Los Angeles-Gateway Freight Advanced Traveler Information System

Demonstration Team Final Report

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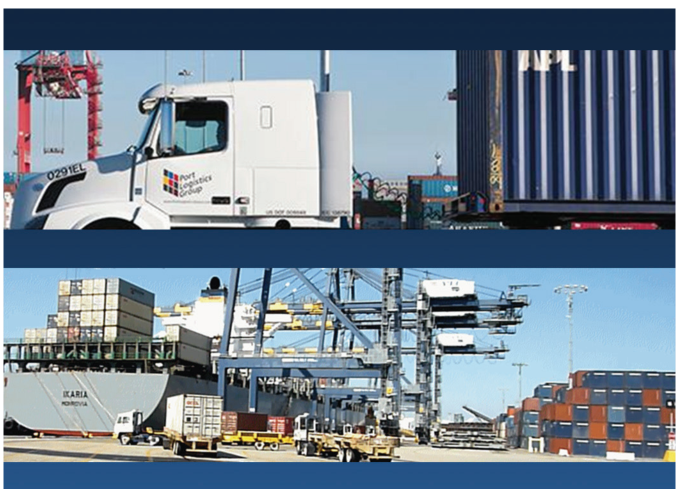

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16. Abstract

This Demonstration Team Final Report has been prepared to provide an overview of the conduct and qualitative findings of the LA-Gateway FRATIS development and testing program. More specifically, this document provides:

- A description of the testing program;
- Information and lessons learned related to stakeholder/user engagement during the program;
- Information and lessons learned related to system testing during the program; and
- Recommendations concerning future FRATIS and freight connected vehicle programs.

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1.0 Introduction

This report provides summary-level information and lessons learned in the conduct of the Freight Advanced Traveler Information System (FRATIS) Small-Scale Testing Program in the Los Angeles and Gateway Cities regions of Southern California (“LA-Gateway FRATIS”), which was funded by the U.S. DOT’s ITS Joint Programs Office. The report has been prepared by key members of the LA-Gateway FRATIS Demonstration Team, including Cambridge Systematics (prime contractor), Productivity Apex (system integrator) and Susan DeSantis (stakeholder engagement lead). Please note that quantitative findings regarding the performance of the LA-Gateway FRATIS test applications are being currently developed by an Independent Assessment (IA) contractor, and are expected to be published by U.S. DOT later this year. In preparing this document, the reader is directed towards three previous documents, which provide both the full context and the technical detail associated with this small-scale test:

- **Freight Advanced Traveler Information System: Concept of Operations Final Report,** August 2012, FHWA-JPO-12-065 (http://ntl.bts.gov/lib/54000/54100/54104/12-065.pdf). This document provides the technical basis for the FRATIS bundle of applications, and provides information on user needs, the conceptual framework, and example FRATIS operational scenarios. This document served as the blueprint for the development of the LA-Gateway FRATIS project.
- **Los Angeles-Gateway Freight Advanced Traveler Information System: Final System Design and Architecture,** May 23, 2013, FHWA-JPO-14-179 (http://ntl.bts.gov/lib/54000/54400/54477/Fratis_FHWA-JPO-14-179.pdf). This document provides the technical specification for the system design and architecture of the LA-Gateway FRATIS system.
- **Los Angeles-Gateway Freight Advanced Traveler Information System: Prototype Development and Small-Scale Demonstration for FRATIS,** June 28, 2013, FHWA-JPO-14-180 (http://ntl.bts.gov/lib/54000/54400/54478/Fratis_FHWA-JPO-14-180.pdf). This is the detailed planning document that contains all of the necessary site, system, user, data, and other key information for the small-scale test to be implemented and operated.

The purpose of the LA-Gateway FRATIS project was to develop a prototype of the U.S. DOT’s FRATIS bundle of applications—centered around improved communications between trucking companies and intermodal terminals, application of advanced algorithms to optimize truck routing and deliveries, and provision of dynamic routing of trucks around congestion—and to then conduct a small-scale prototype demonstration for assessing the effectiveness and impacts of a regional-based FRATIS implementation. The region of Southern California was selected, in part, because it is the most important freight gateway in our Nation, and directly affects the success of the U.S. national economy, as well as the global economy. The Ports of Los Angeles (POLA) and Long Beach (POLB), and the freight-centric communities, warehousing/distribution centers, and transportation infrastructure that serve them—collectively termed the Los Angeles-Gateway Region—handle more than 40 percent of the Nation’s total import traffic and about 25 percent of its total exports.

The following “near-term” performance goals for the LA-Gateway FRATIS test were developed, in part, based on the successful conduct of a previous analogous test of FRATIS-like technologies in Memphis, Tennessee, in 2009, under the U.S. DOT’s Cross-Town Improvement Program (C-TIP).

- Reduce the number of bobtail trips (i.e., empty-return loads) by 10 percent;
- Reduce terminal queue times by 20 percent;
- Reduce travel times by 15 percent;
- Reduce fuel consumption by 5 percent; and
- Reduce level of criteria pollutants and GHG by 5 percent.

Using these goals as a yardstick, as mentioned previously, the IA Team is currently conducting a detailed evaluation of the quantitative performance of the LA-Gateway FRATIS system. The IA activity, which is being conducted by a Booz Allen Hamilton—North River Consulting Group team (Ken Troup, IA Team Lead), is expected to publish the final FRATIS Evaluation report in approximately September 2015.

Additionally, several key qualitative goals were also put forward by the LA-Gateway FRATIS Development Team, in consultation with the regional public and private stakeholders that participated in the test program:

- Leverage and integrate public- and private-sector data sources, and add the missing pieces;
- Test the benefits of added functionality—beyond what is readily available today;
- Support regional efforts to build trust and establish a new paradigm for cooperation within the intermodal freight industry; and
- Serve as an incubator for private industry—interested parties could further develop FRATIS functionalities and integrate them into their software offerings.

