a mix of drivers. Both of the DFW drays noted that technology such as FRATIS that involves drivers needs to demonstrate an improvement to the drivers' bottom line. They viewed this as particularly important for owner-operators, since they are paid by the trip whereas company drivers are paid by the hour. These drays said FRATIS-like pilots should therefore demonstrate a reduction in empty miles and reduction in costs to the drivers themselves. What wasn't effective enough in the FRATIS testing was helping the drivers understand the potential impacts of change. The assessment team believes that improvements need to benefit both drivers and the companies if they are going to be successful.

5.1.6 FRATIS Optimization Lessons Learned

Based on the findings discussed in the preceding section, the table below includes four lessons learned from testing the drayage optimization algorithm.

Table 9. Summary of FRATIS Optimization Lessons Learned

Optimization requires major changes in dispatching policy that must be advantageous to both drivers and dispatchers to succeed.
Integration of new capabilities such as the Optimization Algorithm in existing systems and with other dispatch management functions at a dray is essential to a successful test and continued operation.
Frequent runs, if not continuous updating, of optimization are needed to effectively employ optimization in drayage trucking.
FRATIS users thought that automated optimization plans might be especially useful to inexperienced dispatchers in making driver assignments.

Source: CDM Smith

5.2 Advanced Traveler Information

5.2.1 Traveler Information Objectives

As noted in the earlier background on the FRATIS bundles and ConOps requirements effort, FRATIS was intended to provide traveler information, dynamic routing, and performance monitoring elements associated with drayage operations by the dispatchers and drivers of participating drayage companies, and to leverage that information with existing data sources in the public domain. The traveler information was to include traffic updates, construction project location and duration, incidents and expected clearance time, weather, and expected terminal wait time.

The intent was to provide regional and other publicly-available data and combine it with tailored secondary sources, potentially for a fee, to address specific needs of the trucking companies. Examples of publicly-available data include road closures, traffic incidents, or real time traffic. The data would be pulled together in a single user interface to make it easier for trucking dispatchers and drivers to access the information. Examples of more tailored secondary sources include wait and queue time at individual terminals, container status and availability, delivery appointment times, and empty release information.

A key deficiency identified in the FRATIS ConOps was that the publicly-available data tends to be oriented toward passenger travel and does not necessarily include freight-specific information. As has been noted, the ConOps included a survey of trucking companies. A significant finding and impetus for the FRATIS advanced information requirements were that 39 percent of surveyed drayage companies do not use technology-based travel information systems. Even among users, timeliness of the traveler information was a key deterrent in using such systems (ConOps, page 9). The principal reason companies cited for not using technology was inaccurate or untimely information and poor coverage of freight terminals (ConOps, page 14).

Another deficiency that became a focus of the FRATIS prototype developments had to do with additional capability, including advanced arrival information. An example of this requirement was advanced notice provided by the dray company to a terminal for expected arrival. The intent is to include identification of the container and also the expected arrival time, provided from the dray to the terminal in automated form, first a day before the trip and then updated just prior to departure, and to note en-route delays. Working in the other direction, the advanced information was intended to include container availability at a terminal, which would be made available to the dray to allow the dray company to better plan its trips to the terminal. One idea was to provide a list of containers at a terminal to the dray. It should be noted that most import containers, at least at the Yusen terminal, are placed randomly in stacks in the yard, and re-handling is required to find the right container for an arriving truck. Yusen estimated that up to 50 percent of rubber tired gantry moves are re-handles needed to locate and retrieve a particular box (PLG Process Mapping Report, January 2013, page 6). The hope is that advanced information about truck arrivals would be valuable in improving the re-handle process.

While smart phone and other GPS-based routing systems exist, it is important for truckers to use freight-specific systems for dynamic routing. There are vendors of such services, and the intent of FRATIS was to integrate such traffic services with other advanced information and make it available to the dispatcher and truck driver.

5.2.2 FRATIS Prototype Implementations

At the FRATIS prototype sites, contractors built on what the respective dray companies already used and supplemented that with additional capabilities and, in some cases, equipment for use by the drivers. This meant the advanced data and technology stakeholders worked with was not consistent across the prototypes, but resulted in a variety of uses and systems that were used during the test period by the drayage companies involved. The varied experiences may be of use in future drayage technology efforts. What was actually implemented and tested at each prototype site is described below.

Los Angeles – The dray Port Logistics Group used the TMW Truckmate system for overall fleet management of its drayage operations. Most of the owner-operator drivers had cell phones, which they used for communicating with the dispatchers (by both text message and voice) and for GPS-based street maps and routing. Although at the beginning of FRATIS planning in LA the development contractor considered a commercial off-the-shelf application for advanced traveler information, in the end PLG and the drivers stuck with what they already used. Dispatchers already monitored general traffic conditions and provided telephone alerts to drivers on an as-needed basis, and this did not significantly change with FRATIS.

In conjunction with the optimization algorithm testing, the LA development contractor installed TomTom 7150 navigation and messaging devices, shown in Figure 10 below, on the PLG trucks. As discussed in Section 5.1, the concept was that optimization orders would be offered to the driver via the TomTom device. The driver would use the TomTom to review the order information and accept the order, and then use the device in lieu of a cell phone for dynamic routing. Although provided in FRATIS primarily as the communications device for optimization, the 7150 is a navigation system and its use in FRATIS is discussed further in the Section 5.2.3.

Figure 11. TomTom 7150

Source: Cambridge Systematics

The FRATIS LA development contractor developed a two-way interface between the PLG dispatcher and the Yusen terminal operator. The interface was for estimated time of arrival (ETA) for PLG container movements en route to the terminal and terminal-dispatcher messaging and alerts back to PLG, particularly about the availability of particular containers at the terminal. Although there had been discussions of updates being provided directly between the en-route driver and the terminal, both Yusen and PLG decided that, due to liability concerns, they did not want to have direct communications between terminal staff and truck drivers (LA FRATIS Final Report, page 18). Instead, the concept was that when the driver accepted the assignment on the TomTom 7150, a notification would be automatically sent from FRATIS to the Yusen terminal. The system design included a web service in the optimization system that could communicate with Yusen Terminal's Navis-based terminal operations system. The container availability information was to be sent to the PLG dispatchers from Yusen, then subsequently the dispatcher advised drivers by phone or text.

Dallas-Fort Worth – As noted, both drayage companies, Associated Carriers and Southwest Freight, in DFW used the Trinium Transportation Management system for fleet management and dispatching. The development contractor investigated and wanted to use a commercial truck-oriented mapping and traveler information product. Coincidentally, while FRATIS was being designed Trinium was already introducing its MC2, a smartphone app which provides routing, navigation, traffic, and weather. The MC2 information was available on mobile devices so it could be used by drivers as well as dispatchers.

Figure 12. Trinium MC2 App

Source: Trinium Technologies website

The MC2 also was developed by Trinium with mobile capability similar to the TomTom 7150, where the driver could receive and accept assignments using the device. Both DFW drays implemented the MC2 application on drivers' smartphones, but did not require its use. The use of MC2 in DFW is discussed further in the findings, but because it was a product independent of FRATIS, no test per se was included in the FRATIS prototype of the use of the device.

The two DFW dray companies sent notices of ETA of containers via email to the Intermodal Cartage terminal. The intent of this information, according to the DFW contractor, was to improve the planning process at the terminal. By anticipating when containers would arrive and what level of effort would be required to process them, the terminal would be able to better plan for the labor and resources needed to expeditiously process the containers. In addition, the ETA data would provide the terminal with insight and visibility over expected daily volumes. The same notices were emailed to the BNSF railway for containers moving to its intermodal terminal. These automatically-generated emails were query reports from within the Trinium system. The email indicated that the dray was bringing an empty to the terminal, or was coming to pick up an empty as specified by a customer.

The DFW development contractor developed a web-based portal for its FRATIS users. The FRATIS DFW website (portal) provided separate, secure access to these applications to the three primary stakeholders. It included access to traffic systems of the regional offices of the Texas Department of Transportation. It allowed presentation and information-sharing of data, including equipment availability at IMCG-Wilmer from the steamship lines as well as terminal wait time data from IMCG.

Specifically, the FRATIS DFW website portal included:

- Traffic and weather information (for dispatcher use)
- Display of the current and predicted wait time at IMCG-Wilmer
- Display of the IMCG-Wilmer yard status (which articulates the type of containers being accepted at the yard that day)
- A link to the TomTom Webfleet user interface

South Florida – FEC Highway Services, the drayage company in the SFLA FRATIS effort, uses Qualcomm for fleet management that includes two-way messaging capability, so there was no interest in the type of on-board device used in Los Angeles. Because Qualcomm includes truck-specific traveler information, the capability was not part of the SFLA FRATIS test.

5.2.3 FRATIS Prototype Findings

The FRATIS ConOps, in its introduction, states that the advanced traveler information bundle of the Dynamic Mobility Applications program "will leverage existing data in the public domain, as well as emerging private sector applications, to provide benefits to both sectors." In the FRATIS prototypes, the efforts in advanced traveler information essentially proved several concepts that could be useful if applied more widely and in more depth. As noted, a decision was made not to use the advanced traveler functionality in the South Florida test. The advanced traveler applications in LA and DFW were minor in terms of level of effort and outcomes when compared with the optimization functionality discussed in the previous section. Nevertheless, there were efforts and notable successes that resulted in the following findings.

1. **Existing commercial truck devices or smart phones have traveler information for drayage truck drivers. Such traveler information was somewhat useful to the drivers.** Most drivers for all of the drays in the FRATIS tests used mapping available on phones and seemed happy with its capability. As noted earlier, TomTom 7150 devices were tested in LA and the MC2 app was available to the drayage trucks in DFW. Drivers in LA and DFW found the in-cab devices helpful, but no more so than their cell phones. In fact, the PLG drivers found the 7150 more difficult to use than smart phones. This was viewed by officials at PLG as both a training issue and a preference issue on the part of individual drivers. One LA driver said that the 7150 didn't show all the streets, even some truck-ready roads; he liked his Garmin better. The driver suggested the navigation unit have color coded truck routes on a map. Some dray officials interviewed thought some drivers objected to their cell phones being tracked. However, because of the widespread cell phone implementation and use among all the drays, it seems to the assessment team that tracking is not a key concern for these dray drivers.

   In DFW, both drayage companies felt the Trinium-provided dynamic routing, traffic, navigation, and weather information in its MC2 application was somewhat helpful, but neither felt this was an application they would continue using beyond the pilot (FRATIS DFW Final Report, page 34). The DFW dray drivers who did use the advanced information said it was useful to see the real-time traffic information, although routing was not as useful. Associated, which does both regional and local moves, thought the information was better suited to the drivers who perform regional moves since the destination may be one they have not been to before. The dray drivers are already familiar with routes – both primary and alternate – between frequently-visited facilities in the DFW region, especially primary rail hubs and long-term customers, and are less in need of dynamic routing information.

   Because the existing Qualcomm system at SFLA dray already provided advanced traffic information, the SFLA prototype did not test advanced traveler information.

2. **Dray company managers and dispatchers found the Webfleet website to be useful for fleet tracking and monitoring of drivers.** Webfleet also provides fleet and individual truck reports based on the TomTom 510 data transmitted from the devices that were installed in FRATIS trucks. Webfleet was used daily at one of the drays in DFW to track individual drivers. The other dray did not use it on a regular basis, but when the user did he found the information helpful. That dray only had 10 trucks with the TomTom devices, but the user thought it might provide even more utility if additional trucks had devices. The DFW daily user thought the information he obtained from Webfleet could be of use in providing information to

customers about driver progress, but it would be preferable to integrate it into the Trinium system used for dispatching. Such integration was not investigated within the FRATIS project, but the finding does prove that mapping of a fleet's truck location could be popular.

Both the operations manager and the dispatcher for the LA dray company PLG used the Webfleet website to monitor its fleet and track individual drivers, and sometimes used the geo-fencing provision to follow particular trucks. PLG said they found the tracking functionality to be quite good.

The Webfleet website was available to SFLA, and although they did not access it regularly as DFW and LA did, the dispatch manager was impressed with what the system shows about the fleet movements.

3. **Websites developed to display traveler information, wait time, and other data (the FRATIS portal in DFW and the PAI website in LA) were not used regularly by the drays because of the press of business, but users thought such data could be useful.** Essentially the portal created by the development contractor in DFW was a one-stop shop for advanced traveler information that could be used by drayage companies. For the most part, the information available on the portal was nice-to-have for the dispatcher and, as a result, was rarely used during the test. The developer noted that it had to remind the users to check the portal; when they did, they found the information somewhat useful. Feedback from users at all of the prototype sites indicated the desirability of placing most FRATIS information on the same screen; for example, integrating optimization output results with the existing dispatching software screens.

   The LA website created for using the Optimization Algorithm had a page that allowed access to advanced traveler information and other data from the terminal or from public sources, such as the Harbor Trucking Association data. Both the LA website and the DFW FRATIS portal were steps in the direction of one-stop shopping, providing access to advanced traveler information from public or private sources as well as a link to the Webfleet website. Although not really used, both websites represented an idea that should be pursued in future developments where multiple sets of data are brought together.

4. **Test participants in DFW found the Trinium MC2 advanced traveler information application to be useful, but identified some design issues relevant to FRATIS.** Trinium's relatively new MC2 application for smartphones was of use to the DFW drays, with several relevant findings. The route, traffic, and weather automatically refresh anytime the driver exits and re-enters the MC2 application, but does not necessarily refresh as dynamically as some other commercial products. According to the DFW FRATIS developer, Trinium's perspective on this feature was that the routing application can be as dynamic as the driver chooses, similar to the way a personal driver can "update from here" within Google Maps. A design gap noted by the DFW FRATIS developer was that if a driver went to the drayage office to pick up a hard copy of the order (as was permitted), the routing, navigation, traffic, and weather capability in MC2 would not be dynamically provided to the driver. Finally, a key gap in the application from the development team's perspective was that the application did not include an audio component, which made the driver dependent on written or map-based information. (DFW FRATIS Final Report, page 31)

5. **Participation and cooperation by system suppliers to the dray companies helped the FRATIS project as well as the suppliers themselves, but sometimes affected the FRATIS schedule.** One positive effect of FRATIS was on IT suppliers to the companies involved in the test. For example, the DFW drays found that Trinium Technologies, provider of the system

used by both drays in DFW, paid more attention to DFW-related enhancements because of the FRATIS test. In particular, the MC2 application was actually implemented at DFW sooner than the drays expected because of the attention given to the FRATIS project. Trinium was also quite interested in the progress on optimization and was considering future applications in its system.

Trinium also played a vital role in assisting with the automated input of orders to the optimization algorithm and with the advanced notice emails from the Trinium system to the IMCG and BNSF terminals. Trinium, as well as TMW in LA and Qualcomm in SLFA, played key roles in the data mapping needed to integrate the entry of orders for optimization into FRATIS. The data mapping, in particular, was complicated and time-consuming; all three sites found that it took longer than hoped and adversely affected FRATIS schedules. As noted earlier, the order entry interface was not completed in time to complete the FRATIS test in LA. Since all FRATIS software is open source, it is available to all of the system providers if they were to decide the applications were compatible and complementary with their systems.

6. **The automated daily query that sends an email of expected daily arrivals information from the dray company to an intermodal container terminal at the DFW test site was well-received by users and will continue in operation after FRATIS ends**. The advanced information identifies the estimated time of arrival of drayage trucks to bring empty containers to the terminal or pick up empty containers that a steamship line has identified to the dray company for pickup. The automated emails generated as daily queries from within Trinium were used by both DFW drays. The depot manager at the intermodal terminal used the reports and was reportedly enthusiastic about the information until that manager left employment. The notification helped the terminal identify what specific equipment was to be dropped off or picked up; in the case of a pickup, the advanced notice could provide the terminal with the information necessary to unbury the container in advance of the pickup. The new depot manager who arrived at the end of the test thought the email notices would be quite useful. He thought any information would help the staff prepare, adjust, and manage the flow of operations in the terminal. The terminal managers believe it would be even more useful if advanced notices could be obtained from more drayage companies. Although the same kind of email advanced notice was sent to BNSF during the test, there was no indication they used the information. Nevertheless, both DFW drays indicated they will continue to provide the automated emails to IMCG and BNSF as part of on-going operations.

7. **The communications link to provide advanced notice by the LA dray company to the marine terminal for expected arrival time was successfully established, but was not used.** The design concept was to provide information on what was being sent to Yusen at least 24 hours in advance. This would allow the terminal to plan its labor. There was not enough traffic volume between the dray and Yusen during the test to affect terminal operations, but everyone knew that at the start and viewed it as a proof of concept which was largely successful, but benefits could not be directly measured. Both the terminal and the dray view the interface as promising. The test proved data could be sent from the dray to the terminal from systems in automated form, but test data was inaccurate and terminal operators felt it was not timely, so it couldn’t be used by the terminal. This was discouraging to the terminal operators, but they thought that with time and attention and enough volume to justify the effort, such errors could be overcome.

   During the test, the dray company and terminal operators discussed the possibility of providing the dray access to a “peel off” lane that Yusen was implementing for speedier pick up of containers in a different portion of the yard. This was to have been tied in with the advanced notice information the dray was sending to the terminal. Unfortunately, the overall congestion at the ports of LA and Long Beach during the test period led to shutdown of the peel-off lane before it could be used by PLG.

The interface was primarily, if not exclusively, from dray office to terminal. Although the link was designed for use with the 7150 device in trucks, trucks did not communicate with the terminal; instead, as noted previously, FRATIS automatically sent notifications to the terminal after drivers accepted orders via the 7150. All stakeholders viewed such real time communications as worthwhile and something that should be pursued in the future with more partners.

8. **The interface between the dray and marine terminal at LA was also used successfully during a portion of the test to provide one-time container availability at terminal to dray.** Even prior to FRATIS, the Yusen Terminal website (and some other terminals' websites) was available to the dray. The website contained gate video as well as estimates of wait time. The new notification in FRATIS about container availability was only a one-time indication of whether a container was unavailable or available. It was communicated at PLG to a single Customer Service Representative, and displayed on a FRATIS webpage. PLG managers explained that when the port situation deteriorated later in the test, the container availability was no longer provided to PLG by Yusen. That said, the concept was shown to work and PLG said the information was potentially useful in the dispatching process. It should be noted that from the beginning of FRATIS, everyone was cognizant of the small container volume between Yusen and PLG, but stakeholders like the idea of container availability information for more widespread use with more terminals and more drays. What is also clear from discussions with the stakeholders, from press articles, and from the July 2015 Federal Maritime Commission port congestion report is that communications of port status information between and among terminals and drayage companies is needed and offers the promise of benefits to the dray companies. For example, in discussing improvements suggested by participants in the 2014 FMC Port Forums, the following improvement speaks directly to this finding (and perhaps not coincidentally included a reference to FRATIS):

    > **Leverage current and emerging technologies to create real-time channels of communication**. According to this suggestion, greater integration of information technology could facilitate more efficient flows of containers moving in and out of terminals on trucks and trains, and eliminate some of the current bottlenecks being experienced. Examples of such initiatives already underway include FRATIS, *Cargomatic* (a kind of Uber scheme for trucking), and virtual container yards. (FMC Report, page 58)

9. **Drayage companies and marine terminals, like the shippers and consignees they serve, are looking to squeeze costs anywhere they can.** This has resulted in advances in the logistics information technology suppliers, with cloud computing causing huge changes in what buyers and sellers do. "The new trend in software as a service (SaaS) offers dynamic systems that are clearly intended as mid-level enterprise solutions, providing visibility and communications tools that empower operations," according to an article and annual survey in the April 2015 issue of *Inbound Logistics* (page 44). Slightly less than half (47 percent) of logistics IT suppliers provide web-based solutions and a majority offer web and local systems. One supplier said currently close to 50 percent of new implementations opt for a SaaS deployment model, which they expect to grow to 80 percent in the next few years.