The lessons learned findings contained later in this report, respond to these goals, and provide additional qualitative findings in numerous areas relating to both stakeholder involvement and system testing.

The remainder of this document is organized as follows:

- **Test Overview (section 2.0).** This section provides a comprehensive overview of the elements of the LA-Gateway FRATIS Small-Scale Test Program.
- **Stakeholder Involvement Summary and Lessons Learned (section 3.0).** This section, after providing a description of all the key users and stakeholders involved in the LA-Gateway FRATIS test, presents key lessons learned regarding the user recruitment, user training, and user experience with the system.
- **System Testing Summary and Lessons Learned (section 4.0).** This section, after providing a summary of the testing areas and focus, presents key lessons learned regarding the design, content and technical issues/opportunities with the LA-Gateway FRATIS deployed system.

- **Recommendations for Future FRATIS and Freight DMA Programs (section 5.0).** Based on a synthesis of the results of the lessons learned, this section provides recommendations that may be applicable to future FRATIS-like programs.

2.0 Test Overview

The LA-Gateway FRATIS demonstration project was focused on:

1. **Drayage-to-MTO Communications Improvements—**Improving communications and sharing intermodal logistics information between the truck drayage industry and port terminals such that terminals are less congested during peak hours.
2. **Freight-Focused Dynamic Traveler Information—**Improving traveler information available to intermodal truck drayage fleets so that they can more effectively plan around traffic and port congestion.
3. **Drayage Optimization—**Employment of an optimization algorithm which will allow for the technologies to work together in a way which optimizes the drayage fleet deliveries and movements based on several key constraints (e.g., time of day, PierPass restrictions,[1] terminal queue status, etc.).

Figure 1 below provides an overview of the information exchanges that were developed for the LA-Gateway FRATIS system.

[1] PierPass is a partnership among the marine terminal operators at the Port of Long Beach and the Port of Los Angeles aimed at easing truck congestion, improving security and helping air quality. A traffic mitigation fee is paid to PierPass Inc. by the Beneficial Owner of Cargo of an intermodal container that enters or leaves a Los Angeles or Long Beach marine terminal by truck during peak hours. The fee is waived or credited if the container enters or leaves a terminal during off-peak hours or by rail. This acts to incentivize trucking companies are encouraged to spread their services among the shifts to prevent bottlenecks. In terms of a FRATIS constraint, the PierPass fee waiver time of 6 p.m. daily is the constraint that some trucking companies may wish to apply to the optimization algorithm to avoid the peak hours container fee.

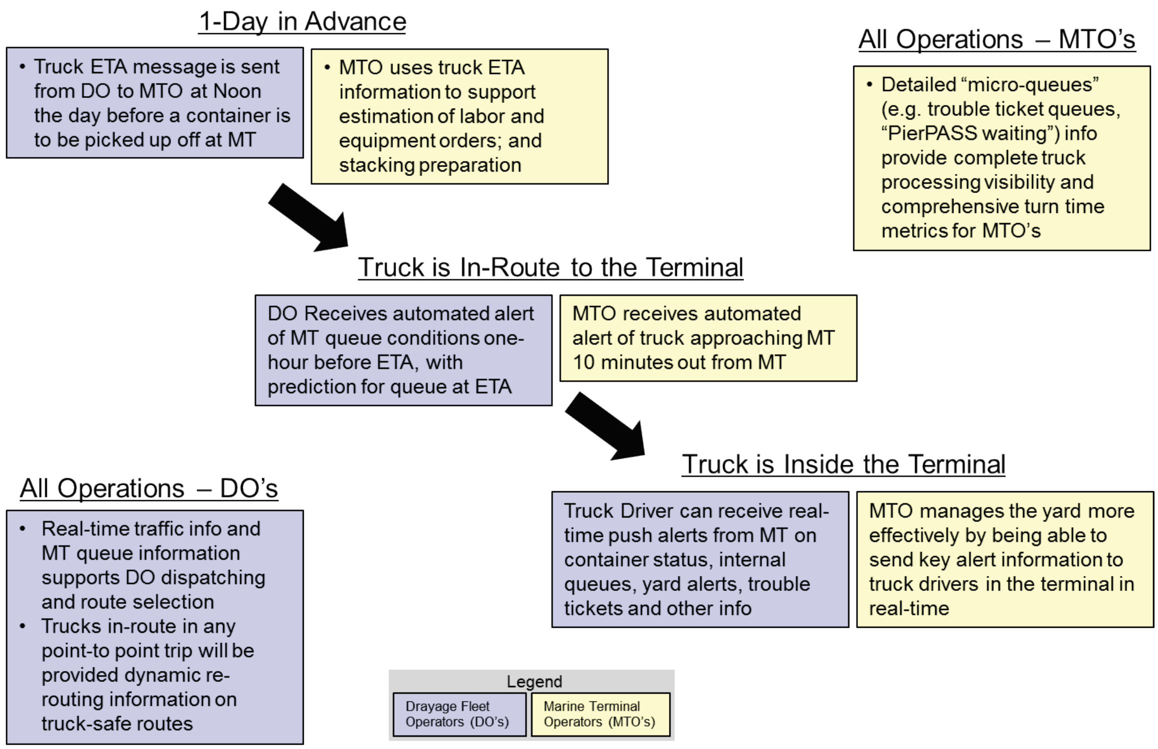

Figure 1. Overview of FRATIS information exchanges
(Source: Cambridge Systematics, Inc.)

Together, the above three areas of focus were expected to result in significant improvements in intermodal efficiency, including reductions in truck trips, reductions in travel times, and improved terminal gate and processing efficiency. These benefits, in turn, would be expected to directly result in the public-sector benefits of congestion reduction and improved air quality.