    The Inbound Logistics survey listed the top challenges for the IT buyers, meaning the principal focus where they apply IT and hope to achieve benefits:

Table 10. Logistics IT Buyers' Top Challenges

Cost Reduction	86%
Visibility	71%
Integration	69%
Customer Service	65%
Transport Optimization	63%
Data Management	61%
Inventory Management	46%

Source: Inbound Logistics April 2015

As will be discussed further in Section 8, the top challenges above, when applied to drayage companies, mirror many of the problems the prototype participants faced. The SaaS trends and the importance of information technology including FRATIS cannot be overemphasized. With so many companies offering so many software products that help transportation companies, including drayage companies, manage their operations, it is important for any drayage company – and any proposed government-sponsored transportation research project – to investigate what is in the commercial marketplace before embarking on a custom-built software program.

5.2.4 Lessons Learned

Based on the findings discussed in more detail in the preceding section, the table below includes four lessons learned from the testing of the advanced traveler information in FRATIS.

Table 11. Summary of FRATIS Advanced Traveler Information Lessons Learned

Take advantage of existing commercial information, logistics technologies, and smart phones whenever possible.
Implementation of any advanced information technology capability requires careful attention to the needs of users and training prior to and at the beginning of successful use.
Automated information about the availability of containers at terminals is useful to drayage companies, particularly when multiple terminals provide the information.
Advanced arrival information is useful to terminals that handle containers. With large enough container volumes and careful implementation of the data, the data can help a terminal better manage its operations.

Source: CDM Smith

5.3 Terminal Queue and Wait Time

5.3.1 Terminal Queue Time Objectives

The FRATIS ConOps' Prior Research Report noted that long queues of trucks at intermodal terminals are a recurring feature of many urban areas, especially around major port complexes and large intermodal rail hubs. These trucks create safety, traffic, and emissions concerns for the surrounding community. Queues result when a ship arrives in port and shippers scramble to get their containers; when terminal operators have labor shift changes; when part of a marine terminal is closed off for some reason; and for a variety of other reasons. Dray truckers and dispatchers often are not aware of long queues at the gates until they arrive, and therefore cannot reallocate resources to avoid the lines, for example by picking up an available load at another terminal. (FRATIS Prior Research Report, page 63)

On a given day, turn times for trucks can vary substantially, even when trucks enter the terminal under similar conditions. When a terminal is operating close to its capacity, the probability of high turn times (the noted that the capacity of a terminal is dependent not only on the physical attributes of the terminal, such as the number of lanes and cranes, but also the amount of labor that has been assigned to work a particular shift. Terminals attempt to anticipate high-volume periods and assign labor accordingly. If the terminal misjudges the volume for a particular day, higher average turn times and greater variability can result. (NCFRP Report 11, page 42)

Because of these terminal uncertainties and delays for drayage truckers, the FRATIS ConOps identified the need for automated terminal queue information, including video feeds for relevant terminals, to be made available to drayage companies. The intent was that dispatchers and operations managers be able to access this information at any time. The FRATIS concept was that, with advanced knowledge of terminal queue length and waiting times, dispatchers and drivers could alter schedules, where possible, to avoid inordinately long waits at the gates. The concept included sensors positioned at key points approaching the terminal gates, which can detect when the queue exceeds a certain length, and video cameras that provide a live webcam view of real-time queuing activity. (FRATIS ConOps, page 57)

There are two components of terminal delay; turn time within the terminal as mentioned above, and queue time waiting at the entry gate. The entrance gate queues at marine container terminals have long been identified as bottlenecks and sources of delay for port drayage. Time spent in the queue is unproductive, and idling in the queue is easily identifiable as a significant source of unnecessary emissions and noise. Satisfactory data on queue times is not readily available. Terminal information systems do not capture queue times. Almost all the data available in the literature are from driver surveys. (NCFRP Report 11, page 47)

There have been turn time studies, most notably at the ports of LA and Long Beach. Some terminals have video cameras available on their websites. Others publish wait time information on their websites. There is, however, a dilemma: some terminals don't want customers to know the wait time for competitive reasons. On the other hand, the Harbor Trucking Association in Southern California has on-line data for turn time at each terminal in LA and Long Beach. The FRATIS concept is to make terminal wait time or queue time data available to drayage companies. Armed with up-to-date information, the drayage companies should then be able to make better decisions about when to send trucks to the terminals. In addition, the FRATIS intent is to use wait time as one of the constraints in the optimization algorithm.

5.3.2 FRATIS Prototype Implementations

The DFW and LA prototypes of FRATIS investigated measurement and reporting of terminal wait time with the objective of providing dray companies with terminal status information they could use in operations planning. The LA terminal wait time effort involved the drayage company and the marine terminal operator Yusen Terminal. The DFW wait time effort involved the two drayage companies and Intermodal Cartage Group's empty container yard in Wilmer, TX. Both efforts were aimed at establishing communications links between the terminals and drays, and demonstrating the feasibility of using technology to measure truck passages and then calculate wait time. Both LA and DFW installed Bluetooth/WiFi devices from Acyclica at strategic locations within and along the approach to the terminals and collected data for much of the baseline and test periods. DFW also installed dedicated short range communications (DSRC) devices for a limited, approximately 30-day pilot to see how the technology compared with Bluetooth/WiFi.

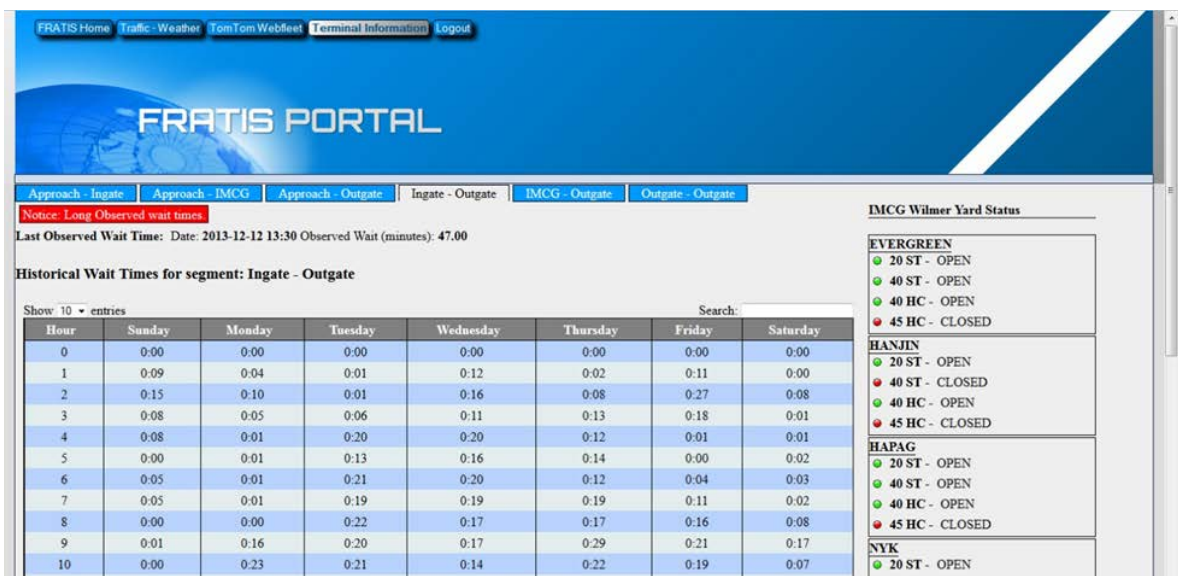
In DFW, the Bluetooth/Wi-Fi wait time equipment for FRATIS included four readers: at the approach, the in-gate, the IMCG-Wilmer gate (the gate IMCG company trucks are to use), and the out gate, as shown in the figure below.

Figure 13. Acyclica Sensor Location at IMCG

Source: DFW FRATIS Final Report

For the FRATIS DFW prototype, the readers were operational and data was shared between the Acyclica back-end server and the FRATIS server between May 10, 2013 and September 30, 2014. The Acyclica algorithm processes the media access control (MAC) addresses and calculates the current wait time for each route segment. These times were provided to the FRATIS server via web service every 15 minutes, which made it available to authorized users via the FRATIS portal. The figure below shows the type of wait time information that was made available to users on the FRATIS portal.

Figure 14. DFW FRATIS Portal Wait Times



Hour	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
0	0:00	0:00	0:00	0:00	0:00	0:00	0:00
1	0:09	0:04	0:01	0:12	0:02	0:11	0:00
2	0:15	0:10	0:01	0:16	0:08	0:27	0:08
3	0:08	0:05	0:06	0:11	0:13	0:18	0:01
4	0:08	0:01	0:20	0:20	0:12	0:01	0:01
5	0:00	0:01	0:13	0:16	0:14	0:00	0:02
6	0:05	0:01	0:21	0:20	0:12	0:04	0:03
7	0:05	0:01	0:19	0:19	0:19	0:11	0:02
8	0:00	0:00	0:22	0:17	0:17	0:16	0:08
9	0:01	0:16	0:20	0:17	0:29	0:21	0:17
10	0:00	0:23	0:21	0:14	0:22	0:19	0:07

Source: Leidos

The information was also stored and used to predict expected times. More detail regarding that data can be found in the DFW FRATIS Final Report.

For the FRATIS LA prototype, the Acyclica terminal queue measurement system was installed in and around Yusen terminal in June 2013. Eight WiFi MAC Address Readers were deployed at the Yusen terminal approach, key choke points within the terminal, and at the terminal exit as shown in the figure below.

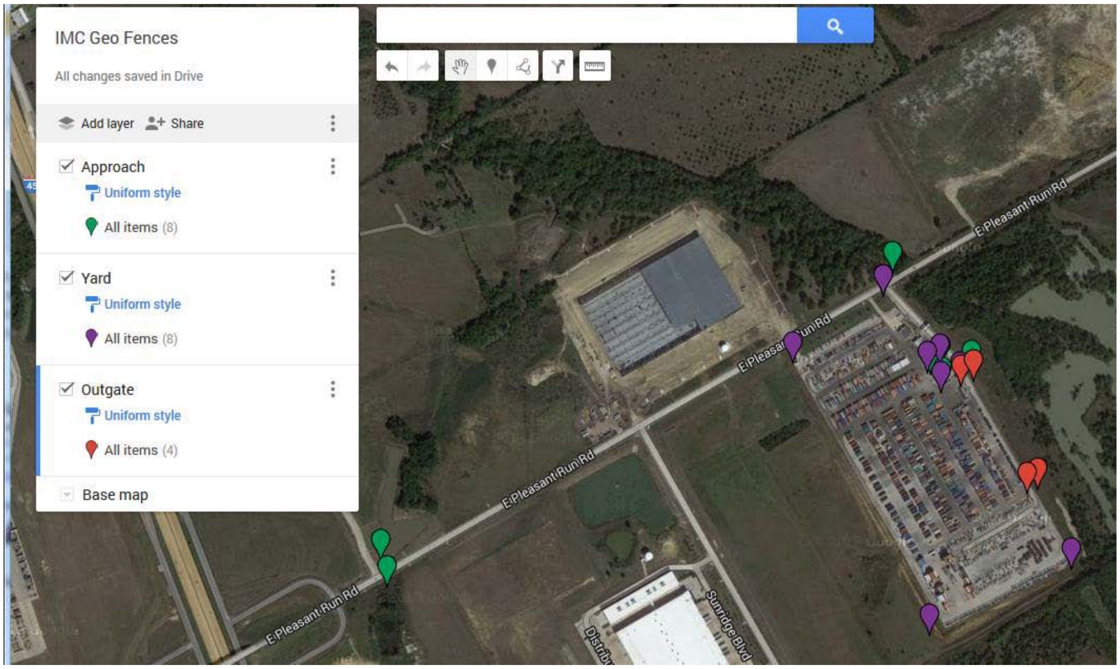
Figure 15. Acyclica Sensor Locations at Yusen Terminal in LA

Source: Cambridge Systematics – FRATIS presentation Jan. 2015

At both prototype sites, the measurement devices included Internet connections to the Acyclica server in Denver. The Acyclica system read signals from any truck with active Bluetooth and WiFi cellphones. The waiting times and turn times inside the terminal were collected and analyzed to estimate wait times. At DFW, the wait time was downloaded to the FRATIS portal website, which was available to dray users. At LA, the wait time was used at the beginning of the period as an input to the optimization algorithm and was available to dray users on the FRATIS website at PAI. Because of data errors discussed in Section 5.3.3, Finding 3, the optimization developer in LA later used turn time data from the Harbor Trucking Association as the optimization input. The developer noted that the HTA data was actually a superior source because it represented all LA and Long Beach terminals.

In DFW at IMCG-Wilmer, the development contractor implemented DSRC and the Basic Safety Message (BSM) for a limited, one-month proof-of-concept test from the second week in December 2013 until January 29, 2014. The installed equipment consisted of stationary roadside units (shown in the figure below) and DSRC radios on five company trucks in IMCG's dedicated fleet. Although the intent was to collect data for a continuous 30-day period, multiple issues impacted the collection of the BSMs including power outages that occurred during the holiday weeks. BSMs were collected for 19 days during this period, for a total of just over two million BSMs. Once collected, the team had to retrieve and analyze the BSMs in CSV format in order to calculate the wait time. According to the DFW developer, more than 579,000 records were collected and stored on the FRATIS server from May 2013 to September 2014. (DFW Final Report, page 25)

Figure 16. DSRC Reader Installations at IMCG-Wilmer



Source: DFW FRATIS Final Report

5.3.3 Findings and Lessons Learned

The terminal wait time efforts at DFW and LA showed that data can be collected and wait times calculated, and that presenting wait times on websites available to drayage companies could be useful. Below are some findings from the DFW and LA tests related to wait time.

1. **The drays made little actual use of the terminal wait time information on the FRATIS websites.** In DFW, as noted in the DFW Final Report,

   > The use of the [web]site was not significant during the test, as described by the participants... Although the site highlighted when a wait time was significant, it still required the user to log on to the site to view the information. A more dynamic interface that facilitated alerts regarding current wait times and equipment availability possibly holds more potential for users. (pages 25-26)

   In LA, the dispatchers' normal duties were so time-consuming during both the baseline and test periods that even remembering to check new websites was often difficult. The FRATIS website provided by the developer included short tables with calculated wait times approaching the Yusen gate and at two points within the Yusen terminal, but the website was not used by the drayage dispatchers or managers.

   However, drayage users in both LA and DFW, as well as various documents and articles that have been cited in this final report, clearly indicate the negative impact of terminal delays on transit time and note that reducing the time in queues at the terminals would be an important cost and time savings for drayage companies and their drivers.

   One of the FRATIS hypotheses was that terminal queue information from FRATIS would assist the dispatcher in minimizing terminal wait time. Generally speaking, and in particular with the LA dray's interaction with the Yusen terminal, the PLG drayage trucks did not affect terminal wait time (as discussed earlier, the volume of PLG traffic to YTI was very small), but having wait time data for each terminal certainly would allow the dispatcher to make alternative routings or assignments in the face of terminal congestion.

2. **The Bluetooth/WiFi devices reliably collect data of vehicles passing them, but in the test they suffered from occasional weather-related outages and inadvertent shutdowns.** In DFW, the issue was the human and environmental interference with the readers, including being disconnected from their power source. Acyclica installed protective enclosures to reduce human interference with the readers and their connection to power and network interfaces. There were numerous instances of severe weather outages, and the time required to troubleshoot and resolve them varied from a few hours to a few days. In LA, installation issues with two readers led to early equipment failure, but they were readily fixed. An incident temporarily interrupted the internet connection, but it was discovered and corrected. Therefore, while the software and collection approach worked, the hardware at the site can be impacted by numerous factors, causing temporary outages of varying duration.

3. **The depot manager at the intermodal terminal in DFW thought wait time measurement would be useful to the terminal.** The new depot manager at IMCG (who arrived at the end of the test, after the Acyclica devices were turned off) was unfamiliar with the Acyclica devices or wait time measurements. The manager did say that wait time data would be useful for staff allocation, notifications to trucking companies, and general public relations from IMCG about comparative wait times. He also thought the data could help identify peaks and valleys in operations. The manager noted that IMCG has queues of bobtails waiting in the morning, but has no website or other means of showing wait time status. The FRATIS wait time test with the wait time data available on the FRATIS portal showed that such data, if used more widely with more companies, could be helpful both to the IMCG and to the 15 trucking companies who operate at IMCG. In LA, the wait time data on the FRATIS/PAI website was not used because of the press of other business. However, the Harbor Trucking Association turn time data, which is available by annual subscription, is used throughout the LA/Long Beach port complex and can be of continuing use to the many drays in that area. What the HTA data does not have that is needed by drayage users is the wait time approaching the terminal gate.

4. **Although the Acyclica data was not analyzed by the assessment team, the data will be provided to USDOT for limited research.** One of the plans in FRATIS was for the wait time data from Acyclica to be available to the assessment team. Raw data measuring the time between two points in a terminal were recorded daily and this data was indeed made available to the team. The assessment team found the data to be extremely difficult to work with calculating wait times proved difficult as well. Even so, the wait time data and queue issue were relatively low priority aspects of the assessment compared with the overall daily performance measures of mileage and time that viewed the overall operations of the drayage companies, and potentially could identify the impact of use of the higher priority optimization algorithm. The Acyclica data will be available to researchers who access the server that will be located in the Saxton Transportation Operations Laboratory located at Turner-Fairbank Highway Research Center, and may be of future use to analysts of terminal operations.

5. **Although the assessment team did not separately assess the differences between DSRC and WiFi as tested at the IMCG facility in the DFW pilot testing, the key finding from the Leidos final report on the DFW project is reproduced below.** Their results may be useful to future efforts to implement wait time measurement equipment at terminals.

   The use of DSRC to calculate wait time is not yet as accurate as other methods, in this case Bluetooth/Wi-Fi, although the reliability of the equipment seems comparable.

The average wait time at the approach using DSRC technology was 13 minutes, while the Bluetooth/Wi-Fi system was 25 minutes. Similarly, the time in the yard (from in gate to out gate) varied significantly between the two technologies, with DSRC calculating an average of 75 minutes while Bluetooth/Wi-Fi calculating 29 minutes. While these seem like significant gaps, it is important to highlight that the DSRC prototype was extremely limited, with only 5 trucks being equipped with these devices. Moreover, these were company trucks belonging to IMCG; therefore, it was not unusual that they would remain parked at the facility overnight; this would cause a very long time in the yard to be noted by the technology. In addition, the IMCG-owned trucks are allowed to enter the facility through a dedicated lane, whereas other providers are restricted to a single lane that must be shared among the multiple drayage companies who call that facility. That said, the limited test illustrated important points, including:

- The BSM provides sufficient information needed to calculate wait time
- The development team wrote accurate code which calculated the time between two geo-fenced locations
- The existing connected vehicle test bed data management system did not require significant change in order to facilitate the collection of the messages and the calculation of wait time(pages 32-33)

Table 12. Summary of FRATIS Terminal and Queue Time Lessons Learned

Terminal wait time information can be useful to the terminal itself and, if properly used, can improve overall terminal operations.
Developing information technology tools such as new websites requires careful attention to users both during and after implementation to help assure use of the tools and data provided.
Queue time waiting to enter a terminal is difficult to measure, but is of use to drayage users in their route planning.