The two primary private-sector participants in the Los Angeles FRATIS demonstration project were Yusen Terminals, Inc. (a Port of Los Angeles Terminal) and Port Logistics Group (a regional drayage fleet). The primary regional public-sector agencies that supported the test were LA Metro, The Gateway Cities Council of Governments, and the Port of Los Angeles.

A major new software technology that was tested during the project was the employment of a ***Drayage Optimization Algorithm*** which allows for the technologies to work together in a way which optimizes the PLG truck deliveries and movements based on several key constraints (e.g., time of day, PierPass restrictions, terminal queue status, etc.). Table 1 presents a listing of both the constraints and the outputs from this optimization algorithm. In ideal use, the algorithm is applied during the preplanning dispatch stage to all 50 trucks and drivers of PLG's fleet; the trucks then follow this plan for that day, and expected significant reductions of miles traveled, time spent, and fuel usage, are achieved.

Table 1. FRATIS Drayage Optimization Approach Summary of Constraints and Outputs

LA-Gateway FRATIS Optimization Constraints	LA-Gateway FRATIS Optimization Outputs

• 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
• PierPass hours of operation
• Special requirements (e.g., Hazmat)
	• Optimum plan for the day for the fleet by truck/driver
	• Daily miles driven
	• Total miles driven
	  – Total miles driven per truck
	  – Total bobtail miles driven
	  – Estimated time of arrival
	• Order status and estimated order end time per truck/driver
	• Total estimated driving time and stop time
	• Driving hours, idle time, and standstill per driver

(Source: Productivity Apex Inc.)

The primary hardware component that was utilized and tested was the TomTom in-vehicle tracking, traveler information and information exchange system. As detailed in figure 2, this consisted of two primary hardware components—the TomTom Pro 7150 GPS and the TomTom Link 510. These two TomTom devices were installed across all of the 50 trucks at PLG. This deployment required the installation of TomTom truck-specific communication and navigation hardware on the participating fleet to enable drayage optimization and two-way communications between drivers and dispatch. All PLG-related testing data/metrics were captured for use by the IA Team via the TomTom fleet management suite.

- Track Fleet 10sec/1min (GPS)
- Trace Fleet (GPS)
- 2-Way Communication with Back Office (GSM)
- 2-Way Communication with GPS unit (Bluetooth)
- Driving Behavior (IO cable)
- Driving and Idling time (IO cable)
- Ignition events (Power cable)

- Truck Navigation (GPS)
- Dynamic Routing Type 1
- 2-Way Communication with Link 510 (Bluetooth)
- 2 Way Text Messaging (Bluetooth)
- Work Menu
- IQ Traffic
- Weather
- Speed Cameras

Figure 2. TomTom Link 510 tracking/communications and Pro 7150 navigation
(Source: Productivity Apex Inc.)

The remaining critical technology element of the LA-Gateway FRATIS program was the web service-enabled communications exchange capability that was set up to allow for automated communication between PLG and Yusen Terminal. This included the provision of enabling automated ETA messaging to the terminals one day in advance of truck arrivals. This was accomplished via a web service linked to the FRATIS Drayage Optimization Algorithm and the TomTom navigation/messaging devices on the PLG trucks. A creative element of the system design here involved developing a specialized API that could communicate with Yusen Terminal's Navis-based terminal operations system.

Other supporting technologies that were utilized during the demonstration test included: advanced traveler information (Nokia applications), and port terminal truck queue time measurement, including detailed internal terminal queues (from Acyclica Wi-Fi sensors).

Figure 3 below presents a full process view of the steps involved in the use of the LA-Gateway FRATIS system by PLG dispatching staff, and including information exchange with YTI terminal. Here, The Drayage Optimization Algorithm was deployed with a customized web-based PLG interface to allow dispatchers to provide detailed specific inputs to the algorithm application on a daily basis. Order data entered by PLG included all data inputs required for the algorithm to run, including shipper and consignee locations, freight actions, stop time, time windows, due date, equipment details, and driver data, such as driving availability based on driver's hours of service. The primary user interfaces for this overall system were the web application for drayage truck dispatchers, a mobile application for drayage truck drivers and messaging/alerts functionality for terminal operators.