Source: CDM Smith

5.4 Increasing Emergency Preparedness and Response Efficiency

5.4.1 Emergency Response Objectives

In South Florida, in addition to the testing of the optimization algorithm in FRATIS at FEC Highway Services, the prototype contractor developed an emergency preparedness and response mobile application intended to improve the handling of real-time information following natural disasters such as hurricanes, including pre-event staging of supplies, post-event relief delivery coordination, and critical road and facility closures. One focus was to be on post-event recovery related to the freight industry, such as identifying a company with trucks and unimpeded roadways which could move critical supplies to accessible locations that need them. Knowing that it is unlikely an event would occur during a proposed test period, the objective was to create a prototype application that could be used during an event simulation by emergency response organizations and some private companies in Florida.

With input from various public and private stakeholders, the development contractor developed an application for Android-based smartphones to provide automated data collection and sharing among emergency response personnel and relevant supply chain partners in order to streamline post-event recovery activities. Examples include identifying staging areas for recovery, open gasoline stations, and the availability of construction materials from suppliers such as local home stores.

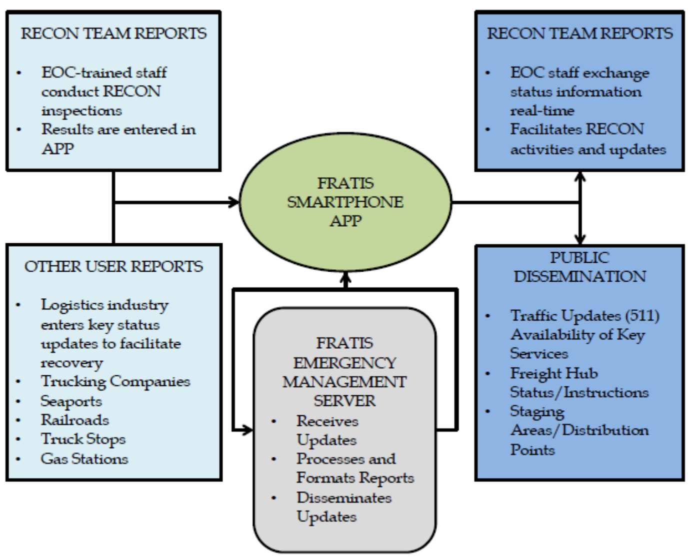
An important use identified for the app was to automate portions of the area reconnaissance (RECON) process that local and regional emergency management agencies in Florida use to determine the extent of damage from an event and record infrastructure and other impacts. In RECON, trained staff conduct inspections, fill out reports on pre-printed forms, and enter the data in the existing Emergency Operations system for use by the Florida Department of Transportation (FDOT), which decides if they want to release such reports. The objective of the app was to automate the entry and preparation of RECON reports.

Three test scenarios were developed representing progressively worsening hurricane conditions, and as the scenarios increased in severity, the conditions reported by users were anticipated to increase in severity.

5.4.2 FRATIS Prototype Proof of Concept

It was understood from the beginning that the development was a prototype that could show the capabilities and effects such an app might have. The diagram below, from the South Florida FRATIS Final Report, shows the concept that was developed and tested. The proof of concept focused on the smartphone app as well as the FRATIS server that handled the information, and both are shown in the diagram. The app works on a web browser as well as an Android smartphone. Inputs of situational data from the field are entered in the light blue boxes on the left while outputs made available to the emergency response staff are shown in the dark blue box. Data and reports are then distributed as appropriate. The app can be used to filter out types of facilities or infrastructure for examination or presentation. The FRATIS Emergency Management server handles storage of appropriate data and software to generate reports and update users as needed.

Figure 17. Overview of FRATIS Smart Phone Application



Source: Cambridge Systematics, Inc., South Florida Report, page 9

A number of public and private entities were involved in different parts of the effort. Port Everglades planning staff as well as Crowley marine terminal operator at Everglades were involved in the simulation test along with Broward and Miami-Dade County Emergency Management staffs. FDOT was also involved in testing the app and provided technical input throughout the effort. Other terminals and public entities supported the testing or earlier development planning, including FEC Highway Services. During the simulation and test, the role of private businesses was played by Port Everglades, Crowley, FEC, and the development team and by other test participants willing to take on multiple roles.

The application was tested over the course of three separate days in November and December 2014. Users were given three separate hurricane scenarios to simulate. As the test progressed, each scenario represented more severe events, such as a Category 3 storm versus a Category 1 storm, and users were expected to adjust the severity of the conditions reported accordingly. Some participants used web browsers on their personal non-Android smartphones, tablets, or office computers, some used their Android phones, and still others were given pre-paid Android phones for the occasion. The prototype development included the app and a server, but no way of communicating or distributing the information except to the server. The app used available Google-based software for Android devices, including Google Application Program Interfaces (API) such as maps, geocoding, and location information.

An important part of the app was a RECON form that was automated on the smartphone app. It digitized field data collection that had previously been manually recorded on paper in the field and then entered into emergency management systems back in the office. The test scenario for RECON was to identify the GPS location, make various forms available, takes picture of the scene, and transmit it to the server via WiFi. (Means of transmission was not a problem during the test, although there are concerns that cell phone coverage may be lacking during an emergency event.) The prototype also included the ability to send a smartphone photo to the server, allowing a field agent to visually document damage. All users with access to the server are able to see the data.

5.4.3 Findings and Lessons Learned

There were two types of findings and lessons learned in the emergency response app development and test. The findings by the development contractor, as documented in the South Florida Final Report, are important and some of those findings are quoted in this section. In addition, the assessment team participated in several meetings and interviews to discuss the perceptions and observations of the stakeholders. Both include suggestions concerning full development and implementation of such an emergency response application.

1. **The RECON portion of the emergency response app that automates a manual reporting function was shown to be worthwhile**. The Florida public agencies which manage reconnaissance and recovery activities were particularly interested in the functionality of the app and how it would serve their RECON efforts, and how the app could assist them in collecting and disseminating data. Participants in the test judged the RECON function to be about an 8-hour improvement in timeliness of data. The following four points from the SFLA Final Report provide additional detail about the development and test participants' views of the RECON functionality:

    - **App allows for the faster reporting of data.** The app eliminates the need to fill out paper forms, which are only entered into the emergency management system once RECON teams have returned from their shift. An automatic upload of this information allows for conditions to be reported in near-real time and can allow for repairs and debris removal to begin sooner.
    - **Manual process of RECON reporting is digitalized.** By digitizing the manual RECON process, fewer resources are needed by emergency management officials to process the data. RECON teams can go out in the field without worrying about having enough paper forms. In addition, it reduces the effort required at the central command center to enter the information when crews return.

- **Better data is available through the app.** The app allows users to attach pictures with each report. This is possible with current RECON procedures; however, the image is not attached to the report and must be done manually when the report is entered into the system.
- **Lower resource usage for information management.** Post-event conditions are a state of "controlled chaos" with limited personnel resources. The app will reduce the amount of time needed to enter and process the data from RECON reports, freeing up personnel time for other tasks. (SFLA Final Report, page 24)

2. **Integration with existing technologies and emergency management systems will be crucial for full development and implementation of the emergency response app.** Because this was a demonstration and simulation, no integration was done in the pilot. However, if the system is fully implemented it should be integrated with other systems. FDOT currently sends data to emergency operations systems; stakeholders agreed that emergency response data could be added to what is sent. Future enhancements and expansion of the system should focus on integration with user systems to improve data collection and dissemination activities. Here is a recommendation from the SFLA Final Report about integration:

    > For future development of this app, it is recommended that it be integrated with existing systems, such as 511, which already provide some information to supplement the user inputs. Integration was not done as part of this demonstration due to the limited nature of the pilot test, as well as a relatively decentralized emergency management operation; that is, each agency has its own system; integration is done verbally in a joint emergency operations center during the event. The full benefits of an app like this would require a centralized server or, at a minimum, system integration for each set of users. This would limit the need for double data entry, as well as provide the ability to see all available information in one location. (page 12)

    Even in the simulation, stakeholders and users, particularly participants at the terminals (Port Everglades and Port Miami), complained that they did not want to perform duplicate data entry.

3. **The prototype system user performance and handling of data were degraded as the number of users and extent of system activities increased.** Many performance issues in the test were phone-based; some older model Android phones could not always handle the app and the data. Port Everglades users were involved in planning and used the web browser but not the phone app, and had difficulty accessing the system. The Broward County office firewall interfered with system operation, particularly compared with accessing it from home. The following comment from the SFLA Final Report relates to this finding:

    > As the scenario testing progressed, more data points were available on the map which slowed down the functions of the app. Modifying the main page of the app to an options menu, rather than the map interface, may increase functionalities. (page 10)

4. **Stakeholders and participants in the scenario testing were generally positive toward app capabilities that could be of use to their organizations if fully implemented.** Broward County emergency management people thought that citizens' inputs of a situation at a particular place might be interesting and useful. The County representatives expressed

interest in movement of freight, but usually in conjunction with emergency management at the ports. The ports, particularly Port Miami, are responsible for their own roadways, but often know the condition of access roads and could provide status information to FDOT and public safety officials through the app.

Miami-Dade County already has an emergency response system in place and thought the app might be more useful in places with less capability. Port Miami didn't want another tool because they already had ways of notifying users. They send email blasts on road status and emergency information and also provide such information as an input to the port's and various terminals' websites; Port Everglades also sends an email blast. Counties and their public safety organizations don't currently have reports from most businesses, such as gas stations, which would be useful in an emergency situation. They thought the app and reports from private companies might be useful for emergency response actions.

A stakeholder commented that the app is able to provide GPS location and speed of a vehicle. Thus, the public agencies could track drivers or inspectors, who could provide status information about road conditions. Test participants also felt that the map available with the app could be useful to citizens. However, there was also interest in a 3-D scrolling map which was not part of the Android-based prototype.

5. **It is critical that full versions of the emergency response app work on other platforms**. While some users were familiar with or had Android phones, many did not. iPhone users, in particular, were reluctant to learn the new platform. The developer provided training, but even that didn't satisfy some users. If the expectation is that commercial businesses or freight carriers or ordinary citizens may eventually use the app to provide field input and updates or to receive alerts and information, the app is going to have to be available on other popular platforms. This may increase the cost of development and on-going maintenance, but it is crucial to future use of the system.

6. **The prototype development and the scenario testing resulted in a much better definition and understanding by the developer and stakeholders of what features need to be in the future app.** The following points from the As Built document for South Florida describes in more detail some of the features that should be included and some of the important constraints that need to be addressed during full development:

> Now that the project team has a better understanding of what the final product should look like, and what functions are desired by the users, future work should include rebuilding a large portion of the code from the ground up. A list of the major coding areas that should be revised to make the software fully operational and therefore scalable are listed below.
>
> - **Alternate Map Source** – An important improvement would be to provide support for offline map caching so that the app would be completely usable offline.
> - **Alternate Map Engine** – A map engine that is pseudo 3-dimensional that allows the map to tilt and pan with the device would greatly improve the user friendly factor for the app. Another improvement is that the Google Maps web APIs cannot be used offline but there are many other free solutions that do.
> - **Map Drawing Revisit** – To fix the performance issues in regards to markers (both for reported events and for GPS vehicle speed points) it would be useful to revisit some of the core functions that are responsible for displaying data on the screen to find more CPU efficient ways to cache, process, and display these markers.

- **Improvements to Reports** – Report taking (e.g., submittal of RECON reports) is perhaps the most important feature of the system and currently works for the purposes which were described during the prototyping process, but two specific improvements should be made to make the reporting function easier to use and more comprehensive. These improvements are: the ability to select the report location on mobile devices by clicking on the map, and the ability to select an "Area" that is affected by the event being reported, so that issues like widespread damage or flooding can be more effectively reported.
- **Administrator Interface** – The system needs to have an Administrative Interface to be able to perform functions that were done manually in the prototype version of the app. The administrative functions need to include: User Management Functions; Report Editing; Change System Configuration Settings; and Edit/Delete Reports
- **Routing** – It would be nice if a basic routing function could be added that would take into consideration blocked roads and damaged/flooded areas. This feature would require extensive effort.
- **Google Play Services** – As noted earlier, the current system requires that the Android device have an up-to-date version of Google Play Services. When this did not occur, the software did not work, and many phones tested did not have up-to-date Google Play Services. Re-writing the software to use the built in Android APIs, rather than Google Play Services would provide a more robust software outcome. Also, if the most widespread deployment of the system was desired, future work should consider developing low level APIs for other operating systems such as the iOS (Apple Devices), or the Windows Phone or Blackberry operating systems. (South Florida As Built Report, pages 29-30)

7. **Somewhat related to the previous findings about a future operational system, some stakeholders raised the important question about who would take over the project to carry the app development and system integration to the next steps.** Some of the private sector and county-level officials wondered whether it might be FDOT. A related question was where the funding comes from. Related to that was the issue of the need for continuing support of the app and its server. In response to these questions, the development contractor noted the following in the SFLA Final Report:

> Subsequent meetings with key partners, including FDOT, suggest that there is interest in identifying and pursuing a follow-on project to build off of the existing smart phone app to, at a minimum, develop a closed loop system for a specific agency. (page 24)

Table 13. Summary of FRATIS Emergency Response Lessons Learned

Information from a variety of public and private sources can be useful in orchestrating a response to a natural emergency situation.
Proof of concept prototypes can be useful to stakeholders in helping refine requirements and functional capabilities and to better coordinate future public sector planning.
To achieve lasting benefits, a proof of concept prototype test needs to have a well-funded follow on project that integrates the enhanced capabilities into the existing systems and communications environment of the agencies involved.

Source: CDM Smith

Section 6: FRATIS Data Analysis

One of the tasks the Assessment Team performed early in the project, in close coordination with the prototype development contractors, was to identify what data would be collected throughout the project at each site. The key data collected was the truck operations data from the TomTom 510 Data Collection devices on approximately 50 trucks at each site. Data was collected and provided to the assessment team from September 2013 until the end of the development contracts in the February through April 2015 timeframe.

The intent of the FRATIS project was to make the 510 data and analysis results available through the USDOT Research Data Exchange so that additional analysis can be performed if desired. Because the 510 movement data is considered company sensitive by the drayage companies (in that it contains origin and destination information for individual shipments), the 510 data will be restricted to approved researchers with access to the server in the Saxton Transportation Operations Laboratory located at Turner-Fairbank Highway Research Center. The various spreadsheets and analysis results are also available to such researchers.

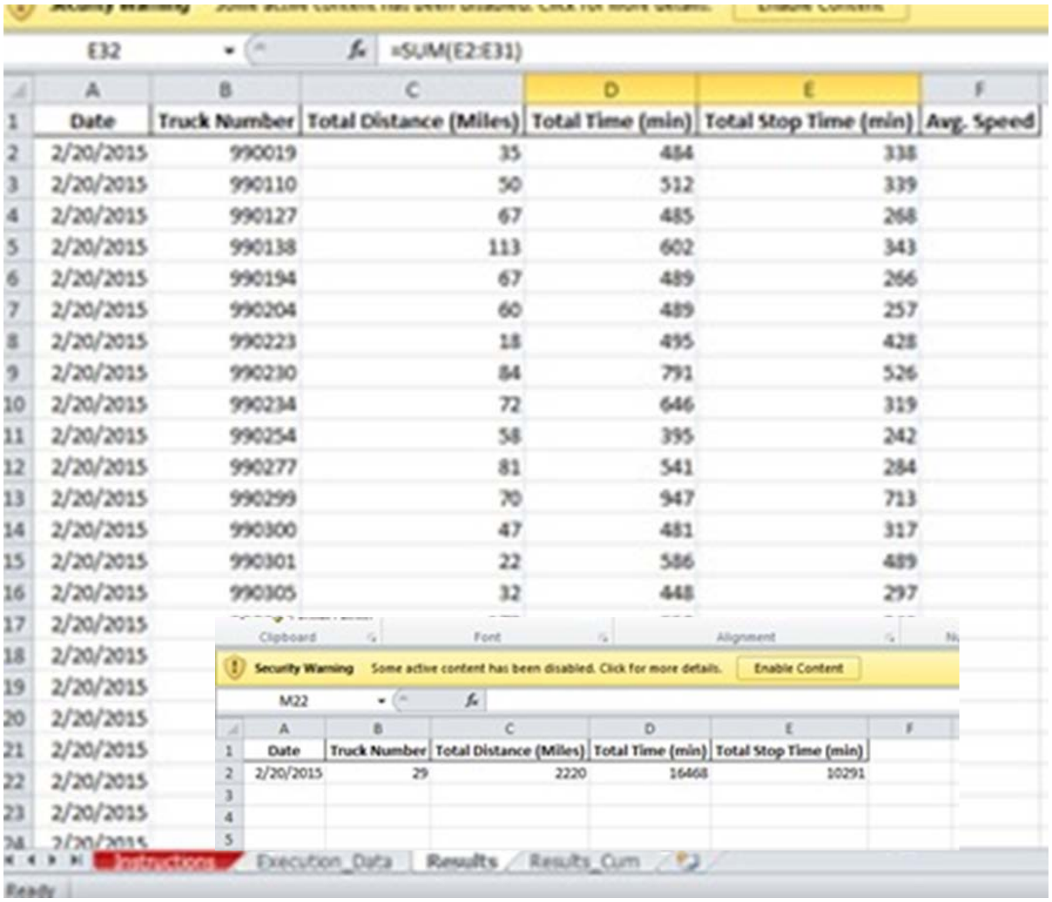
Productive Apex Inc. (PAI), the developer of the optimization software as well as the software developer for the LA and SFLA prototypes, developed the following Excel-based tools to analyze the TomTom data:

- Execution Evaluation with high level fleet measures of total mileage, total time, and stop time
- Trip Identification with number of trips, and origin-destination for each trip with trip miles and trip time
- Plan Comparison to compare performance measures of pre-test period days and test period days

Execution and Trip Identification analyses were performed for each site. Figure 18 shows what is included in the execution runs for one day for a group of trucks. The lower portion of the figure shows the summary daily results for all of the trucks with TomTom 150 devices at a drayage company.

The assessment team analyzed daily data during both the baseline and test periods, and recorded the daily information in a spreadsheet. A sample is shown below in Figure 19.