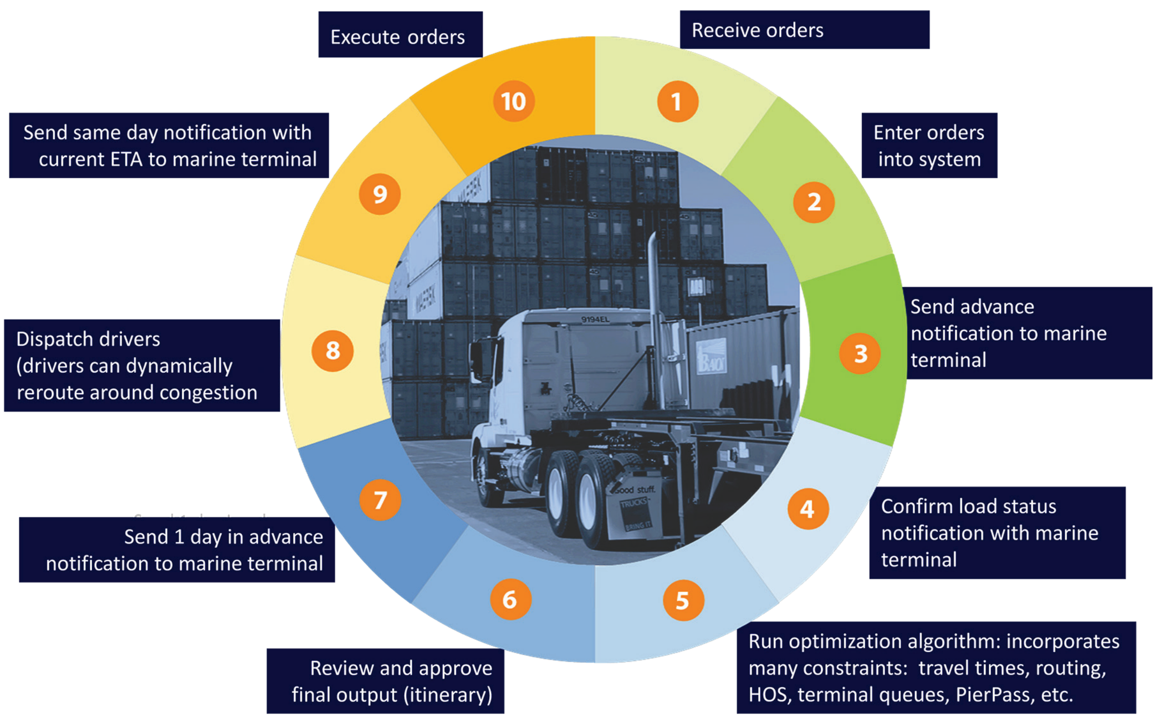

Figure 3. Overview of FRATIS system 10-step process for users
(Source: Susan DeSantis)

The following summarizes key schedule milestones in the development and testing of the LA-Gateway FRATIS:

- Concept Development and Systems Engineering Activities—October 2012 through December 2013.
- LA baseline data collection began September 2013:
  - Included the installation on 50 trucks of the TomTom in-vehicle devices.
- FRATIS software installed at PLG during January-February 2014.
- Test data collection began in March 2014 (provided to IA Team regularly as required).
- Marine terminal communications system activated in August 2014.
- Independent evaluation of data ongoing by IA Team (Ken Troup).
- Testing to conclude on February 13, 2015.

3.0 Stakeholder Involvement Summary and Lessons Learned

3.1 Demonstration Participants and Roles

The key participants in the LA-Gateway FRATIS demonstration test are summarized below. Of note here, key FHWA staff, including Mr. Edward Fok (current U.S. DOT FRATIS Technical Manager) and Mr. Randy Butler (former U.S. DOT FRATIS Technical Manager), were also involved as key Federal-level stakeholders in this effort.

Intermodal Freight Industry Test Participants

- **Port Logistics Group (PLG)** is a 50-truck drayage firm in Rancho Dominguez serving the Ports of Los Angeles and Long Beach. PLG agreed to deploy both equipment and software for the FRATIS project, which allowed for the full testing of the FRATIS drayage applications, including deployment of TomToms on its entire fleet, and daily implementation of the Drayage Optimization Algorithm. PLG moves about 25,000 containers annually and was the primary test fleet for the FRATIS deployment. PLG has eight facilities in the Los Angeles region, that serve both ports, with three million square feet of space and a complete range of services, including drayage, transloading, cross-docking, warehousing, distribution, and 3PL services. Mike Johnson, the lead at PLG that supported the FRATIS prototype testing program, has been a leader in working with the U.S. DOT, LA Metro, and the Gateway Cities COG in advancing the FRATIS and related ITS efforts; Mr. Johnson also is president of the Harbor Trucking Association.
- **Yusen Terminals Inc. (YTI)** is a major marine terminal operator (MTO) at the Port of Los Angeles, which agreed to deploy a queue measurement system for FRATIS, as well as two-way communications between YTI and PLG. YTI operates a state-of-the-art 185-acre terminal on Terminal Island at the Port of Los Angeles which handles 1,400 containers per week. This intermodal container "grounded/stacked operations" terminal includes four Super Post-Panamax cranes, four Post-Panamax cranes, and two Panamax cranes. The facilities include a 22,000-square-foot administration/in-gate building, a 24,000-square-foot maintenance and repair building with 10 bays, a 5,000-square-foot marine building, 1,200 wheeled slots (including 500 reefer plugs), 16 entry lanes with 6 scales, 7 exit lanes, and a near-dock rail facility. Doug Hansen, the YTI lead for the FRATIS test, has been involved in major recent regional developments to improve the communications and information exchange between marine terminals and drayage fleets, and has been a leader in working with the U.S. DOT, LA Metro, and the Gateway Cities COG in advancing the FRATIS and related ITS efforts.

Public-Sector Test Participants/Stakeholders

- **LA Metro** was the public-sector test partner which was interested in examining FRATIS data outputs to potentially help plan for infrastructure improvements in the region to facilitate movement; LA Metro is the major regional transportation agency that funds the Los Angeles freeway network infrastructure.
- **Gateway Cities Council of Governments** is a key public-sector sub-MPO (covering the port region and the I-710 freeway, and encompassing two million citizens living in Southeast Los Angeles) stakeholder which developed the Gateway Cities Technology Plan for Goods Movement—this plan laid the institutional groundwork for the LA-Gateway FRATIS test.
- **Port of Los Angeles and Port of Long Beach—**the largest port complex in North America—were both supporters and stakeholder for this project. Port personnel have been working closely with U.S. DOT and YTI concerning potential deployments of FRATIS and related ITS in the region.

Development Team Participants and Vendors

- **Cambridge Systematics, Inc.** was the prototype demonstration contractor lead, responsible for overall task management and project coordination and ensuring that all data requirements to facilitate the impacts assessment were met.
- **Productivity Apex Inc.** was the software development and systems engineering lead, responsible for all *agile development*, system implementation, and testing.
- **The University of Washington (UW)** acted as the formal coordinator between the demonstration contractor team and the IA team.
- **TomTom** provided the fleet tracking, fleet management, and in-cab navigation/ communication suite to facilitate drayage optimization, truck dynamic routing, and two-way communications features of FRATIS.
- **Nokia-Navteq** provided traffic data to support the drayage optimization algorithm and traffic reporting features of FRATIS.
- **Acyclica** supplied the queue measurement technology deployed at YTI.

3.2 Stakeholder Involvement Lessons Learned

A critical component of any pilot program is identifying and documenting the key lessons learned during the project. The purpose of this is two-fold; first, it helps provide the project sponsor with a comprehensive understanding of the results of the pilot program as identifying opportunities, successes, challenges, and roadblocks is a primary objective of pilot programs; second, and most importantly, understanding these opportunities and challenges helps provide the insight needed to positively impact future deployments and related follow-on efforts. As such, the project team documented key lessons learned, actions, and mitigation strategies throughout the life of the project in order to ensure successful completion of the pilot program and to help ensure the success of follow-on efforts. The following section describes the key lessons learned that are related to the LA-Gateway FRATIS stakeholder involvement activities.

(1) Early and consistent involvement of public and private freight stakeholders is key to the success of Freight ITS test programs

A major success factor in the LA-Gateway FRATIS program was the significant background work in developing stakeholders and partners well before the FRATIS small-scale testing program RFP was released by U.S. DOT. These early activities include the involvement of Los Angeles and Gateway Cities regional stakeholders in the preceding U.S. DOT FRATIS Concept of Operations effort, which in parallel, was conducted in the same timeframe with the same consultant (Cambridge Systematics, Inc.) that was developing the Gateway Cities Technology Plan for Goods Movement. This Plan created a wide ranging program to apply technologies to improve goods movement in the Gateway Cities and the larger Los Angeles County region. Moreover, this project dramatically succeeded in bringing together public transportation and private-sector freight and logistics firms into an "ITS Working Group"—this group has acted as a localized steering group that has been instrumental in ensuring success for both the Gateway Cities ITS and FRATIS projects. A key aspect of these two projects was the development of drayage industry surveys, focus groups, and multiple visits to marine terminals, trucking companies and other private-sector entities.

In summary, as compared to many ITS tests conducted since the inception of the program in the 1990s, the combined FRATIS ConOps/Gateway Cities Technology Plan for Goods Movement projects, allowed for an unprecedented level of repeated outreach and partnership-building activities for the future LA-Gateway FRATIS program in this region. Thus, when U.S. DOT released the FRATIS Small-Scale Testing RFP, stakeholders, partners and potential system users had already been identified, and a public-private support group—the ITS Working Group—had over a year of momentum built up to support this LA-Gateway FRATIS demonstration program.

(2) Leveraging innovation to improve the relationship between the port trucking community and the port terminals community

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 (see above), 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.

The earlier planning activities and subsequent FRATIS test program highlighted a new paradigm of information sharing which could benefit all parties. It was understood, that if the FRATIS Marine Terminal-to-Drayage Company Communications Interface were deployed on a large scale, and supported by all parties (including shippers), that it would have the potential to radically improved port terminal and trucking efficiencies. Moreover, this FRATIS element highlighted a future vision of a Dynamic Appointment System—a system which could provide for "automated handshakes" between trucking companies and terminals that would result in agreement by both sides on the best time for a truck to access a terminal to pick up or deliver a container—this approach has the potential to spread out truck traffic throughout shifts, and substantially improve truck movement and terminal efficiency, resulting in both private-sector efficiency benefits, and corresponding public-sector benefits, for congestion reduction and air quality improvements.

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.

(3) Identifying stakeholders that see the value in innovation as a means to improve their operations is critical to maximizing the benefits of a deployment

Identifying stakeholders that see the value in innovation, are invested in improving the operating environment, have efficient and effective management systems in place, and understand the potential benefits of increased integration with other stakeholders are critical to the success not just of future FRATIS deployments, but of any pilot programs relying on increased connectivity and communication. The concept of leveraging new technology to share specific order information between stakeholders in real-time and optimize and coordinate plans amongst stakeholders can create concerns related to technology integration, proprietary data and information, and a general sense of some loss of control.

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.

During the course of the project, the team was able to develop a new capability to automate communication between the drayage operators and marine terminals relative to expected arrival and pickup times. The most effective way to leverage this information and positively impact wait times at the marine terminals would be to use this information to influence operations within the terminal to better plan not only their resources but the placement of their containers in a way that expedites the process of serving drivers. This would also apply to other types of intermodal facilities like railroads, which could share with drayage companies the status of the inbound containers, and take advantage of the advance notification in order to better plan their resources and their container allocation.

(4) Backdrop—the real-world port environment and how it impacted the FRATIS pilot project

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.

In terms of specific LA-Gateway FRATIS test partners, Mike Johnson at PLG reported losing tens of thousands of dollars weekly due to the chassis shortage and these congestion related issues—and for the PLG Dispatch Team, the larger volume of TEUs[2] coming into the ports also increased overall workload, which caused the team to continually fall behind and play catch-up. Additionally, for FRATIS test partner Yusen Terminal, a major business change occurred during this same timeframe as their parent company joined the new G6 Alliance of terminals/shipping lines, resulting in new business procedures, higher volumes, and more drayage companies doing business with the terminal.

These factors severely limited the use of the FRATIS Drayage Optimization Algorithm during the fall of 2014. With the PLG dispatchers forced to make changes to their "daily plan" on, in many cases, an hourly basis, this rendered the FRATIS-recommended plan for that day as "dead-on-arrival."

The above discussion points to two key qualitative findings that should be considered in future FRATIS-like testing programs. First, 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. In retrospect, for this FRATIS test, if the testing program requirements and schedule constraints could have been made more flexible, a three-month "time-out" could have been implemented for the September to December 2014 period, which would have given PLG and Yusen Terminals some time to regroup, while also saving valuable Demonstration Team resources that could have been used to extend the test later on.

Secondly, these factors illustrate the obvious conclusion that 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.

(5) PLG use of TomTom device

TomTom WebFleet is an online application used as part of FRATIS that enables managing a trucking fleet from PC, and was used by Port Logistics Group to track the information flows between dispatchers and drivers, through the FRATIS Dispatch System (FDS) tools and TomTom vehicle devices. Weekly reports summarized TomTom WebFleet records to identify potential trends and issues on the use of WebFleet by Port Logistics Group (PLG) dispatchers and drivers. WebFleet can generate many types of reports for a selected time period. Through monitoring reports, we were able to determine how many dispatchers were using the TomTom device to dispatch a job to a driver, and how many drivers were using the TomTom device to accept and complete jobs (finished job actions).