Figure 18. Sample FRATIS Execution Data Results and Cumulative Results



E32 =SUM(E2:E31)

	Date	Truck Number	Total Distance (Miles)	Total Time (min)	Total Stop Time (min)	Avg. Speed
2	2/20/2015	990019	35	484	338	
3	2/20/2015	990110	50	512	339	
4	2/20/2015	990127	67	485	268	
5	2/20/2015	990138	113	602	343	
6	2/20/2015	990194	67	489	266	
7	2/20/2015	990204	60	489	257	
8	2/20/2015	990223	18	495	428	
9	2/20/2015	990230	84	791	526	
10	2/20/2015	990234	72	646	319	
11	2/20/2015	990254	58	395	242	
12	2/20/2015	990277	81	541	284	
13	2/20/2015	990299	70	947	713	
14	2/20/2015	990300	47	481	317	
15	2/20/2015	990301	22	586	489	
16	2/20/2015	990305	32	448	297	
17	2/20/2015					
18	2/20/2015					
19	2/20/2015					
20	2/20/2015					
21	2/20/2015					
22	2/20/2015					
23	2/20/2015					

Security Warning Some active content has been disabled. Click for more details. Enable Content

M22

	Date	Truck Number	Total Distance (Miles)	Total Time (min)	Total Stop Time (min)
2	2/20/2015	29	2220	16468	10291

Instructions | Execution_Data | Results | Results_Cum

Ready

Source: CDM Smith

Figure 19. Sample Daily FRATIS Data Analysis

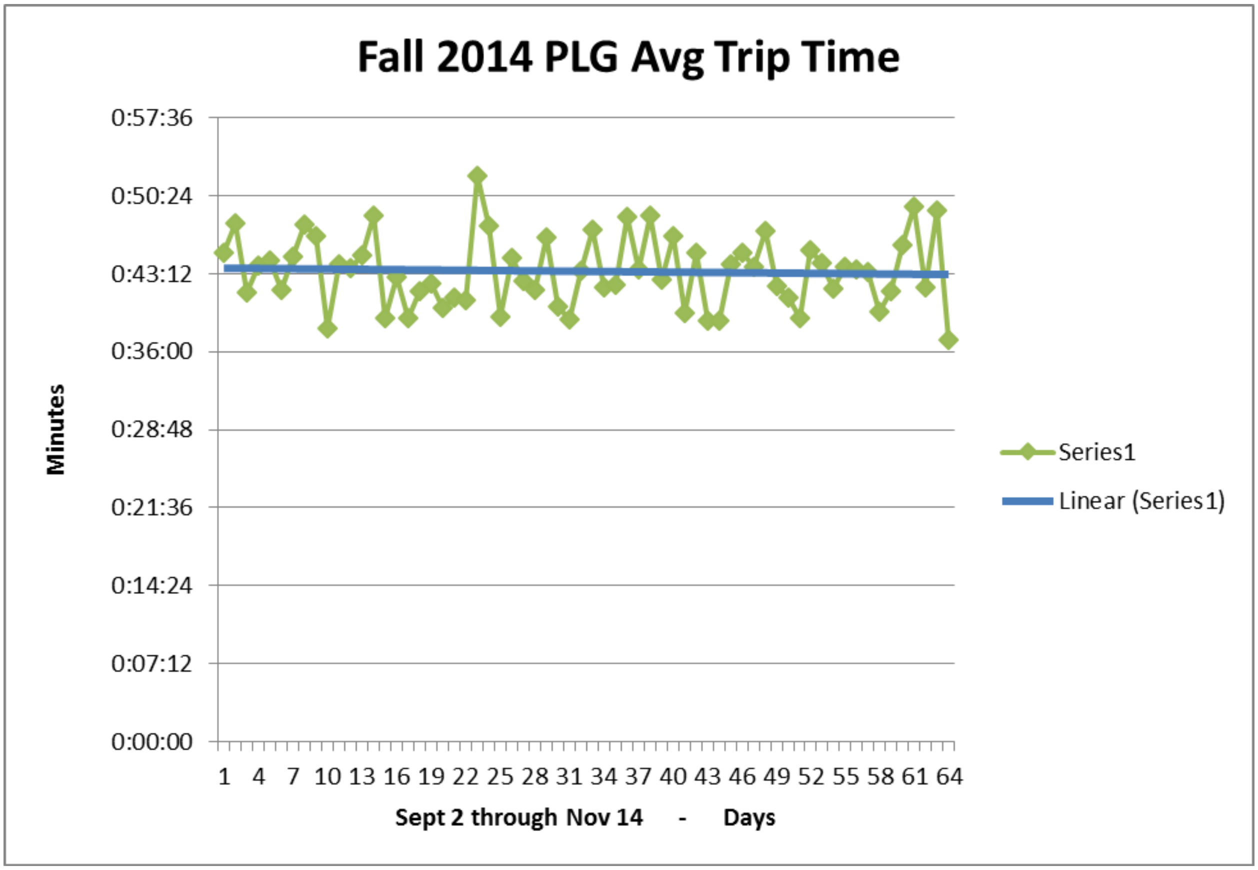
	A	B	C	D	E	F	G	H	I	J	K	L	M
4	Final Test Period												
5			Date	#trips	total time	average trip time		#trucks	miles	time	stop time		Average Trip Time
6		Mon	20150105	191	118:36:00	0:37:15		30	3266	19033	10689		0:43:07
7		Tues	20150106	204	154:33:00	0:45:27		27	4536	26544	15891		
8		Wed	20150107	211	154:50:00	0:44:02		32	4727	28914	18034		
9		Thurs	20150108	161	116:59:00	0:43:36		32	3768	20263	12180		
0		Fri	20150109	163	122:57:00	0:45:15		27	4024	18139	9468		
1		Mon	20150112	182	114:30:00	0:37:45		30	3303	19286	17783		0:44:37
2		Tues	20150113	198	161:50:00	0:49:02		29	4523	29337	18013		
3		Wed	20150114	233	170:33:00	0:43:55		30	5179	28841	17091		
4		Thurs	20150115	233	183:57:00	0:47:22		31	5618	30395	17671		
5		Fri	20150116	180	135:01:00	0:45:00		30	4081	22058	12642		
6		Mon	20150119	201	146:09:00	0:43:38		31	4397	21005	11033		0:43:24
7		Tues	20150120	241	172:23:00	0:42:55		30	4981	30229	18236		
8		Wed	20150121	207	139:51:00	0:40:32		32	4225	28212	17828		
9		Thurs	20150122	230	176:42:00	0:46:06		31	5090	30529	18181		
0		Fri	20150123	169	123:28:00	0:43:50		29	3640	18994	10725		
1		Mon	20150126	182	121:35:00	0:40:05		30	3584	21601	12932		0:43:09
2		Tues	20150127	270	168:17:00	0:37:24		32	4508	28411	17951		
3		Wed	20150128	244	164:00:00	0:40:20		31	4833	27686	17434		
4		Thurs	20150129	212	162:56:00	0:46:07		30	4779	25165	14185		
5		Fri	20150130	166	139:16:00	0:50:20		27	4718	18420	8894		
6		Mon	20150202	168	117:32:00	0:41:59		31	3593	18545	9913		0:43:49
7		Tues	20150203	222	165:49:00	0:44:49		31	4913	29623	18237		
8		Wed	20150204	232	167:56:00	0:43:26		32	5269	28795	17190		

Source: CDM Smith

The overall results spreadsheet includes results from the daily trip analysis module, which computes the number of trips and average trip time for each drayage carrier. The sample shows a day on each row, with color coding for a five-day week. To the right of the data, the weekly average trip time is shown. Several summary tables shown in this section were created from the spreadsheets to illustrate overall results of comparing baseline and test periods.

The assessment team found the analysis tools developed by PAI to be very useful, and created individual spreadsheets of daily data at each prototype site for various time periods, especially from November 2014 until the end of the test in February through April 2015. At USDOT's request, the assessment team provided weekly results to the LA stakeholders during the fall of 2014 with an objective of helping incentivize FRATIS use. Those results, along with the later data analysis for all of the sites, showed variations over periods of time but no real trends as shown in the figure below.

Figure 20. Average Trip Time Analysis Results - LA



Source: CDM Smith

It should be noted that the period covered in the chart above, September through November 2014, was a time of heavy congestion and delays in the LA ports. Trip time in this instance did not include waiting time at the terminal gates, but it was interesting to note that while there was variation from day to day or week to week, the overall trend during that period was a flat average trip time.

The assessment team believes the spreadsheets contain useful data to characterize the movements of the drayage fleets, some of which is shown later in this section. Because no prototype site used optimization in any significant way, baseline versus test data does not show improvement that can be attributed to FRATIS. This is discussed further in the sections below.

One premise of the FRATIS assessment plan was that bins representing similar days would be created to enable an apples-to apples comparison. The assessment team investigated differences in the volume of orders handled in a day in LA, and defined four levels based on several months' worth of data: less than 250 orders per day, 200 to 249 orders, 150 to 199 orders, and 50 to 149 orders per day. The team analyzed a preliminary sample of LA data from late 2013 and the first half of 2014, assigning each day in the sample to one of the order number groups. The team selected those days with the highest number of orders and computed and compared daily averages of mileage, time, and stop time. The team found no noticeable difference among the days or between the 2013 period and the 2014 period.

With assistance from analysts at PLG and PAI, the assessment team then considered segmenting the data by trip distance. In this case, the team defined bins for trips of greater than 50 miles, between 31 and 49 miles, between 11 and 30 miles, and 10 miles or less. PAI developed the Trip Identification Module that the assessment team then used to create the data included in Tables 14 through 16 in Section 6.1. The team analyzed the preliminary data set, assigned trips to the four distance bins, and compared results. Again, however, the assessment team found no significant difference among days in one group or another. In consultation with USDOT, the assessment team decided the effort required to create the bins, assign days to them, and make comparisons was not justified. That said, the data collected and analyzed at the three sites generated tens of thousands of trips with accompanying statistics. Regrettably, comparisons of different time periods did not provide meaningful differences and since the use of the FRATIS technologies, particularly optimization, was spotty at best, it was not possible for the assessment team to attribute changes to the use of FRATIS.

6.1 SFLA Data Analysis

The assessment team ran the Trip Identification module and the Execution module and recorded daily totals and averages for trips and for fleet mileage and operating times. FEC Highway Services ran the optimization algorithm from January 26, 2015 through February 12, 2015 and, according to the users and development contractor, used the optimizations for the first and sometimes second job assignments for each day. Table 14 below contains comparative statistics for five periods including the test period.

Table 14. SFLA FRATIS Data Analysis Results

Date Range	Average Trip Time	Average Fleet Miles	Average Fleet Time	Average Fleet Stop Time	Percent Stop to Total Time
Nov 3-19, 2014	39:13 min	2636.08 miles	353.83 hours	230.15 hours	65.04%
Dec 3-23, 2014	37:38 min	2682.46 miles	360.65 hours	233.60 hours	64.77%
Jan 5-23, 2015	37:33 min	2199.00 miles	295.75 hours	191.71 hours	64.82%
Jan 26-Feb 12, 2015	37:38 min	2068.08 miles	309.25 hours	205.25 hours	66.37%
Feb 13-Mar 2, 2015	37:42 min	2075.67 miles	300.77 hours	194.38 hours	64.63%

Source: CDM Smith

The test period is shown with light blue shading in the above table. Note in the table that the average fleet time after the holidays was more than 15 percent lower than before. Except for the November period shown in the first row, all of the average trip times were essentially equal. The percentage of stop time to total time varied during the period, with the highest occurring during the test but with a lower percentage in the following period. In summary, there do not appear to be differences that could be attributed to the use or non-use of the optimization algorithm. The spreadsheet with daily analysis results is included in Appendix 1.

Los Angeles Data Analysis:

The assessment team ran the Trip Identification module and the Execution module and recorded daily totals and averages for trips and for fleet mileage and operating times. Port Logistics Group applied a small number of the recommended optimization results for night shift assignments during January and early February 2015. Table 15 below contains comparative statistics for five three-week periods from October 2014 through the end of the test on February 13, 2015.

Table 15. Los Angeles FRATIS Data Analysis Results

Date Range	Average Trip Time	Average Fleet Miles	Average Fleet Time	Average Fleet Stop Time	Percent Stop to Total Time
Oct 6-24, 2014	43:29 min	5081.93 miles	502.62 hours	306.27 hours	60.93%
Nov 3-21, 2014	43:02 min	4415.27 miles	454.68 hours	286.36 hours	62.98%
Dec 1-19, 2014	46:45 min	4863.53 miles	423.36 hours	265.56 hours	62.73%
Jan 5-23, 2015	43:47 min	4355.33 miles	421.72 hours	242.25 hours	57.44%
Jan 26-Feb 13, 2015	43:14 min	4156.87 miles	377.67 hours	220.88 hours	58.49%

Source: CDM Smith

It should be kept in mind that the periods shown in the table were all during unprecedented times of port congestion, delay, labor disruptions, and significant build-up of inbound container ships in the waters off Los Angeles and Long Beach. Average trip time was more or less unchanged throughout this period, and it mirrored the findings that had been previously documented from September 2014 through November 2014, with somewhat higher trip times in December than either before or after.

Interestingly, although the average trip time was higher in December, the fleet hours were approximately 8.5 percent lower in the last three weeks than earlier in January, and even lower compared with November (16.9 percent) and December (10.8 percent). Stop times were also less in the last period compared with November (22.9 percent), December (16.8 percent), and January (8.8 percent). It is indeed tempting to claim that the better use of FRATIS data during the last period resulted in the reduction in time of operation of the PLG truck fleet. However, all of the circumstances described in this report concerning manual data entry, extremely limited use of the results by one dispatcher and not at all by others, and the lack of use of the 7150 device for accepting orders argue that the FRATIS data was not used enough to achieve such results.

DFW Data Analysis:
The assessment team ran the Execution module and recorded daily totals and averages for trips and for fleet mileage and operating times. Southwest Freight equipped 10 of its trucks with TomTom devices, about 20-25 percent of the number the other FRATIS dray carriers had. Southwest used an Alternative Optimization Program sparingly during the February-March 2015 period and, according to its operations manager, used the results to assign the first or second order of the day for each truck. Table 16 below contains comparative statistics for six periods from November 2014 through mid-April 2015. Due to errors in the data conversion to run in the trip time tool, trip time averages could not be computed for several periods as noted in the table. These six periods covered time both before and after use of the optimization algorithm.

Table 16. Southwest Freight DFW FRATIS Data Analysis Results

Date Range	Average Trip Time	Average Fleet Miles	Average Fleet Time	Average Fleet Stop Time	Percent Stop to Total Time
Nov 3-26, 2014	Min	2239.47 miles	102.30 hours	41.17 hours	40.24%
Dec 1-19, 2014	51:59 min	2274.20 miles	100.76 hours	39.65 hours	39.35%
Jan 5-29, 2015	49:48 min	2063.21 miles	96.30 hours	41.29 hours	42.88%
Feb 2-18, 2015	min	1335.92 miles	65.93 hours	32.33 hours	49.05%
Feb 23-Mar 20, 2015	min	1466.56 miles	76.38 hours	31.36 hours	41.06%
Mar 23-Apr 10 2015	min	1641.27 miles	80.49 hours	38.33 hours	47.62%

Source: CDM Smith

Because of the need to convert each day's data for Associated Carriers in Dallas, resources did not permit the assessment team to analyze the TomTom data for that Dallas-Fort Worth carrier. As noted in the narrative discussion of the various functional capabilities of FRATIS, Associated was similar to Southwest Freight and the carriers in SFLA and LA, so the assessment team believes it is unlikely that the results for Associated would have been very different from Southwest, nor would they have added much to the conclusions.

Section 7: Overall FRATIS Findings and Lessons Learned

The subsections that dealt with each of the FRATIS technologies included findings and lessons learned. This section repeats some of the most important of those findings, but primarily includes findings and lessons learned that cut across all of the technologies or the prototype sites and that will hopefully provide guidance to future pilot demonstrations and tests of logistics technologies. Some of the findings also deal with how these and other prototype tests could be conducted more effectively. To reinforce some of the findings and lessons learned here, the assessment team quotes from the three FRATIS prototype final reports. The findings are numbered for reference, but are not necessarily in the order of importance to the assessment team.

1. **Optimization requires major changes in dispatching policy that must be advantageous to drivers and dispatchers to succeed**. The issue of major changes to dispatching policy is a crucial one for achieving real benefit from optimization. The dispatchers and drivers need to find advantages to optimization, and these are not necessarily the same as benefits to the overall fleet. All of the drays in the test thought economic equity among drivers was an important criterion that was not accounted for in the optimization software. Particularly when there are driver shortages, drayage companies cannot afford to give extra moves to some drivers and none to other drivers. The assessment team found that owner-operators are more active in influencing loads they receive. This often runs counter to recommended assignments from optimization, and makes it more difficult for a company to change its dispatching policy. Implementing a new policy requires real commitment to the changes on the part of the company, with extra effort needed to demonstrate and presumably share the benefits of optimization with the dispatchers and drivers. This excerpt from the DFW Final Report reinforces this point:

   > The core FRATIS applications, regardless of deployment location, require driver buy-in to fully achieve potential benefits – these applications being the drayage optimization application and the dynamic routing and navigation application. The drayage optimization application requires the driver to accept a change in his assigned work, while the dynamic routing component requires the driver to trust the recommendations regarding congestion and routing regarding his upcoming destinations. The drayage community includes many experienced drivers, and these are the most difficult individuals from which to obtain buy-in. Both of the DFW participating drayage companies recommended that when technology requires driver interaction and acceptance, it must demonstrate an improvement to the drivers' bottom line, especially when owner-operators are the majority of the staff for many companies. (page 17)

   The LA Final Report made a similar comment that provides a useful lesson learned for future projects:

   > Some stakeholders were resistant to participate fully or change their business rules even it would ultimately provide a more efficient and effective operating environment. This demonstrated the need for gaining clear buy-in from the most influential stakeholders at the outset of a deployment (marine terminal operators, large beneficial cargo operators, large drayage operators). Ideally this buy-in

> would include a commitment to integrate key technologies to enable a truly connected operating environment as well as a willingness to implement changes to operations that provide value throughout the entire network. (page 12)

In the South Florida Final Report, the developers reinforced the point about the impact on drivers:

> Dispatch staff received a lot of complaints from drivers during the test period due to an unwillingness by drivers to see a change in load assignment protocols. In addition, due to lack of full system integration, dispatch staff experienced a significant increase in time necessary to assign loads using the tool. (page 15)

Despite the above concerns, FRATIS users thought automated optimization plans might be especially useful to inexperienced dispatchers in making driver assignments. They also thought the software would be more effectively used with company drivers than owner-operators. Whatever the case, paying close attention to the needs of dispatchers and drivers is essential. It is also important that future iterations of the optimization algorithm incorporate, to the extent feasible, the current dispatching rules to help reduce the need to change dispatch policy.