[2] A TEU represents the "twenty-foot equivalent unit" measurement of container ship capacity. For example, a 10,000 TEU ship can hold 10,000 20-foot containers, or 5,000 40-foot containers.

It was clear from our test data that there was a correlation between the level of dispatch actions and driver use of the TomTom device. The data analyzed during the Demonstration Project indicated that the PLG nighttime dispatcher was effectively using the system to dispatch jobs. Consequently, there was a higher level of participation by drivers on the nighttime shift than the daytime shift. When dispatch actions declined, the total driver assignment and finished job also dropped off.

The above illustrate that how a change in culture and mindset is a critical success factor in promoting system use by stakeholders. For the LA-Gateway FRATIS, dispatchers are the most important user/stakeholder in the FRATIS system process. If they are not on board, then the Demonstration Project cannot succeed. The skill level and mind set of the dispatcher, and his/her comfort level in adapting technology to do their job more efficiently and effectively is key. It is a matter of changing the culture of how the job gets done… it starts with the dispatcher using the FRATIS system to plan the day's dispatches based on the Optimization Plan and then actually dispatching the job using the technology (TomTom device). That sets the stage for the driver to use the technology to accept the assignment and communication more efficiently with the dispatcher.

For FRATIS-like programs in the future that involve trucking companies, steps need to be taken to encourage dispatchers and drivers to use the system more actively. Key elements include using change management techniques, providing training to dispatchers, providing training and rewards to drivers, and setting up demonstration of the process to both dispatchers and drivers to show how using the system can benefit them, in terms of time saving on phone calling and higher efficiency. Moreover, it is also important that the trucking company and marine terminal have good management systems in place.

(6) Limited implementation of solutions versus portwide applications

In the Demonstration Team's proposal to U.S. DOT for the LA-Gateway FRATIS, the team recommended—based on the development of user needs and stakeholder involvement in region in the prior 1.5 years—that this FRATIS site should primarily focus on what the users desired—the Marine Terminal-to-Drayage Company Communications Interface.

However, following project initiation, direction was provided to the three FRATIS sites that the predominate 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.

Additionally, the unavoidable nature of this being a small-scale test exacerbated this issue. With a trucking company with 50 trucks, and one marine terminal involved, the number of visits between PLG and Yusen terminals per week was very low—and this led to an understandable lack of use and interest by the test partners in testing this element, especially during the port congestion crisis in fall 2014. More specifically, the dispatchers were not inclined to change their mode of operations because the Yusen Terminal dispatches represented only a small percentage of the overall jobs. On the marine terminal side, Yusen Terminals was not inclined to change how it did business and how it managed its yard operations because the number of PLG dispatch jobs represented a very small proportion of its overall business.

Two qualitative findings here come to the surface. First, more flexibility in testing programs need 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.

Secondly, Demonstration Teams need to be more creative in how they design tests and involve stakeholders, so as to avoid situations where the volume of interactions between two test participants does not meet a minimum standard of success. More specifically, there here needs to be a large enough volume of business between the trucking company and the marine terminal to support testing of this element. For the next phases of FRATIS in the LA-Gateway region, significant effort should be put in at the front end to pairing up the trucking and marine terminal partners with enough business to warrant investment in changing the way business is done.

(7) Improve test planning to deploy technology at the right time and in the right place to promote stakeholder acceptance

During the Demonstration project, the stakeholder engagement activities and the technology deployment efforts were carried out in parallel. The appeal of the LA-Gateway FRATIS System for the dispatchers and the drivers was the promise to cut down on waiting times at gate queues, and increase the number of daily truck trips. The stakeholder engagement efforts were directed at collecting information from drivers, dispatchers, and other key stakeholders with regards to the issues and potential strategies to help achieve this objective. In parallel with these engagement efforts, the team also began introducing the TomTom device to the PLG drivers; this proved to be premature. Feedback from the stakeholder engagement efforts drove a number of changes to the technology enhancement and deployment plan and ultimately impacted the level of commitment from the drayage operator.

The lesson learned here is that the various component parts of the Demonstration Project need to be timed and sequenced so that all the parts come together at the right time, and no components are implemented prematurely. There also needs to be a clear understanding at the front end of the project on the part of the participating partners as to their roles and responsibilities, and expected outcomes. For future FRATIS and similar programs, stakeholder confidence building actions such as these need to be implemented order to succeed and get buy-in from the dispatchers and drivers.

4.0 System Testing Summary and Lessons Learned

4.1 System Testing Summary

Development of the LA-Gateway FRATIS included a comprehensive process to develop specific user needs, map those needs to system requirements, and then to develop the software solutions (and hardware integration) that delivered on the promise to meet the user needs. To facilitate this process, Cambridge Systematics and Productivity Apex staff implemented a comprehensive *Agile Process* for system development. A key feature of this process was the involvement of key user groups—including PLG, Yusen Terminals and LA Metro staff—at key phases in the system development process. Readers that may be interested more in the details of this process are referred to the following documentation:

- **Los Angeles-Gateway Freight Advanced Traveler Information System: Final System Design and Architecture,** May 23, 2013, FHWA-JPO-14-179 (http://ntl.bts.gov/lib/54000/54400/54477/Fratis_FHWA-JPO-14-179.pdf). This document provides the technical specification for the system the architecture of the LA-Gateway FRATIS system.

Additionally, all LA-Gateway FRATIS software developed for the small-scale test, including the Optimization Algorithm, has been uploaded to the U.S. DOT's Open Source Applications Development Portal, and can be accessed directly at:

- http://www.itsforge.net.