2. **Drayage operations are very dynamic and cannot be efficiently conducted using assignments from a once-per-day or even twice-per-day optimization run.** More frequent runs, if not continuous updating, of optimization are needed to effectively employ optimization in drayage trucking. Otherwise the amount of time dispatchers must take to accommodate new or changed business exceeds any savings from optimization. The excerpts below from the FRATIS final reports for each pilot location further illustrates the point:

> A Drayage Optimization Algorithm approach much have the capability to be modified "on the fly"—the dispatcher needs to be able to reset the daily plan as needed when conditions change in the port environment (LA Report, page 13)
>
> The system does not capture load updates or changes. Daily assignments are based on static data. The data push was timed to capture the greatest percentage of loads; however, changes or updates are not reflected in the tool. The dispatcher had to correct where possible during the load planning and real-time operations. (SFLA Report, page 22)
>
> Southwest, as with Associated, received many orders throughout the day and so the plans became less effective as the day went on. Near-constant re-optimization would be needed to account for these orders, in conjunction with in-vehicle devices, which their drivers may resist. (DFW Report, page 23)

3. **Integration of new capabilities such as the optimization algorithm into existing systems is essential to a successful test.** In FRATIS, shipment orders were integrated successfully and duplicate data entry was avoided, but the full integration of the use of FRATIS results would have required resources beyond those available in the FRATIS project. Duplicate data entry in LA seriously impeded progress and the use of FRATIS. Integration of order input was reasonably successful in both DFW and SFLA, but caused delay which adversely affected stakeholders and resulted in unanticipated resource uses. Both identified issues with the data mapping and with the accuracy of data being input via the interface from the existing system. Data mapping issues prevented completion of the order input integration in LA. At all three sites, additional contractor resources were needed to assist with order entry and running the

optimization algorithm. The technologies tested for communications between the dray and a terminal at DFW and LA were proofs of concept, so were not integrated, but users noted it would be preferable to have advanced information available on existing systems to simplify their use. The FRATIS prototype mobile phone application on emergency response in South Florida was well received and showed promise, but if implemented it would need to be properly interfaced with other public systems in order to avoid duplicate data entry. Each of the three prototype test final reports addressed integration as noted below:

> During the system implementation with PLG, a key challenge was the need for the office operations staff to enter orders into both the FRATIS system as well as TMW, their order management system. Orders come in daily and the office staff at the drayage company are responsible for entering the order details data into TMW. In order to leverage the planning and optimization capabilities of the tool, the tool required the staff to re-enter many of the same order details into the FRATIS system. This not only doubled the work load on the office staff, but also led to an increase in order entry errors. (LA Report, page 19)
>
> Partial system integration does not provide a real-time, reactive environment. While the data mapping and daily data feed eliminated the need for manual data entry, the system was unable to reflect changes to orders from time of load planning to time of dispatch. When changes did occur, they had to be identified and corrected manually during the dispatch process (SFLA Report, page 7)
>
> Utilizing the PAI algorithm required much modification, which had schedule and budgetary modifications for the prototype team. Once the development team began internal testing of the algorithm, it was found that manual order entry was required. Given that both of the participating drayage companies used off-the-shelf dispatch software, the team did not want to require the dispatchers to enter orders twice. This led to the team to develop the pre-optimization processor. Similarly, the format of the optimized plan was not usable to the participants and needed to 'speak their language' and include similar fields to what they found within their Trinium software. The development team then had to build the back-end, post-optimization processor. The development of these items was not anticipated and significantly impacted the budget and schedule. (DFW Report, page 32)

4. **The emphasis on optimization in the three FRATIS prototypes consumed resources that could have been devoted to more robust technology testing related to information exchange about terminal wait time.** While FRATIS was supposed to include two bundles, USDOT priorities and guidance led to concentration of development efforts and resources on the optimization algorithm. It was easier for the assessment team to assess optimization use across the sites, but it was clear to the team that there was much less emphasis and pilot testing progress on other, perhaps equally important, information sharing technologies. The assumption made at the beginning of the program was that drayage improvement from optimization would be so overwhelmingly positive that the before and after comparison of operations data would provide quantitative benefits. The reality, as discussed in Section 5.1 and in other overall findings, was that even with all of the prototype resources consumed on optimization, the use was limited at best and it was very difficult to quantitatively demonstrate improvement. The three development contractors were clearly frustrated by the amount of resources used on optimization for the gain in the project. The three excerpts below indicate

the concerns and perceived impacts that each of the development teams observed. Readers are urged to review all of the developer comments on this matter in the respective reports.

> Customization of the established drayage optimization tool was not a simple process. The established tool had to be modified to reflect FEC's operation; and more importantly, be modified to receive a daily data feed from FEC's legacy system. This data feed represented a one-way static push multiple times per day. Development of special rules complicated the algorithm and compromised its stability (South Florida, page 7)

The DFW comments are even more direct because they worked with two drayage companies that in the end used different optimization algorithms.

> The guidance from USDOT indicated that a major focus of the FRATIS prototypes was the drayage optimization program…the business environment of the participating drays in DFW varied from those in Memphis, resulting in many changes that had to be made to the algorithm. In this environment, trying to use a canned or pre-created algorithm was inefficient; a better approach would have been for USDOT and the prototype teams to evaluate the participating drayage company workflows prior to the start of the prototype and assess whether the PAI program was the best suited to optimizing their work.
>
> The development team had to initiate a subcontract with PAI to create and implement the constraints requested by the drayage companies. The development team, however, had to remain engaged in this process especially with respect to testing the changes once they were incorporated because the development team was more familiar with the operations of the drays than PAI. In addition, PAI's work had to be added to their development calendar. These activities also contributed to development delays and unanticipated costs. (DFW page 32)

In the LA report, the developer noted the relative importance, in the view of users, of dray-to-terminal communications compared with optimization.

> Following project initiation, direction was provided to the three FRATIS sites that the predominant focus of the testing would be an application of the Drayage Optimization Algorithm. This was understandable given the success of the previous test in Memphis of this technology. However, while there was interest in testing this technology by PLG and Yusen Terminals, both entities were much more interested in the Marine Terminal-to-Drayage Company Communications Interface, and a successful demonstration of that technology could highlight to the entire port community a new method of improving the efficiency of intermodal truck pickups and deliveries at the port terminals.
>
> More flexibility in testing programs needs to be provided so that test programs such as FRATIS can be allowed to focus on significantly different elements across sites, if that is what the user needs tell us. The needs of the user should be more important than the commonality of a testing program—because the ultimate goal of these programs is to facilitate adoption of Connected Vehicle technologies across the United States. (pages 14 and 15)

5. **Successful tests with transportation companies require significant development contractor resources to help users deal with the added responsibilities of testing.** In

comparing the results of Memphis with those of the three FRATIS sites, it makes sense on the one hand to introduce the software to larger, more complex terminal area operations and yet those complexities can overwhelm the participants as they did in LA and thus interfere with what all test participants hope they can accomplish when they start the pilot. In South Florida, the realization that drayage personnel were busy with their jobs required additional work on the part of the developers, as noted in the South Florida Final Report:

> Two dispatch staff made themselves available to help test the tool in an iterative process that lasted a few months, followed by a few months of live testing. This required a significant time commitment on the part of the project team to accommodate their real-time operational setting. (South Florida page 16)

The sponsors of the pilot tests need to provide enough resources and flexibility in the development contract so that adjustments can be made as the project proceeds. Here is an excerpt from the DFW Final Report Lessons Learned to illustrate:

> The trucking/drayage industry is fast-paced and can experience frequent staff turnover, with dispatchers sometimes changing or leaving roles every few months. The FRATIS DFW prototype dealt with that early in the development process, when Associated had an intended dispatcher and potential user of the prototype, depart…In October 2014, Associated consolidated their Houston operations in the DFW office without a corresponding increase in operations staff. This significantly impacted the time that all staff involved…had to participate in the prototype. Associated continued to work with the development team to identify a means to continue their participation. (DFW Report page 15)

6. **The FRATIS users were overwhelmed with current operations within their regions, which often made it difficult for them to devote time to FRATIS testing.** All of the prototype tests involved overlaying or integrating new technologies with existing systems and operations. Each of the drayage companies at all three sites and each of the terminals involved in FRATIS (LA and DFW) had to continue their very busy day-to-day operations. During most of the period of the FRATIS development and test, the Los Angeles port complexes faced unprecedented congestion and operating problems. DFW's drays were very busy with their existing operations and had to deal with near-continual highway construction in the DFW area. In addition, the DFW container movements were affected by the larger volume and uncertain operations on the West Coast. While ultimately FRATIS technologies are intended to address the very problems occurring at the sites, the reality was continual interference or disruption of testing because of operational issues. The LA Final Report had a particularly interesting background description of the situation. An excerpt is included below, along with comments from the DFW and SFLA Final Reports. Readers are urged to review the entire set of findings and comments in all three reports.

> Both our partners in the LA-Gateway FRATIS project (Yusen Terminals and Port Logistics Group) experienced major disruptions from August 2014 through December 2014 due the growing congestion problems in the ports. This congestion, the worst since the early 2000s, stemmed from a surge of cargo before the holidays, the rise of massive container ships that are now deluging the docks with cargo, and a shortage of the intermodal chassis that truckers use to haul cargo from the ports to sprawling warehouses in the Inland Empire. In early October, the Port of Long Beach (POLB) convened a Congestion Relief Team to facilitate solutions to port congestion. The team reported a three to five day backlog in drayage container pick-up and deliveries

due to chassis shortage, and identified the key issue as an imbalance of container chassis to meet supply and demand.

More flexibility is required towards “emergency stakeholder situations” such as this—the contractor(s) conducting the test, the testing partners, and the U.S. DOT, need to better identify these situations early, and be willing to allow for mitigation options that are available to be implemented. (LA Report, pages 12-13)

A common factor when dealing with freight technology is the implementation of these solutions in the real-world environment. This may impact the time the participants have to participate in the development process, their usage of the prototype system once complete, and even the volumes of freight considered by the prototype system. The trucking/drayage industry is fast-paced and can experience frequent staff turnover, with dispatchers sometimes changing or leaving roles every few months. The FRATIS DFW prototype dealt with that early in the development process, when Associated had an intended dispatcher and potential user of the prototype, depart. (DFW Report page 15)

Drayage companies are consistently trying to do more with less. While they may be willing participants in a pilot, operational priorities will always be ahead of their participation in a voluntary pilot. That does not necessarily indicate their lack of interest, but it is reflective of the time they have available to contribute to the agile development process and the testing/prototyping of the solution. (DFW Report, page 33)

IT staff assigned to support this project was overloaded with multiple assignments and could not commit to the timely delivery of necessary system information and data required for the data mapping/partial system integration process. Two dispatch staff made themselves available to help test the tool in an iterative process that lasted a few months, followed by a few months of live testing. This required a significant time commitment on the part of the project team to accommodate their real-time operational setting. (SFLA Report, page 16)

7. **The cooperation among stakeholders at all of the prototype sites was important to what was achieved, and the relationships and cooperation established are likely to continue well beyond FRATIS to the benefit of the region.** Particularly in LA, the project brought stakeholders to the table who had previously not cooperated with each other. All LA stakeholders thought the cooperation among stakeholders in the project was an important benefit. Here is an excerpt from the LA Final Report in that regard:

    Prior to these programs, over the past decade, relationships between the port trucking and terminals communities became severely strained. This was based on years of mistrust, lack of accurate communications, disagreements over the application of PierPass, and business practices on both sides that were perceived at causing inefficiencies to the other side… An enabling factor in the above was the continuous outreach conducted over three years by the team of consultants involved the FRATIS and Gateway Cities programs. This included group meetings, one-on-one meetings, association meetings, participation in industry events, and frequent articles in intermodal freight trade publications. (pages 11-12)

The South Florida developers made similar reinforcing comments in the SFLA Final Report:

> It is critical to have the support and commitment of senior management at the onset to communicate to the organization that participation is supported and expected. As the project progresses, the personal commitment of the daily operations staff becomes most important. Commitment was there from all levels, but significant delay was introduced due to their inability to commit the time necessary to advance the project at critical times. In the end, their commitment came through. (page 16)

The DFW developers made the point that stakeholders can affect what is actually deployed, as in the following comment from the DFW Final Report:

> The FRATIS DFW prototype that was ultimately deployed was slightly different from what was planned. This was due to the engagement of both first and second tier stakeholders. For example, the participating drayage companies both articulated the opportunity for a terminal queue time solution at one of the container yards in the DFW region. Ultimately, this led IMCG-Wilmer to sign on. (page 14)

Future pilots should attempt to engage a wide range of stakeholders and invest time at the beginning to involve the stakeholders and take their needs and desires into account.

8. F**RATIS technologies show promise of more efficient drayage operations, particularly avoiding traffic congestion and reducing delay from better information about wait-time and status at intermodal container terminals, thus reducing overall travel time.** The experience with optimization in FRATIS, judged to be a positive experience by drayage dispatchers, should improve the likelihood of success of several follow-on pilot applications. One DFW dray interviewed by the assessment team thought FRATIS was a good experience, but it didn't really help them because of the complexity of their dispatch process. Despite limited testing and numerous problems with optimization as noted in the report, the three prototype developers had positive comments that show the promise of these FRATIS technologies.

> Plans can even be further improved, first by frequent and consistent use by dispatchers which allows them to learn about how to better predict what is causing deviation from the plan and correct it thereafter during the plan and optimization setup or preparation. (LA Report page 21)
>
> The primary point of contact at Southwest was overall very pleased with the AOP. He was especially pleased with the matching capability and the ability to adjust the number of drivers. The primary user was extremely experienced; his feedback was that the program created plans much like the ones he would manually create. To that end, though, the program will be useful in training new or inexperienced staff. (DFW Report, pages 22-23)
>
> High level feedback from the key dispatcher at Associated felt that the plans provided by Vesco the night before were helpful in identifying load sequences for drivers. The re-optimized plan, which was sent at 9 a.m. the next morning, was also helpful for the dispatcher to see how new orders received had been incorporated into the existing plans for their drivers. (DFW Report, page 20)
>
> Perhaps most significantly, although integrating the optimization into the Trinium dispatch software was not possible for this pilot, establishing this connection would allow the optimized plans to be displayed via the dispatch sequencing screen in Trinium, where load assignments are made. (DFW Report, page 33)

9. **Truck-mounted data collection devices provided useful truck operations data which can be analyzed to characterize drayage operations but are not universally accepted by drivers.** Such devices provide data without human intervention and are the best way to collect reliable test data. The FRATIS data collected and analyzed at the three sites will be available for non-public analysis via a server at the Turner-Fairbank Highway Research Center. With analysis tools developed in the FRATIS project, it is possible to determine and compare trip distance and time, total operating time and total stop time by truck, and daily mileage per truck. These data help characterize drayage operations and allow comparisons of different time periods.

   Some drivers for some of the drayage companies in the FRATIS test had issues with the placement of devices on their trucks that could track their location. The original dray company planned for the South Florida prototype dropped out of the project in part because of disputes with its owner-operator drivers over the devices. At one of the DFW drays, devices were installed on company trucks rather than owner-operators to avoid disputes about the devices.

   The assessment team found its data analysis, particularly for some of the LA trucks, had occasional problems with the devices that resulted in erroneous readings. In some cases, after being notified the dray company and development contractor were able to reinstall or repair the device. In the data analysis, the assessment team deleted trucks that had obviously erroneous data. While this improved the results of the data analysis, the assessment team observed in reports produced by the WebFleet system for the same trucks that the errors were not detected, therefore some of the WebFleet reports were inaccurate. The lesson learned here is that when such data collection devices are used, some data should be analyzed as soon as possible so users can investigate and repair any devices that are causing problems.

10. **The variety of stakeholders involved in the prototype projects was important to the conduct of the projects, and is important for follow on pilots or further implementation.** USDOT and the development contractors expended considerable effort at the beginning of the FRATIS program to bring together drayage companies, terminal operators, port officials, and various public sector agencies to facilitate. In LA, there was significant cooperation involving port and carrier associations who had not necessarily worked well together in the past. The LA Final Report described some of the benefits of such coordination:

    > Perhaps the most important legacy of the LA-Gateway FRATIS program will be the significant positive effect it had concerning the relationship between the port trucking community and the port terminal community. Beginning with the predecessor FRATIS ConOps and Gateway Cities Technology Plan for Goods Movement projects, and continuing through the LA-Gateway FRATIS test, the project was consistently exposed in these communities as an example of a potential solution to a key need concerning lack of information exchange between these two private stakeholder groups.
    >
    > Prior to these programs, over the past decade, relationships between the port trucking and terminals communities became severely strained. This was based on years of mistrust, lack of accurate communications, disagreements over the application of PierPass, and business practices on both sides that were perceived at causing inefficiencies to the other side. (page 11)

    The development of the emergency management mobile application in South Florida included public agencies involved in transportation and emergency response. The SFLA Report described some of the roles of these stakeholders. The DFW Report noted the role played by its local council of governments.

> The key stakeholders involved in this effort covered both the public sector and the private sector. This is necessary as emergency management activities require the coordination between these two groups. Public entities are responsible for reconnaissance activities post-event, and participants saw a value in the app's capabilities of automating the current manual processes. However, issues with testing and phone compatibility limited some participation by these stakeholders. (South Florida Report, page 19)
>
> North Central Texas Council of Governments (NCTCOG) remained an interested party throughout the pilot. The NCTCOG has an active freight transportation component. The DFW region represents one of the largest inland ports in the nation, where freight is moved, transferred, and distributed to destinations across the State and around the world. In addition, North Central Texas has one of the most extensive surface and air transportation networks in the world, providing extensive trade opportunities for the hundreds of motor/trucking carriers and freight forwarders operating in the DFW area.
>
> During the baseline stage, they provided input to the development team regarding data that would be useful for their freight planning. The development team remained engaged with the NCTCOG throughout the prototype, providing regular updates. Ultimately, the goals for the NCTCOG are longer-term in nature than the goals for the FRATIS DFW prototype. (DFW Report, pages 12-13)

11. **The automated exchange of information about the availability of containers at terminals or about estimated arrival of a container was shown to work in the FRATIS prototypes.** In the proof of concept test, only a small amount of sporadic information was exchanged, which was not enough to affect operations of either the terminal or the drayage company. However, the potential users said such information would be useful to drayage companies, particularly when multiple stakeholders (e.g., multiple terminals providing availability information to a dray company or multiple dray companies providing arrival information to a terminal) are participating and providing such information.

    As a proof of concept, all parties were cognizant of the small container volume between Yusen and PLG in LA, but stakeholders like the idea of container availability information for more widespread use with more terminals and more drays. Of particular significance, advanced arrival emails that were sent from the dray companies to the intermodal terminal and railroad in DFW will continue to be provided. Terminal stakeholders believe the information will continue to be useful. The drayage company in LA said the container availability information was potentially useful in the dispatching process. At both DFW and LA, the hope is that as additional dray companies provide arrival information, it will help the terminals plan their work and assist with their allocation of labor.

    As noted earlier in the more detailed discussion of advanced information, there appears to be promise in both the capture and reporting of queue time data approaching the gate of a terminal. As installed at one terminal each in LA and DFW, the concept of recording the information and providing it to drays was viewed positively by potential users. This was one of the areas where additional FRATIS test resources would have been appropriate to better capture the data and make it available. In DFW, the data was made available on a FRATIS-provided website, although because of the press of operations, dray users seldom looked at the data. Users in both DFW and LA felt that such data would be more usable as an alert message that does not require initiative on the part of the dispatcher to look for the information. Nevertheless, the FRATIS test showed that queue time information can be captured and is useful. What is needed at this point is more widespread implementation of queue measurement devices and a consistent method of providing the information to any and all potential users.

12. **When considering logistics improvements or pilot projects, proponents and stakeholders should take advantage of existing commercial information, logistics technologies, and smart phones whenever possible.** In FRATIS, even though one of the bundles to be deployed was for publicly-available traveler information for freight, none of the sites tested that technology. In each case, an existing commercial solution met or nearly met the requirements and was much easier for the drayage companies to use, and would not consume project resources. In the case of South Florida, their use of the Qualcomm system provided the required data, so from the beginning that capability was not included in their FRATIS prototype. In DFW, the transportation management system provider for the two dray companies (Trinium) introduced and provided a mobile app that met most of the FRATIS traveler information requirements. As noted in the following excerpt from the DFW Final Report, the developer thought other capabilities met the FRATIS requirements better, but everyone found it preferable to use the Trinium-provided capability.

> The development team was in the midst of exploring the ALK Co-Pilot application for satisfaction of these requirements, when in related talks with Trinium Technologies, the dispatch software provider, it was revealed that they intended to enhance their web-based work order application MC2 to include routing, navigation, traffic, and weather information via an interface with a similar ALK product. The development calendar and planned roll out coincided with the prototype schedule, which eliminated the need for the drivers to have multiple applications open on their smartphone. The MC2 web application integrated with the ALK Maps product as the back end tool for the routing, traffic, and weather information.
>
> From the perspective of the development team, the application could have been more dynamic in nature, especially compared to the ALK Co-Pilot application that the team evaluated. For example, the user had to refresh their interface in order to update the route after they accepted their work order. It should be noted, though that the route, traffic and weather did automatically refresh anytime the driver exited and re-entered the MC2 application. Trinium's perspective on this feature was that the routing application can be as dynamic as the driver chooses, similar to anytime a personal driver were to "update from here" within Google Maps. Finally, a key gap in the application from the development team's perspective was that the application did not include an audio component, which made the driver dependent on written or map-based information. (DFW Report, page 31)

The LA prototype effort included the TomTom 7150 in-cab device, which among other capabilities was to provide dynamic routing based on traveler information and mapping in the TomTom system. As noted elsewhere, the drivers who tested the 7150 found it to be more difficult to use than their cell phones. Even so, the TomTom itself represented a commercial product that did not need additional development except for integration with the dispatch application. The lesson learned here is that the proponents of advanced technology pilots should concentrate development efforts on technologies that do not exist in the commercial marketplace. This will concentrate developer attention and resources on the new technologies and not try to reinvent the wheel. While FRATIS ended up using commercially-available traveler data, it took both planning and investigation time that could have been better devoted to analyzing drayage operations.

Table 17. Summary of FRATIS Overall Lessons Learned

Optimization requires major changes in dispatching policy that must be advantageous to drivers and dispatchers to succeed.
For optimization to be successful, the optimization software needs to be run frequently and have both the inputs and outputs integrated with the dray company's dispatch system. Otherwise, optimization will not be used consistently by dray companies.
Effort needs to be expended at the very beginning of a pilot project to assure alignment between stakeholder needs and sponsoring agency objectives. This should concentrate resources on problems that best address user requirements.
Pilot users are extremely busy with current operations, so developers need to have enough resources to be able to assist the users. Financial incentives to users may be appropriate.
Care is needed in selecting stakeholders to represent all of the interests in a pilot project and to assist with project coordination and cooperation of pilot users.
Wider implementation of queue measurement devices and a consistent method of providing the information to any and all potential users will benefit operations at multiple terminals in a region.
Proponents of advanced technology pilots should concentrate development efforts on technologies that do not exist in the commercial marketplace.

Source: CDM Smith

Section 8: Overall Benefits and Potential for Regional Expansion

This section builds upon the findings of the three FRATIS prototype tests discussed in Section 5 and examines the extent to which the prototypes reduced costs, improved efficiency, and otherwise addressed the Transformative and Concept of Operations Benefits discussed in Section 3. The hope for the FRATIS prototypes, as described in the FRATIS Assessment Plan, was that each prototype would improve the operations of the participating drayage carriers and produce quantifiable benefits when comparing operations prior to FRATIS with the operations during the FRATIS test. The drayage companies and the other stakeholders are part of domestic and international supply chains that deliver imports to customers in the U.S. and ship exports to customers overseas. NCFRP Report 11 *Drayage Productivity Guide* sums up the goals associated with that international supply chain:

> The primary goal of importers and exporters is to obtain their import goods (or ship their export goods) at their preferred time at lowest possible cost. Customers see the cost, time, and uncertainty associated with drayage and seek to minimize all three, but are first and foremost concerned with the cost. [NCFRP Report 11, page 44]

What the FRATIS assessment team found were important proofs of concept and advances in the uses of technology to improve drayage operations. As has been described, the nature of the test environment and the inability of any dray company to change its operations to fully use the capabilities of FRATIS meant that the sometimes subtle improvements could not be measured. As a result, it was not possible to tell whether costs were actually reduced with FRATIS.

The NCFRP 11 Report defined a series of drayage problems and potential improvements derived from the research described in that report. The list is reproduced here, expressed in terms of operational improvements that could save drayage costs; as derived in the NCFRP 11 report, these represent at least a portion of the range of benefits in making drayage improvements.

> **Reducing Terminal Time** – this is the turn time that is measured daily in the LA/LB ports, and is the time a truck spends inside the terminal gate whether waiting, dropping off an export container or empty, picking up an import container, or being inspected or scanned before entering and leaving the terminal.
>
> **Reducing Queue Time** – this is the time spent waiting in line to reach the terminal gate. It is harder to measure than turn time, and can be influenced by evening hour programs such as Pier Pass at the LA/LB ports.
>
> **Reducing Trouble Tickets** – this involves having better operating equipment to reduce the likelihood of problems identified during inspection of chassis and containers.
>
> **Reducing Idling** – Trucks idling in queues or traffic delays can be reduced by using hybrid trucks that do not idle, or improving operations at various points on the container's route to avoid delays so that the truck is moving more often.
>
> **Increasing Neutral Chassis Pools** – Chassis shortages or chassis location issues represent a significant cost to drayage operations. One approach to increasing chassis availability is to increase the number of pools or containers in pools.

Trucker-supplied Chassis – Historically chassis were owned and supplied by the steamship lines, but currently they are owned by chassis leasing companies. A potential way to reduce the chassis availability problem is for trucking companies to own the chassis they depend on to move containers. (NCFRP 11, Transportation Research Board, Tioga Group et al., 2011. From Table 12-2 and pages 95-97)

As supplements to the NCFRP 11 discussions, two relevant presentations by one of that report's authors, Dan Smith of Tioga Group, help to define areas of potential benefit and include overall potential national drayage cost savings as discussed in later sub-sections. They are *Fixing Port Drayage*, March 2014 and *Managing Port Drayage*, June 2014. The question explored below is whether FRATIS technologies are likely to affect any of the drayage problems noted above.

Since FRATIS's target is the assignment of container moves to drivers and communications about those moves between the drayage company and the terminals at which it does business, **it would appear that trouble tickets are not affected by FRATIS** and that chassis management issues are also not affected by FRATIS, but that terminal time, queue time, and idling are all potentially affected by FRATIS.

NCFRP 11 identified a potential cost savings related to the use of hybrid vehicles and other ways to reduce emissions during idling. **FRATIS could make a contribution by reducing in the amount of stop time or idle time through improved traffic management of the drayage fleet**. This is discussed in more detail below.

Two other areas for potential improvement identified by NCFRP 11 were improvement of terminal and queue times. **FRATIS only scratched the surface in its investigations and attempted measurement of these times**. An important point is that FRATIS is by no means the only way that terminals and dray companies could improve terminal and queue time. These issues are discussed further below.

What follows is a discussion of the assessment team's perceptions of the impact FRATIS could have on cost reductions to the drays and their customers. That leads to a more detailed examination of the costs of drayage operations and how FRATIS could affect those costs if fully implemented.

8.1 Cost of Drayage Operations

The NCFRP 11 Drayage Guide included useful calculations of the costs of drayage operations. Adjusting for changes between 2008 and 2013, as included in ATRI's annual trucking operations costs (*An Analysis of the Operational Costs of Trucking: A 2014 Update* Sept. 2014), the cost of drayage operations can be expressed in at least two ways of relevance to FRATIS: per hour and per mile. NCFRP 11 defined two scenarios that are quite applicable to FRATIS, particularly LA. One is for a 5 mile one-way trip, which defines some of the near-to-terminal drayage moves; and the other is for a 25 mile one-way trip, which covers many of the moves around the LA/LB ports and also around DFW and SFLA. The table below includes three different measures of drayage cost:

Table 18. Drayage Operations Cost Estimates

Scenario	$/container	$/mile	$/hour
5 mile one way	$114	$35.03	$37.34
25 mile one way	*$162*	*$35.22*	*$38.06*

Source: NCFRP 11 (Tioga Group) adjusted by CDM Smith using data from ATRI.

These two scenarios, particularly the 25 mile one, are relevant for the dray companies in the FRATIS prototype tests. During December 2014 the average trip length in the LA data collected by FRATIS was

23.61 miles. In LA the average percentage of trips less than or equal to 5 miles was just under 9 percent, and for trips less than or equal to 25 miles it was slightly more than 75 percent. During the period from January 5 through February 13, 2015, the average trip length was 21.83 miles. While there was no evidence that the difference was caused by FRATIS, these average trip lengths are very much in line with the larger of these two scenarios.

In the case of South Florida, where the shipments travel from the FEC rail intermodal terminal to area distribution centers, the average is somewhat smaller than in LA at 14.4 miles. Nearly 23 percent of trips were less than or equal to 5 miles and nearly 92 percent were less than or equal to 25 miles. While the average varied somewhat from day to day, from a low of 10.2 miles to a high daily average of 18.2 miles, the difference was more a function of several longer trips occurring on some days, rather than because FRATIS was being used at the dray company. The DFW average trip lengths were a bit longer at about 32 miles.

From the above discussion and the average trip lengths computed for FRATIS, it seems reasonable to use the 25 mile scenario and the adjusted estimated cost per hour of drayage operations in the table above of $38.06. Knowing that a typical day for a drayage truck is in the order of 10 hours, a quantitative representation of the cost of operating a drayage truck would be at least $380.60 per day.

If wait time can be reduced in the FRATIS regions or if average mileage could be reduced through better scheduling or by avoiding congestion, that time may be able to be applied to productive operation of the vehicle with concomitant savings in fuel and emissions. The question then is: what is a reasonable and achievable reduction in wait time? Further compounding the ability to calculate benefits, owner-operator drivers are paid by the trip. Reducing trip time or stop time or the overall time of operation has an economic value only if over a period of time the number of trips increases. In FRATIS we measured trip time and mileage. As shown in Section 6, there was no trend of continued reduction of trip time or mileage; the daily averages related more to having a few long trips.

The next two sub-sections discuss attempts to measure improvement from FRATIS and further address the problem of monetizing any improvement benefits.

8.2 Measuring FRATIS Benefits

According to a May 2015 article in the Port of Los Angeles' business newsletter *LAttitude*, "Efficient goods movement through U.S. ports is limited by the timely availability of information between terminal operators, freight operators, and truck operators," said Nancy Singer, spokesperson for the USDOT's Federal Highway Administration. "FRATIS is testing technologies and processes to reduce delays by improving situational awareness for these stakeholders." The question becomes how to measure the value of situational awareness. In this section, the assessment team discusses the potential benefit from reducing trip time as well as stop time for the drayage fleets in the test.

Reduced Trip Time. As discussed in Section 4 and the FRATIS Assessment Plan, FRATIS was intended to reduce trip time through better scheduling and better real time information. The overall trip time in this case is the one-way time from inland yards or distribution centers to intermodal terminals (rail or ports) or from terminals to inland destinations. There are two measures involved here: individual trip time and overall drayage time. Each of the FRATIS prototype final reports mentioned slight variations on mileage driven daily by a fleet, which relate to trip time. The DFW Final Report said the optimization objective "was that the daily plan seeks to minimize miles traveled for the fleet, not for the individual driver" (page 16). The SFLA Final Report said the daily plan "will maximize productive moves and minimize nonproductive ones" (page 21). The LA report said: "the trucks then follow this plan for that day, and expected significant reductions of miles traveled, time spent, and fuel usage, are achieved" (page 5).

In the earlier Memphis optimization pilot, the objective was to "maximize the loaded moves and minimize the unproductive ones (e.g., Bobtail moves), which improves drayage companies' efficiencies, reduces congestion on the roads, and will positively impact the environment by decreasing the carbon footprint" (page 5). However, in describing its results, the Memphis report showed "no significant difference in the total miles between the plans and their execution," but did find that "the total stop time in the execution was significantly different from the plans". (page 10)

It is important to note that the Memphis effort did not analyze or even speculate on how the reduced mileage would be used or how it would benefit the drayage company (except for a reference to reducing fleet size) or its drivers. The recommendations and next steps were for refinements to the optimization algorithm, but not to its actual use with, or impact on, a drayage company. The assessment team believes that FRATIS indeed improved the algorithm as well as its place in the dispatching policy, but that FRATIS was not able to measure *how* drayage operations could be improved.

According to the aforementioned May 2015 Port of LA article about technological advances including FRATIS, Port of Los Angeles Executive Director Gene Seroka said "Web-based drayage technologies can help the entire supply chain move goods faster and more efficiently. We're working with our industry partners and technology experts to advance those innovative strategies."

Reduced Stop Time. Building on the FRATIS data analysis in which both stop time and total time are measured, the assessment team next examined the potential benefit of reducing the amount of stop time. Typical average stop time percentages are shown in the table below.

Table 19. Stop Time Averages

NCFRP 11 National Average Idle Time (% total time)	FRATIS LA TomTom Stop Time (% total)	FRATIS SFLA Tom-Tom Stop Time (% total)	FRATIS DFW Tom-Tom Stop Time (% total)
45.0%	59.6%	64.9%	42.7%

Source: CDM Smith

The NCFRP 11 Drayage report noted that the EPA DrayFLEET model produced the national estimate in the table and that it was consistent with most driver survey results (page 94). Note that the stop time measurement on the TomTom used in FRATIS is a measure of the time the engine was running but the truck not moving, which of course is idle time. The LA stop time measured represents drayage operations in the congested ports of LA and Long Beach. The higher South Florida measurement is primarily because so many of the container movements are live unloads, in which the driver waits for the container to be unloaded and then returns the empty to the railroad. The stop time percentage was near the national average in DFW, where movements are more diverse and less prone to terminal congestion than in LA, for example. Earlier in Section 6, the assessment team included some analysis results related to trip time, total operating time, and stop time. Further discussion of stop time is in order to examine the value of reductions in stop time.

The table below includes the major reasons for stop actions as identified by the assessment team. These include times that are external to the truck movement, such as traffic delays; delays at terminals, both in queues at the gate and within the terminal; and waiting time related to delivery of the cargo in a loaded container, including unloading the container. The assessment team then identified ways that stop time could be reduced and commented on whether there is a FRATIS function that affects stop time. The two right hand columns of the table describe the quantitative and qualitative benefits related to particular reductions in stop time.

Table 20. Analysis of Stop Time

Reasons for Stop Time	Ways to Reduce Stop Time	FRATIS Data Used	Quantitative Impact of Reduction	Qualitative Benefit
Traffic Accident Delay	Take alternative route or postpone departure	Advanced traveler information	Fuel savings from less idling offset by potential additional mileage	More consistent travel time. Less wear on driver.
Construction Delay	Take alternative route or postpone departure	Advanced traveler information	Fuel savings from less idling offset by potential additional mileage	More consistent travel time. Less wear on driver.
Queue at Terminal Gate	Postpone departure until queue abates	Queue time measurement	Fuel savings from less idling. Reduced overall trip time.	Less wear on driver.
Waiting for Container inside Terminal	Make container available sooner	Container availability information	Fuel savings from less idling and creeping. Reduced turn time.	Additional time that can be reallocated
Waiting at Outgate	Improve paperwork processing at gate	No involvement from FRATIS	Fuel savings from less idling and creeping. Reduced turn time.	Additional time that can be reallocated
Delivery of a Container	Advanced notice of delivery	Arrival notice	Fuel savings from less idling. Reduced driving time.	Additional time that can be reallocated
Live Unload of Container	Drop container and return later for empty	Not considered in FRATIS, but optimization plan would have different suggested plans	Fuel savings from less idling, but additional trip from depot to customer to retrieve empty	Additional time that can be reallocated

Source: CDM Smith

What is notable in this table is that advanced traveler information that was tested in FRATIS may be able to reduce stop time, but drayage dispatching policy based on optimization in FRATIS, as observed by the assessment team, does not appear to affect stop time. Simply reducing stop time does not necessarily yield benefits. There can be fuel savings and related emissions reductions if the truck idles less, but it is also possible that re-routing around delays could actually increase mileage and fuel consumption. A key question in this analysis is: What is done with stop time saved? If it reduces the work day for the driver, that is a quality of life benefit. It may also be possible to assign a longer- duration trip to a driver enough time is saved, but in a sense that is a zero sum game since some other driver would not get that longer-duration trip. The conundrum with time savings is that, for the most part, unless an owner-operator increases the number of trips in a day, there is no economic impact on either the drayage company or the driver. Freed-up stop time can be allocated to moving containers (or chassis), but this would not really be a benefit unless more trips can be worked. Thus, in the qualitative benefit column of the table, several of the potential reductions note that the time can be reallocated, but to what?

The exception in this analysis of stop time involves live unloads. As previously noted, some high stop time days are the result of the driver waiting at the consignee's for the container to be unloaded. In South

Florida, with its many live unloads, the average time per truck during the FRATIS test was nearly 384 minutes waiting out of a daily total of 591 minutes, or 64.9 percent. Unfortunately FRATIS cannot affect this time, but it may be worth determining in conjunction with a consignee whether live unloads could perhaps be converted to dropping the container and returning later to pick up the empty. The drayage company could determine if there are trips that could be made with the time saved by simply dropping off the container, with the understanding that an additional trip back to the consignee would offset potential gains from more revenue trips. Additional studies of drayage operations could address the extent to which partial increases in the number of trips help the driver and/or the company.

Improved Trip Time Reliability. As has been noted, FRATIS proponents hoped that the ability to avoid congestion, re-route in case of accidents, and schedule using such information as traffic conditions could reduce some of the uncertainty in the trip and potentially improve reliability. This would, for example, be useful to terminals or to consignees if they can count on the truck arriving when the advanced information says it would arrive. The externalities that the drayage companies face certainly work against improved reliability. And, even more difficult than measuring the benefit of reduced trip time, reliability improvement is of no value to the owner-operator unless the number of trips can increase.

A wiki website called Transportation Benefit Cost Analysis affiliated with TRB's Transportation Economics Committee (www.transportationeconomics.org) discusses trip time reliability. While the reliability measurement discussion on the website is more about passenger travel, the site notes the need to establish the *value* of reliability if a quantitative benefit is to be determined. Here again, the per-trip payment scenario for owner-operators limits the value of reliability in drayage movements. On the other hand, the increasing popularity of appointment systems at ports may increase the importance of reliability. High variability in trip time means that appointment intervals need to be large enough to assure that most trips can be completed around the time of the appointment. There are neither rewards nor penalties for not adhering to an appointment, but drayage drivers certainly want to avoid being turned away because of missing an appointment.

The transportation cost benefit analysis website cited above noted that "Empirical evidence shows that the value for reliability is likely to vary by individual, trip purpose, and monetary advantage from better scheduling in the case of freight."

8.3 Impact of Owner-Operators on Quantitative Benefits

Throughout the test findings in Section 5 and the overall findings in Section 7, this report has discussed the significance of owner-operators in the drayage industry. Additional discussion is relevant to efforts to determine benefits of technology improvements such as FRATIS. Two reports are drawn upon in this discussion: *Key Performance Parameters for Drayage Trucks Operating at the Ports of Los Angeles and Long Beach* (Nov. 13, 2013) and the previously-mentioned FMC Port Congestion Report (July 2015).

The Key Performance Parameters study (hereafter referred to as KPP Study) looked at the expectations of "turns per day," which are round trips into and out of a port terminal. These turns are the basis for paying owner-operators. The KPP Study noted the following:

> Because drivers are independent contractors who make a wide variety of deliveries to destinations both within and outside Gateway Cities, the dray operators have limited control over their actions. A strategy of limited routes is most feasible when drivers are directly employed by the operator, and can be assigned to predetermined routes. (page 2)

The FMC Port Congestion report, based on a series of port forums held throughout the U.S. during 2014 and early 2015, includes a detailed discussion about drayage problems. A relevant comment from that report was included earlier in Section 1, and is repeated here for its importance to the owner-operator issue:

> Although the underlying causes of this congestion usually have little or nothing to do with draymen, congestion costs are felt most immediately and acutely by them. This is because the predominant model for drayage trucking in the U.S. is the independent owner operator (IOO) who contracts his services to a licensed motor carrier (LMC) and gets paid by the trip. Port congestion severely impacts the number of trips per day the driver is able to achieve. Consequently, the most immediate cost of container terminal congestion is not borne by the terminal operators, longshore labor, steamship lines, shippers or the port authority, but by drayage drivers. (page 51)

To illustrate this point, a March 8, 2015 article in the Long Beach Press Telegram included an interview with a drayage owner-operator who typically averaged 30 moves per week, but because of the LA area port congestion more recently averaged 10 to 15 moves a week. That driver said he was seeing improvement from the chassis pool that has been implemented, in line with the aforementioned improvement identified in NCFRP 11.