As detailed previously, the LA-Gateway FRATIS system incorporated three main elements, the optimization algorithm, the TomTom in-vehicle devices, and the communications system between PLG and Yusen terminal. As highlighted below in figure 4, these and other components were connected in an overall system that employed a back office which provided a cloud connection between PLG and FRATIS application, use of cellular communication for bidirectional communication with the in-vehicle TomTom devices, and a web service which supported the communications system with Yusen terminal's Navis terminal operations system.

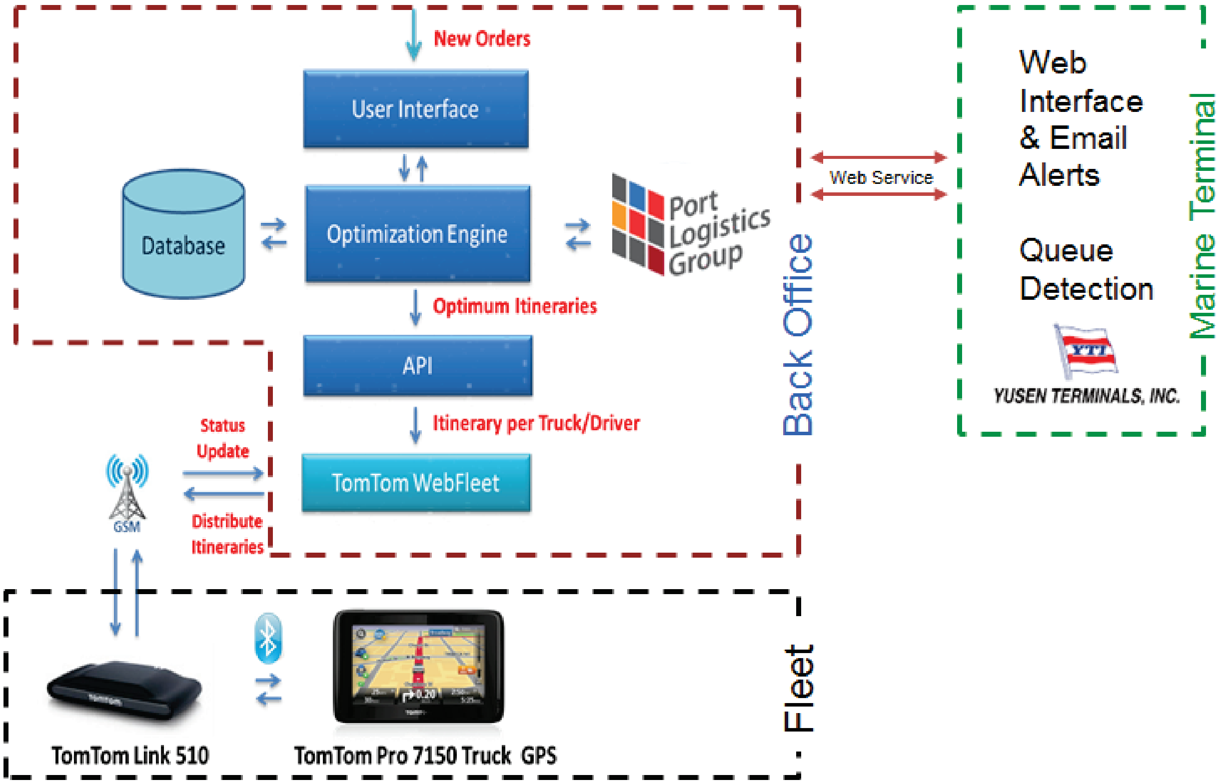

Figure 4. FRATIS system overview
(Source: Productivity Apex Inc.)

Table 2 below provides a summary of the focus of which elements of FRATIS were tested, and relates these to the expected benefits hypotheses that were developed early on based on user needs and expected benefits to the users. The IA Team is currently assessing the results of the LA-Gateway FRATIS in relation to these hypotheses, and it is expected the U.S. DOT will publish the IA Team's evaluation final report later this year.

Table 2. Test Hypotheses

System	Elements	Test Hypotheses
Drayage Optimization	• Order Entry—simple Excel spreadsheet to be populated manually. • Optimization algorithm—Runs through the spreadsheet and provides a daily plan that will maximize productive moves and minimize nonproductive ones, accounting for historical traffic and terminal waiting times. • Dispatch—PLG dispatchers can accept or reject algorithm-recommended moves based on business needs; they will communicate instructions as they do now or using TomTom devices.	• The drayage optimization algorithm will provide an optimized plan for the day's moves that will accomplish all required moves in the most efficient manner possible, accounting for the business constraints—this will result in reduced miles traveled, reduced trips, fewer bobtails, less bobtail miles, and corresponding reductions in emissions.
Freight Traveler Information Dissemination	• Traveler information Web site 'one-stop shop' with real-time route and marine terminal operators (MTO) information for dispatchers and drivers. • Dynamic route guidance for drivers—routing, including real-time truck-friendly dynamic routing. • Public-sector freight performance monitoring—Web site with freight movement data compiled throughout the test.	• Truck drivers will use dynamic route guidance feature to route around congestion, saving travel time and potentially reducing emissions. • Public agencies will use data generated by FRATIS to assist in freight planning and investment decisionmaking.
Drayage-to-Marine Terminal Operators Communications	• Dray advance estimated time of arrival notification messages to the marine terminal operators. • Dray 10-minute en route real-time advance notification message to marine terminal operators. • Marine terminal operators queue time information and alerts to dray dispatcher. • Marine terminal operators general messaging and alerts communication to drayage companies while trucks are in terminal.[1] • A basic web interface for drayage dispatcher, and either a web interface or an email-driven solution for the marine terminal operator.	• This system will develop an effective communications linkage between the drayage dispatchers and the Yusen terminal operators at the port. • PLG dispatchers will use the predictive queue-time information to avoid sending trucks to YTI during the most congested times of the day, resulting in shorter overall turn times for participating trucks. • MTO operations staff will use dray approach advance notification features to better plan labor and equipment orders, and container stacking in the yard (proof of concept only).