It is well documented (including in the KPP Study) that operators need to run at least three turns, which is actually six trips, per day to cover owner-operator costs and a salary for the driver. The KPP Study described it this way:

> Operators expect to run at least 3 turns per day per truck, which may reach 4 or 5 on a productive day. The number of turns depends greatly on delays when picking up containers at the ports; dwell times can range from 30 minutes to over two hours. In some cases, the trucks are parked for a portion of this time, which allows the driver (or causes the anti-idle device) to shut down the engine. In other cases, trucks are creeping in a long queue, and the trucks remain in an idle or near-idle state for long stretches of time.

The KPP Study says that “Because the drivers are independent contractors, the drayage companies are very limited in how they can direct the drivers to do their jobs” (page 14). What the FRATIS assessment team observed is that for most of the owner-operators who worked for the prototype drayage companies, the companies generally have contractual relationships with these drivers and typically schedule the trucks throughout the day. As noted in earlier sections, the drays did tell the assessment team about drivers who would or could not accept certain containers or customers. The team also learned that many owner-operators obtain their insurance and operating certifications under the auspices of the drays for which they work. The interviews with the FRATIS drayage companies noted the importance of working relationships between the dispatchers and the drivers, and the emphasis that dispatchers place on equity in assigning moves among drivers. The KPP Study reinforced this practice and noted that “if a driver’s route were restricted, this would raise equity concerns if the drivers turn fewer containers and earn less money”. (page 19)

One of the controversies surrounding owner-operators is the determination of whether they are contractors or employees. While those arguments were not part of FRATIS nor are they affected by FRATIS, it is worth noting that the drayage companies’ policies need to walk the line between contractors and employees. The optimization algorithm cannot take the working relationships into account. The KPP Study noted the limitation on drayage assignments to drivers because if a dray company were to specify that a driver is limited to certain routes or certain destinations, this may classify the driver as an employee rather than an independent contractor. In South Florida, some of the owner-operators have working relationships with certain shippers, which the drayage company needs to take into account when assigning trips.

Although Hours of Service (HOS) rules apply equally to owner-operators and drayage employee drivers, it is worth noting in this discussion the important relationship between congestion and delay and what a driver is allowed to do. The optimization algorithm includes the Hours of Service restrictions for each driver in the fleet. Even so, the ability of a driver to complete the three or more round trips discussed above is affected by HOS. For example, a driver has a 14-hour window on duty to complete their travel. During this time the driver can drive 11 hours maximum, after which he or she must take a 10-hour break (FMC Congestion Study, page 55). The bottom line of this and the rest of the discussion about owner-operators is that the drayage environment is exceedingly complex; identifying and calculating the economic impact of operational improvements is difficult at best.

8.4 Other Views of Port Improvement Benefits

The Port Performance Task Force at the Port of New York and New Jersey (NYNJ) released a report in June 2014 that included 23 recommendations to improve the port. The following four recommendations relate to the kind of port congestion and information improvements being explored in FRATIS and this assessment report:

1. **Chassis Management Improvement System** – the two essential components identified were the interoperability of the chassis operating in the NYNJ market and gate integration.
2. **Truck Management System** – to effectively meter the arrival of trucks while stakeholders continued to operate at maximum levels. The initial idea proposed was for trucks to pre-advise their arrival via an automated system. This is similar to what FRATIS advanced arrival functionality was intended to do. The Port Performance Report identified the following anticipated benefits: reduce congestion, allow for more efficient allocation of resources, decrease truck turn times, improve productivity and terminal capacity, reduce the number of trouble tickets/transactions, and decrease emissions.
3. **Real Time Information on Actual Conditions** – a recommendation to implement RFID capability to measure truck movements in and around the ports.
4. **Dashboard of Current Conditions** – real time information regarding conditions posted in a consolidated location accessible on line or by smartphone.

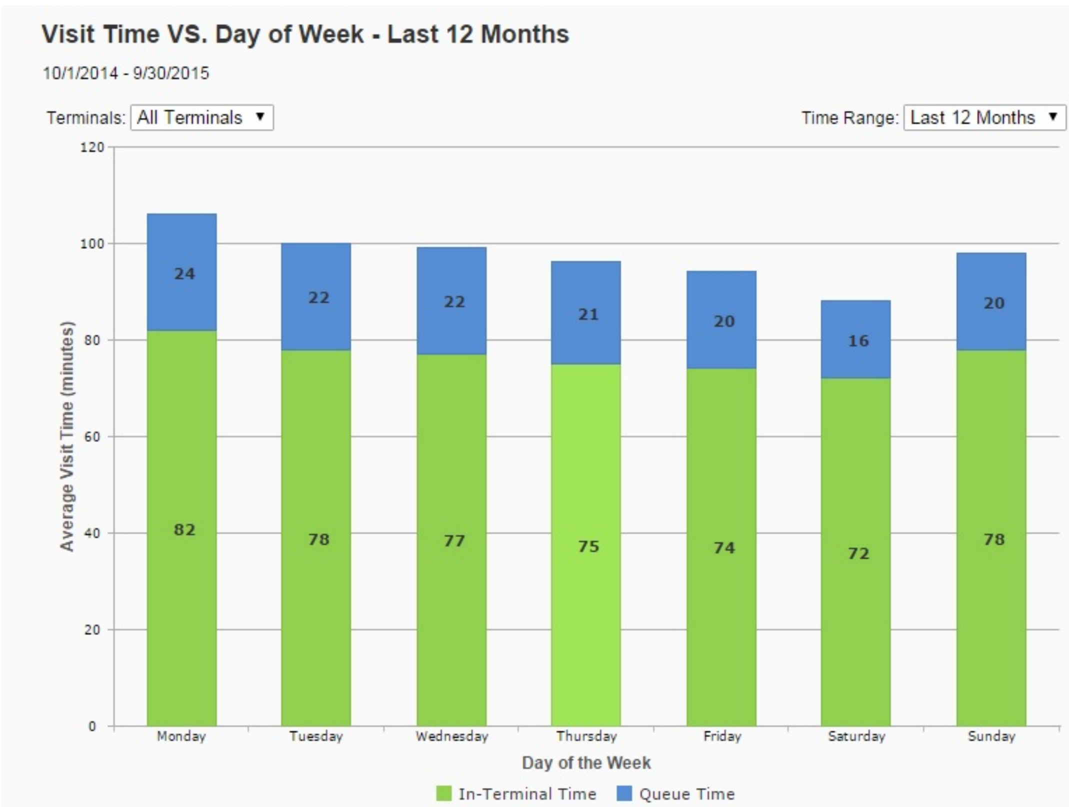
FRATIS envisioned providing a dashboard (as described in item 4 above), and indeed had web pages available to users at each prototype site. However, the web pages were a minor functional capability in FRATIS and were not used consistently by dispatchers. In part, as has been discussed earlier, this was because the FRATIS web pages were separate from the normal dispatcher operations and the press of business tended to limit the use of the FRATIS pages. As tested, the FRATIS web pages were not available to drivers, with the exception of limited use and testing of an on-board device in LA. In that case, the drivers involved preferred use of smartphones, although the application was not available on smartphones.

Real time information was addressed in FRATIS (item 3 above). Rather than using RFID, FRATIS included the TomTom devices on the FRATIS trucks; these tracked truck movements and displayed those on the Webfleet regional maps. FRATIS users at the drayage companies found the Webfleet maps to be useful. FRATIS also showed that strategically-located measurement devices can help measure movements and delays at particular points in a terminal; this was a different approach, with a similar objective near or within a terminal. What FRATIS attempted that showed promise was doing something with that real time information, namely providing it to drayage dispatchers as queue length information.

FRATIS also was intended to provide advanced notification of trucks' expected arrival at terminals (item 2 above), although not on a port-wide or region-wide basis. Again, it was a small-scale proof of concept test that suffered from data errors, so the study could not show measurable improvement. Further, the FRATIS test was with a single ocean terminal in the case of LA and a single intermodal terminal in Dallas. Especially in LA, where there are 13 terminals, the kind of truck management system proposed by the NYNJ group would work best with multiple carriers sending arrival notices to multiple terminals.

Although not specifically addressing the truck arrival issue, the Harbor Trucking Association in LA collects and publishes on its website turn time data for each terminal, which definitely applies to item 2 above. The assessment team found that the LA drayage dispatchers had access to the information and occasionally used it. Also, the HTA data was used as an input to the optimization algorithm to address the historical wait and delay times constraint in the algorithm. A sample of the HTA data is shown below.

Figure 21. Sample Average Terminal Visit and Queue Time – LA/LB Ports



Source: Harbor Trucking Association

FRATIS did not address the chassis problem (item 1 above), although picking up a chassis was a Freight Action in FRATIS and was included as a recommended trip leg in potential assignments for drivers, as recommended by the FRATIS optimization algorithm.

More recently, there have been efforts in the LA/LB ports to coordinate activities in order to reduce congestion and delay at the various terminals. Somewhat surprisingly, the ports of LA and Long Beach had to obtain permission from the Federal Maritime Commission in order to cooperate in operational improvements; that permission was granted in February 2015 (Long Beach Press Telegram, May 27, 2015). Of most significance, ten of the terminals, working through the PierPass organization, agreed to establish appointment systems and share information about wait times and delays (articles in Los Angeles Business Journal and Business Wire, August 27, 2015). It is worth noting, however, that drayage companies will have to go to separate websites for individual terminals' appointment systems. Further, five of the terminals already operate separate appointment systems, but do not share the information. In the same referenced articles, a representative of the Harbor Trucking Association said that it would be better to have a port-wide system.

In Houston, according to a 2008 survey of drayage drivers, those drivers identified the top three actions that could be taken to improve port efficiency as increasing the number of booths at terminal entrances, offering extended port operating hours, and improving terminal yard operations. In LA, they have already extended port hours with the PierPass program. Improving terminal yard operations can be partially achieved through the advanced notice of arrival information that was addressed in FRATIS. In the Houston survey, less than a third as many drivers thought that introducing an appointment system and streamlining driver and carrier operations would improve port efficiency.

The FMC Port Congestion report (page 56) included comments from a motor carrier who attended and spoke at the Southern California forum. He listed five items that he thought would improve stability and sustainability, at least in the LA ports. Four of them are:

1. **Extended gate hours to allow drivers to work at less congested times.** LA already has extended gate hours, although there is congestion in advance of the less expensive evening hours.
2. **Gray chassis pools to relieve the burden of repositioning chassis around the terminals.** NYNJ has created such a pool and LA/LB started such a pool in early 2015. Essentially, this is a pool of pools where multiple chassis owners have complete interoperability across the pools. This allows drivers to pick up or drop off a chassis at any of the terminals, which provides better access to chassis. The motor carrier participant highlighted the additional chassis interoperability problem involving large shippers having accounts with multiple steamship lines.
3. **Rate relief.** The participant noted that trucking costs have gone up at the same time that customer service requirements have increased without changes in the rates paid to the drayage carriers.
4. **Equipment free time.** In this case, drayage companies often have to pay additional penalties for containers when delay occurs because of congestion around the ports. The participant noted that it is "virtually impossible to change the number of available drivers in any one day and that, as a finite number of drivers can only move so many loads, trucking companies need extended free time help." The comment about the finite number of drivers is particularly important in the FRATIS context. The optimization algorithm is trying to maximize the number of moves a fleet can make, but operational realities often result in delays that mean an optimal plan cannot be followed.

8.5 Costs of Port and Terminal Congestion

This sub-section looks at the costs of congestion and discusses whether or not those costs can be reduced by the technology improvements in FRATIS. While most costs would be in regions around ports or intermodal rail hubs, there are also costs to the U.S. economy.

Cost to the Economy. According to the Institute for Supply Management in the January 8, 2015 *American Shipper*, factory production grew at a slower pace in December 2014 and experts pointed to congestion at West Coast ports as a contributing factor. Federal Reserve estimates are that the various port issues on the West Coast cut 0.2 percent off the first quarter 2015 U.S. gross domestic product (GDP).

The FMC Congestion report included a useful discussion of the costs of drayage delays involving port congestion, which is summarized on page 79 as follows:

- A March 15, 2015 Drewry report in *Container Insight Weekly* suggested that delays in the time taken to turn around ships at the ports of LA and Long Beach in the fourth quarter of 2014 cost the ocean carriers serving the ports $150 million, or $600 million on an annualized basis.

> *"The issue of congestion was not brought on by any one event, not even the recent labor talks between West Coast dockworkers and their employers. Rather, it has been the result of a new, ever growing model for how cargo is being delivered."*
>
> - Federal Maritime Commission Chairman Mario Cordero, speaking at the March 15, 2015 Legal Ports Conference (Long Beach Press Telegram, March 19, 2015)

- Updated to reflect higher daily chassis and container rental cost, APL estimated that a one-day delay in import containers at LA would add $10 million annually.
- Sportswear company Nike said it spends $4 million per week (or more than $200 million annually) to carry an extra 7 to 14 days of inventory to hedge on import delays in the LA/LB ports. Repeated across many national retailers and other importers, these extra carrying costs would amount to a very substantial sum. The carrying cost of pipeline inventory could increase nationally by $500 million annually if, for example, cargo took two days longer in transit on average because of congestion delays.
- A 2006 Congressional Budget Office (CBO) report on the economic costs of disruptions in container shipments estimated that a week-long disruption to container movements at the LA/LB ports would cost the U.S. economy between $90 and $200 million per day, when updated for 2015 commodity values. These estimates are based on loss of production (GDP) and are considerably lower than similar estimates from non-government sources because they assume the U.S. economy and trade flows would adjust to a port closure.

Cost of Delay. One potential benefit is the cost of delay and the likelihood of reducing delay through FRATIS-like technologies or other improvements. A May 2014 *American Shipper* cover story noted about 5,000 intermodal truck carriers nationally serve ports and rail terminals, not including large carriers with dray fleets. National drayage delays, according to the Tioga Group, cost businesses $348 million, 14 million lost hours, 9 million gallons of diesel, and 103,000 tons of greenhouse gases per year (*American Shipper*, May 2014, page 34 and FMC Congestion Report, page 77). Another article noted the financial and environmental consequences of port congestion in Southern California. Again according to the Tioga Group, every minute of average truck turn time uses 200,000 gallons of diesel, releases 2,000 tons of carbon dioxide, and costs customers $4.5 million. The article "How an old school technology suddenly contributed to port congestion," quotes a Los Angeles area trucking association executive: "Our ability to deliver loads has been reduced by at least 35% of normal operations." He noted increased per diem bills on empties because truckers have to give priority to loads. (Long Beach Press Telegram, March 8, 2015).

The NCFRP 11 Drayage Guide and subsequent updates and presentations by one of its authors, Dan Smith of Tioga, included estimated costs of congestion that could be reduced if certain improvements, discussed at the beginning of Section 8, were implemented nationwide. The NCFRP 11 report included results of analysis done with the EPA DrayFLEET model, an Excel-based program that calculates costs of drayage in terms of labor hours, fuel usage, and the resulting pollutants from that fuel. The model calculates a base scenario and then allows comparison of different levels of drayage improvement.

According to IDW Publishing, the entirety of its late February 2015 shipment of comic books will be delayed, including latest issues of "Transformers," which was set to release on 2/18/2015. "Due to the ongoing problems at West Coast ports, our normal shipping procedures have been completely interrupted, causing unpredictable delays," the company said in a statement. "Regrettably, this has resulted in all our books planned for release on 2/18 to be delayed. We've looked at every possible scenario to prevent this, but the situation is completely beyond our control. We are taking steps to improve this for the immediate future, but the books and products that are currently on the water cannot be redirected."

- Long Beach Press Telegram, Feb 16, 2015

The NCFRP 11 report used 2008 data to compute national estimates of drayage costs. In a June 2014 presentation to the Agricultural Transportation Coalition, Dan Smith updated the figures to 2012. Of the NCFRP 11 improvements previously mentioned, the assessment team selected those improvements they believed could be affected by FRATIS. Smith's updates to 2012 were incorporated in Table 21 below along with idle reduction estimates from NCFRP 11, as adjusted by the assessment team to represent more current fuel consumption and fuel cost numbers. The table shows calculated fuel savings, carbon dioxide reductions, and total drayage cost reductions for three types of improvements: reducing the time within a terminal, reducing the time in a queue outside the terminal, and reduction in idling. If the three improvements could all be achieved nationwide, there would be a potential 11.3 percent reduction in drayage costs.

Steve Gardner, director of trucking operations at Three Rivers Trucking Inc., had two options when five of his containers filled with citrus were delayed at the LA/LB ports: either take the fruit off the ships and sell it domestically, or let it rot at the docks. The produce was supposed to be on a ship bound for Asia, but was delayed because dozens of other ships were anchored at sea waiting to be unloaded. "By the time the boat got here, it was a month," said Gardner. "They had us take those five containers off that ship and back to the packing house because they would have never made it when it arrived. I'm harboring 90 loaded containers of frozen foods and California agriculture, which I'm still being billed per diem for, though it's not my fault that I can't turn them in," said Gardner, who estimates the added fees amount to hundreds of dollars per month. For the first part of 2015, Three Rivers was down 70 percent from its normal cargo volumes, falling from a peak of 600 loads to 100 loads a week. The company has been looking at other ports to export its citrus.

- Long Beach Press Telegram, May 17, 2015

Table 21. Modeled Impacts of Selected FRATIS-Related Drayage Improvements

Drayage Improvement Scenario	Fuel (mil gals)	CO2 (K tons)	Cost ($Mil)
2012 National Estimate	80.0	891.05	$1,640
Reduced Terminal Time (30 min vs 40 min)	-2.0 -2.5%	-17.82 -2.0%	-$ 90 -5.5%
Reduced Queue Time (10 min vs 20 min)	-2.0 -2.5%	-24.95 -2.8%	-$79 -4.8%
Reduced Idling (reduced by 50%)	-5.9 -7.3%	-65.74 -7.4%	-$17 -1.0%

Source: Dan Smith, Tioga Group (2014) and NCFRP 11, TRB, Tioga Group et al (2011) adjusted and adapted by CDM Smith

How could FRATIS contribute to the above three potential improvements? Earlier we examined the components of stop time and noted those that could be affected by FRATIS. In particular, reduction in stop time could contribute to the $17 million savings in the above table for its reduced idling. Based on the earlier discussion, it's doubtful that FRATIS could reduce idling by 50 percent, but this at least shows potential savings. It was noted earlier that FRATIS advanced the prospects of real time data exchange. Some of that information relates to queue time and terminal time, although at this point it would be difficult to assign a number to either potential savings from FRATIS. Knowing that those two time savings could mean more than a 10 percent savings in drayage costs makes it worthwhile to continue efforts to implement real time information exchanges between drayage carriers and terminal operators.

The NCFRP 11 Report included the cost estimates related to a number of drayage problems, particularly congestion. The ones listed below are most related to the kinds of technology that FRATIS helped develop (page 37):

Time in port and intermodal terminals:	$1 billion/year
Time in queues at the gates:	$83 million/year
Congestion within a container yard:	$42 million/year
Congestion on highways and streets:	$150 million/year

The discussion in this sub-section as well as all of Section 8 is intended to show the scale of the costs of drayage operations and where technologies like FRATIS can fit. The assessment team does not believe that quantitative benefits of the FRATIS prototypes can be calculated, but that the extent of the problems and their costs show where future emphasis is needed in advancing and implementing information technologies.

8.6 Expansion of FRATIS

This sub-section looks at the likelihood of continuing and expanding use of the FRATIS technologies. Part of the original mandate for the FRATIS assessment was to determine the impact if FRATIS were expanded beyond the three limited prototype tests to full operation in the regions involved with the prototypes. The remainder of this sub-section elaborates on potential continuing use by the existing participants, two follow-on pilot projects that show promise, and discussion of expansion to other potential users.

Continued Use. None of the four drayage companies involved in the FRATIS prototypes discussed in this report will continue using FRATIS. The TomTom data collection devices have been turned off (with the exception of LA) and the drayage companies chose not to renew the contractual relationships with Webfleet. Even where there was some integration of a dray's order system with the input to optimization, the prototype drays will not be using the optimization software. None actually changed its dispatching procedure, so the creation of optimization plans and use of the results ceased when the prototype test ended. Most of the information exchanges in FRATIS were proofs of concept and would have needed further enhancement to be used. However, at one of the dray companies in DFW the automated arrival email to the intermodal cartage terminal will continue to be issued and used by the terminal. This was facilitated by the fact that the arrival email was designed to be automatically generated as a report from the existing transportation management system at the dray company.

One of the principal points of contact at the LA dray company left the firm in the months after the FRATIS test ended. When asked if he learned anything from FRATIS that could be applied to his new company, he responded, "We learned that direct text communication could reduce the amount of calls to the dispatchers if the process was easy to use. Sending the dispatches to the trucks from the system would be beneficial if the functionality was better. Seeing all available orders and at least trying to formulate a plan based on the algorithm could benefit if tested under the correct circumstances."

The prototype tests ended without any monetary incentive or facilitation resources that could be applied to assist in continued operational use or expansion. Each drayage company was left on its own to carry on. The problem after the test was the same as before the test: operations personnel within the dray company did not have time to do justice to the use of the test data during the test and continued to lack resources to push system use forward. The FRATIS test had essentially been an "other duty as assigned" for the users. Post-testing they had additional time to do their day to day jobs.

The prototype participants' experiences and their lack of use of the system after the test were not new. Previous pilot tests from Electronic Freight Management in Columbus to crosstown improvement projects in Kansas City and Memphis also were not used after the pilots were completed. In those cases as well as in FRATIS, there were important lessons learned that have been applied to future pilot projects.

Future Pilots. The following additional information is provided regarding the follow-on deployments that are already underway or approved.

LA Phase II. In LA, five dray carriers, multiple terminals, and one or two beneficial cargo owners are involved in a project described as FRATIS Phase II. Working with beneficial cargo owners, the developer will identify ocean terminals and dray companies that have volumes and operations that could show meaningful results.

The pilot will include integration of the pilot technology in existing drayage systems. The FRATIS technology to be deployed will include dynamic planning with multiple optimization runs based on frequency of order input. This means that the optimization will be re-run throughout the day so that the dispatch list is much closer to real time. In addition, the FRATIS software will be adapted for smartphones to be more directly usable by drivers. The developer believes the smartphone application will allow functionality to work with less integration required. Since training was a continuing issue in LA FRATIS, the Phase II effort will include additional training for users. All of these technology upgrades should make optimization results more accurate and, therefore, more likely to be used by the drayage companies and their drivers. A key intent of the project is to base the pilot work on the lessons learned from FRATIS, one of which recommends more frequent runs of the optimization software. Phase II project personnel told the assessment team they were being much more careful and deliberate in selecting participants and laying out what will be done. This, too, was a lesson learned from the FRATIS prototype study.

Whether the Phase II effort is able to accomplish all of its objectives, those objectives would seem to be relevant for future expansion, again based on FRATIS prototype experience and observations. The FRATIS LA Report included the following statement that is relevant to future expansion:

> If FRATIS is to be expanded in the LA-Gateway region, system deployers cannot afford to tailor a back-office software integration with each and every trucking company, and also must be able to integrate with whatever in-vehicle communications platform that the company uses—even cell phones, if that is how the company communicates with drivers (page 24).

I-35 Corridor Optimization for Freight. DFW FRATIS lessons learned are being applied on the I-35 Corridor in a project that is a part of two cooperative efforts between the state of Texas and USDOT: the I-35 Traveler Information during Construction Augmentation cooperative agreement and the Texas Corridor Optimization for Freight project. This freight improvement pilot is a follow-on involving the I-35 corridor and trucks moving on that corridor. Plans are for two trucking companies that use I-35 to participate in testing an enhanced version of the optimization algorithm to make assignment of orders related to I-35 with real time road conditions taken into account. The FRATIS software will be using tablet technology for interfacing with drivers and other users.

The enhancement to the algorithm is based on historical and real-time travel time and speed data, current and future lane closures and their impacts on traffic, and other construction-related information. The intent is to have on-board tablets for the trucks from the two trucking companies which will communicate with the I-35 connected vehicle infrastructure. The objective is for the trucking companies to make dispatching decisions based on the additional information and hopefully reduce or avoid construction-related delays. As with the FRATIS prototypes, the intent is that the two trucking companies involved change their dispatching policy to base it on the results of the optimization algorithm. As has been discussed in previous sections, in FRATIS the drayage companies did not change their dispatching policies and, as a result, FRATIS could not achieve the hoped-for improvements in operations. It is hoped that by applying the lessons learned from FRATIS to both the I-35 pilot and the Phase II LA project the benefits can be achieved. One area of hope in the I-35 project is that the assessment team for that effort is required to develop an expert system simulate optimization runs. Such a system will hopefully overcome the problem the FRATIS assessment team had regarding the incompatibility of “what if” and actual truck movement data.

Expansion Potential. As it was tested at the three prototype sites, FRATIS is scalable and could be used more thoroughly at the prototype drays or could be applied to additional drays, but it requires significant customization, particularly in optimization. Perhaps the tablet and smartphone-based applications planned for the two follow–on projects will make further deployment easier. It will, however, require resources at each new dray company to implement, including the need to coordinate with other partners in drayage moves such as the terminal operations personnel. Particularly if such a system and its information transfer capabilities are to be used by multiple companies, what may be needed is a regional facilitator. That could be through an existing public or quasi-public organization (e.g., the Harbor Trucking Association in LA) or an organization set up for the purpose. Again, that takes resources and leadership to bring the parties together and to work through the various steps involved in establishing interfaces and implementing software. Left to their own devices, existing transportation operators, whether trucking companies or terminal operators, are more likely to look to proven commercial products, preferably ones that integrate easily with their existing systems. The Trinium experience in Dallas-Fort Worth is an example of this. That supplier was involved in aspects of the integration and interfaces in FRATIS, and could at some point embrace optimization-like technology as part of its offerings to its customers.

Information produced by the South Florida FRATIS development contractor is illustrative of what would be needed to expand FRATIS. Table 22 below was extracted from the FRATIS As Built documentation. The estimated costs for customization and integration of the optimization tool with existing systems are important and useful. The optimization enhancements in the two follow-on projects may reduce the customization costs for optimization users. But it is clear from the experience with FRATIS that, unless a drayage company is starting from scratch without any existing system, some form of integration will be needed so that duplicate data entry is avoided and the information from optimization plans can be used seamlessly by dispatchers in their operations. The information exchanges for advanced notice or container availability or traffic emergencies are not included in Table 22, but it was clear from the FRATIS prototypes that management resources at both the drayage company and the terminal operator are needed to work out the details of information exchanges and to correct and overcome start-up errors or problems.

The discussion of costs in the previous sub-section shows that the potential for improvement is great; there are hundreds of millions of dollars to be saved nationally by improving intermodal container movements. Projects like FRATIS help to advance the state of the practice. It is also clear that, just in the several years the FRATIS prototype project was underway, there are technology advances in the commercial sector that also show promise for improving port congestion and reducing transportation costs.

As has been discussed earlier, there are aspects of the drayage problem that are not affected by FRATIS technologies (the chassis pool problem, for example), and there have been local or regional initiatives to address some of those problems. Although they do not necessarily use the kinds of software and data in FRATIS, there are efforts underway at various ports and terminal locations to address port congestion, efficiency, and air pollution issues. Many are private initiatives and some are funded by ports or local or regional governments. All of these efforts should be supported wherever possible and should include, when feasible, benefits measurement abilities. Progress has been made in FRATIS and the other initiatives, but there is much work that needs to be continued to solve freight problems associated with intermodal containers.

Industry participants believe in technological improvements. An example from one of the Federal Maritime Commission port forums noted a solution recommended by a participant:

> **Leverage current and emerging technologies to create real-time channels of communication.** According to this suggestion, greater integration of information technology could facilitate more efficient flows of containers moving in and out of terminals on trucks and trains, and eliminate some of the current bottlenecks being experienced. Examples of such initiatives already underway include FRATIS, Cargomatic (a kind of Uber scheme for trucking), and virtual container yards. (FMC Port Congestion Report, page 58)

Table 22. Drayage Optimization Tool's Software and Hardware

System Component	Technology	Cost	Special Considerations
Drayage Optimization Web Site	• Microsoft Server Operating System • Microsoft IIS 7 Web Server (Internet Information Services) • Microsoft.NET Framework v4.5 • MVC Web Site (Model-View-Controller)	$300/month	N/A
Optimization Algorithm	• Microsoft.NET Framework v4.5 • Real time traffic data (Nokia Here maps) • Weather conditions (Yahoo Weather Services)	$40,000 to $80,000	Optimization Algorithm must be customized for each user; this estimate includes development associated with customization; costs are dependent on complexity of customization.
Database/Repository	• Microsoft SQL Server 2008 R2	$400/month	N/A
Legacy System Data Integration	• .csv Files • Encrypted SSH File Transfer Protocol (SFTP)	$10,000 to $30,000	Integration with legacy system requires mapping, design, development and testing; costs are dependent on type of integration (e.g., API or no API)
Webfleet Web Service	• TomTom Link 510 • TomTom WebFleet Connect	$50,000 including equipment purchase and monthly subscription	N/A
FEC Highway Services Order Management System	• TMW TL2000	$10,000 to $15,000	Participant legacy system was provided as part of test but required data mapping, system resources, and daily data feeds.

Source: South Florida FRATIS As Built Report, Table 6-2, page 27

Section 9: Conclusions and Recommended Next Steps

Conclusion 1. The FRATIS prototype tests were useful proofs of concepts that advanced the technologies, but they did not result in measurable improvements. The FRATIS Impact Assessment Plan included a series of hypotheses and tests that were examined by the assessment team. Each hypothesis is included in Table 23 below along with a narrative description of what the assessment team found concerning each:

Table 23. FRATIS Assessment Hypotheses and Conclusions

Hypothesis	Conclusion
The use of FRATIS real time traffic information by dispatchers and drivers will improve their operations and will save drayage company resources.	While the use of the information was shown to be of some value to the dispatchers, it did not affect operations and did not save resources. Drivers did not use the information directly. The drayage companies and their drivers believed that, if used in full operation, the real time traffic information would improve operations and that is corroborated by other port congestion studies as well. However, the FRATIS project could not quantify company or driver savings, particularly since most drivers are owner-operators who are paid by the trip.
FRATIS will bypass congestion through dynamic routings which will result in a reduction of the percentage of trucks involved in traffic bottlenecks.	There was some congestion-related information available to the dispatchers, but they were generally too busy to communicate with drivers during a trip. FRATIS was not able to provide congestion-avoidance information to drivers in electronic form. The limited testing of an in-cab device did not provide that information any better than existing cell phones. Nevertheless, the concept of using such information was shown in FRATIS, and the drayage companies involved believe that such data could be useful in bypassing congestion and would reduce the number of trucks involved in bottlenecks. Other research and studies at various ports and terminals agree that dynamic routing is worthwhile, but no quantifiable benefits were identified.
FRATIS will result in a bobtail reduction at the drayage companies through implementation of the drayage optimization algorithm and load matching.	FRATIS did not have a measurable effect on bobtails. LA does not perceive a bobtail problem and did not measure improvement. Dallas had some anecdotal evidence that bobtails were reduced at one dray, but the other eliminated bobtails from the initial move in its dispatching practice with optimization. SFLA did not have bobtail issues with the type of traffic the dray company handled, so did not measure improvement. There does not appear to be any measurable benefit in FRATIS regarding bobtail reduction.
FRATIS will result in travel time reductions for drayage company moves to ports and terminals.	The FRATIS data did not exhibit reductions in travel time. This was partly because the FRATIS data was more a proof of concept than something that was used routinely and in an integrated way within the dray company. Centralized scheduling such as was done with the optimization algorithm did not really seem to reduce travel time. In any case, it is not clear how the benefits of travel time reduction result in monetary savings for the dray companies and especially for the drivers who are mostly owner-operators. This is discussed in more detail later.
There will be an overall savings of fuel by the drayage company from the operation of FRATIS.	Although the assessment team could not measure improvements from FRATIS operations, there do seem to be opportunities to save fuel if delay time at terminal gates and within terminals can be reduced. Similarly, reductions in idling because of traffic congestion or accidents, or otherwise reducing the amount of stop or idle time, could save fuel as well. Other studies provide useful quantitative estimates of such fuel savings and the resulting reduction in emissions.
FRATIS will result in reductions in queue times at area or yards and terminal facilities.	Measuring and reporting the queue time as was done in DFW and LA did not actually reduce queue time. Advanced notice of long queues could help a dray delay a trip, but this would only have an effect on queue time if the

Hypothesis	Conclusion
	advanced information were applied across more companies and more terminals. FRATIS did prove the concept of recording and notifying the dray of queues, but the amount of data and its accuracy were too small to measure any actual impact. The queue time is most affected by operations within the terminal and FRATIS does not really address terminal operations.
FRATIS will result in an overall improvement in air quality through a reduction in emissions.	To the extent that the advanced information in FRATIS helps to reduce idling and creep driving, the fuel savings will have a resulting improvement in emissions. The test itself had no effect, but it did show that advanced information can be useful to the drayage company in scheduling its moves to reduce delays and therefore idling and creep. As noted, other studies have quantified the air quality improvements.
The prototype site users will find the FRATIS test results useful and will have concrete plans to implement FRATIS and integrate it with their existing systems after the test has been completed.	While the prototype users did indeed find the test results useful, there was no follow on activity to continue to use FRATIS or to further integrate it with existing operations. None of the drayage carriers actually changed its dispatching procedure, so none is continuing to run optimization or make other changes to their dispatching system. One participant in DFW will continue issuing the automated arrival email to the intermodal cartage terminal and it will continue to be used by the terminal.
Other drayage and freight transportation companies in the region will recognize the cost savings associated with FRATIS and be willing to implement it to benefit from its use.	Although there were no measurable cost savings from the FRATIS prototype tests, the FRATIS information technologies are shown to be useful. With two follow-on pilot projects (one in LA with additional dray companies, additional terminals, and one or more beneficial cargo owners; and the other on I-35 in Texas with two trucking companies), there should be additional data available to show the benefits from FRATIS that other companies may want to invest in.

Conclusion 2. Improvements are needed in the way that Information System Pilot Tests are conducted. The FRATIS Impact Assessment identified in the various findings in Sections 5 and 7 a number of issues related to how the prototype tests were planned and conducted that limited the effectiveness of the results. Table 24 below summarizes some of the key recommendations and lessons learned. All of these are discussed in more detail in the main sections of this report, often with specific examples.

Table 24. Summary of Improvements to Pilot Tests

Care is needed in determining the aspects of operations that are chosen for improvement and the technologies that could be applied.
Integration of any pilot technologies with existing systems within a company is essential.
Private sector stakeholder involvement is essential, and extra care is needed to keep them involved.
Funding private participants during the pilot development and test would help assure retention.
Careful planning is needed to help reduce the likelihood of schedule delays.
If there are schedule delays, participant funding is needed to keep everyone engaged.

Conclusion 3. Expansion beyond individual companies necessitates a regional, probably public or public-private partnership, entity to successfully deploy and operate. Funding sources for such expansion are not clear. No test participant, whether in the three FRATIS sites or the predecessor pilot participants in other locations, continued to use the pilot operationally. Particularly since the benefits of FRATIS-type technology are the greatest when multiple transportation companies are moving freight to and from multiple intermodal terminals, some sort of entity is needed to encourage and facilitate future expansion.

Recommended Next Step. Apply the lessons learned from FRATIS to the two follow-on pilots, concentrating on the technologies that stand the best chance of helping the most stakeholders in the regions surrounding the two pilots. Advanced information exchange related to container availability, congestion, and anticipated arrival should be emphasized.

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Appendix A: List of Acronyms

Acronym	Definition
4G/LTE	4th generation long-term evolution (4G/LTE)
AC	alternating power (AC)
AOP	Alternate optimization program (AOP)
ASD	after-market safety devices (ASDs)
API	Application program interface (API)
BNSF	Burlington Northern-Santa Fe (BNSF)
BSM	Basic Safety Message (BSM)
CFO	Chief Financial Officer (CFO)
ConOps	Concept of Operations
C-TIP	Cross-Town Improvement Project
CSV	Comma separated value (CSV)
DFW	Dallas Forth Worth
DIT	Dallas Intermodal Terminal (DIT)
DLWC	drop load with chassis" (DLWC)
DMA	Dynamic Mobility Applications (DMA)
DMS	Data Management System (DMS)
DOS	disk operating system (DOS)
DOT	Department of transportation (DOT)
DSRC	Dedicated Short-Range Communication (DSRC)
ECL	empty container leg (ECL)
ED	export dray (ED),
ETA	Estimated Time of Arrival (ETA)
FCL	full container leg (FCL)
FDOT	Florida Department of Transportation (FDOT)
FEC	Florida East Coast Railway (FEC)
FHWA	Federal Highway Administration (FHWA)
FMC	Federal Maritime Commission (FMC)
FTL	Full Truckload (FTL)
FTP	File transfer protocol (FTP)
FRATIS	Freight Advanced Traveler Information System (FRATIS)
GCCP	Gulf Consolidated Chassis Pool (GCCP)
Gmail	Google mail
GPS	Global positioning system (GPS)
GSM	Global System for Mobile Communications (GSM)
HOD	Hours of Duty (HOD)
HOS	Hours of Service (HOS)
HTA	Harbor Trucking Association (HTA)
HTML	HyperText Markup Language (HTML)
HTTP	HyperText transfer protocol (HTTP)
IMAP	Internet message access protocol (IMAP)
IMCG	Intermodal Cartage Group (IMCG)
I/O	Input/Output
IOO	Independent Owner-Operator
IP	Internet Protocol (IP)

Acronym	Definition
IT	Information Technology (IT)
ITS	Intelligent Transportation System (ITS)
JPO	Joint Program Office (JPO)
JRE	Java Runtime Environment (JRE)
LA	Los Angeles
LA/LB	Los Angeles/Long Beach
LL	live load (LL)
LMC	Licensed Motor Carrier (LMC)
LTL	Less-than Truckload (LTL)
MAC	media access control (MAC)
NASCO	North American Strategy for Competitiveness
NCFRP	National Cooperative Freight Research Program (NCFRP)
NCTCOG	North Central Texas Council of Governments (NCTCOG)
NYNJ	New York-New Jersey (NYNJ)
OSADP	Open Source Application Development Portal (OSADP)
PAI	Productivity Apex, Inc. (PAI)
PII	personal identifiable information (PII)
PLG	Port Logistics Group
POC	Point of contact (POC)
POLB	Port of Long Beach
RDE	Research Data Exchange (RDE)
RESTful	Representational State Transfer (RESTful)
RFP	Request for Proposals (RFP)
RSU	roadside unit (RSU)
SaaS	Software as a Service (SaaS)
SFLA	South Florida, near Fort Lauderdale area
SMTP	Simple mail transfer protocol (SMTP)
SQL	Structured Query Language (SQL)
TCP	transmission control protocol (TCP)
TFHRC	Turner-Fairbank Highway Research Center (TFHRC)
TRB	Transportation Research Board (TRB)
UP	Union Pacific
USDOT	United States Department of Transportation (USDOT)
YTI	Yusen Terminal, Inc.

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