(Source: Cambridge Systematics, Inc.)

[1] Due to liability concerns, both YTI and PLG determined at the start of testing that they did not want to have direct communications between MTO staff and truck drivers.

4.2 System Testing Lessons Learned

A critical component of any pilot program is identifying and documenting the key lessons learned during the project. The purpose of this is two-fold; first, it helps provide the project sponsor with a comprehensive understanding of the results of the pilot program as identifying opportunities, successes, challenges, and roadblocks is a primary objective of pilot programs; second, and most importantly, understanding these opportunities and challenges helps provide the insight needed to positively impact future deployments and related follow-on efforts. As such, the project team documented key lessons learned, actions, and mitigation strategies throughout the life of the project in order to ensure successful completion of the pilot program and to help ensure the success of follow-on efforts. The following section describes the key lessons learned that are related to the LA-Gateway FRATIS system testing program.

(1) The FRATIS system should allow for integration with drayage operator order management systems

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.

For the pilot program, the team was able to develop a work-around solution that automatically duplicated the existing orders. This significantly reduced the amount of time required to prepare the necessary FRATIS data and reduced the likelihood of order entry errors. In order to fully resolve this issue, integration between the FRATIS system and the drayage company's order management system would provide the best-fit solution. It would be possible in future efforts to utilize web services to fully automate the process and ensure that all relevant order data is exported to FRATIS from the DO order management system.

(2) The FRATIS system should provide automated communication with multiple stakeholders within the network

During the deployment with PLG, the team managed to successfully communicate with Yusen Marine Terminal (YTI), which supported opportunities for the Marine Terminal, from better planning of their resources, to strategic placement and allocation of their containers and equipment based on planned upcoming visits. This process change was significant given that one of the primary concerns for drayage operators was effective planning of marine terminal pickups based on wait times and container availability. Prior to the deployment of the FRATIS system, PLG staff could check the status of containers on Web sites and make calls to see which containers have been made available and ready for pick up at a terminal.

However, this approach placed additional burden on the back office staff and did not provide real-time updates in the event of changes to status, traffic, wait times, etc. This issue highlights the need for automated, real-time communication not just within individual stakeholder organizations but throughout the entire transportation network. Opportunities for efficiency and productivity gains increase as communication and integration between stakeholders increases.

Moreover, the most effective way to leverage this information exchange and positively impact wait times at the marine terminals would be to use this information to influence operations within the terminal to better plan not only their resources but the placement of their containers in a way that expedites the process of serving drivers. This would also apply to other types of intermodal facilities like railroads, which could share with drayage companies the status of the inbound containers, and take advantage of the advance notification in order to better plan their resources and their container allocation.

(3) Effective and targeted user training and retraining during the testing period is critical to success

During the course of the pilot program, the team encountered some initial resistance to technology adoption amongst the participating dispatchers and drivers. Some drivers were reluctant to use the on-board device which in turn generated problems for the system as the status of the orders in the system were not being updated consistently by some drivers. Using the on-board devices is critical for the proper deployment and functioning of FRATIS given that the real-time status of an order and a driver depends on the input on that device. This helped illuminate the need for training and buy-in from both the drayage operators, dispatchers, and the individual drivers (particularly in owner-operator situations).

During the pilot program the team designed and supported several group training sessions with drivers to increase the comfort level and buy-in. Anecdotal evidence showed that drivers who received up front training and used the system for a few days at the beginning were most likely to keep using it in the long term, as it reduced the learning curve and allowed the drivers to realize the benefits of the system, particularly the real-time traffic information and the dynamic routing. Expanded deployments should build on this lesson and provide dispatchers and drivers with more interactive training materials and increased “on-demand” support materials to address questions/concerns.

(4) Preexisting driver preferences and routines can be difficult to change

Optimization techniques are most effective when a true “global” optimum solution can be found that addresses all of the necessary moves in the most efficient and effective ways possible for all of the key stakeholders. The potential solution set becomes more limited as additional constraints are added. Many of these constraints are necessary and address the rules of regulations of the drayage operators, the marine terminals, or public regulatory agencies.

During the course of the project, the team encountered dispatchers and drivers who resisted certain types of orders or moves that deviated from their established routine. There were instances of drivers (particularly owner-operators) rejecting plans generated by the optimization algorithm because they are not accustomed to executing certain types of orders (e.g., new customers, different location, etc.). Neither were the dispatchers inclined to move away from the status quo of how they have done business for the past 25 years (reactive mode), to this new proactive planning approach using the optimization algorithm to plan and dispatch the day’s jobs.

These issues place additional (and often unnecessary) constraints on the system, further limits the solution space, and potentially reduces the overall benefit of the FRATIS-generated plans. This challenge demonstrates that for future FRATIS programs, there is a need to identify participants that are part of the fleet for a drayage operator or owner-operators that are open to new technology adoption, are less resistant to change, and are invested in improving their operations.

(5) Generating a plan provides great value despite the dynamic nature of the operations

The team found that the planning process provides great value, not only because it generates an efficient and effective baseline to start with and follow, but also because it creates a sense of responsibility among the parties to commit to something that was methodically composed for everybody's benefit. However, some skepticism amongst the dispatchers was found on the value of generating plans the day prior to or day of operations, knowing that the plan will need to change during execution to react to the inevitable uncertainty due to factors like stop time at container pickup/dropoff, order availability, empty container readiness, waiting time at gate queues, traffic conditions, road closures, accidents, etc.

It is also important to highlight that 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. Second, as was mentioned in Lesson Learned #2 above, as more parties get connected to the system and start sharing information regarding waiting times, equipment availability, appointment changes, etc., the more accurate the plan output will be.

(6) Identifying the right test user group is critical to maximizing the benefits of a deployment

Identifying test user groups that see the value in innovation, are invested in improving the operating environment, have efficient and effective management systems in place and understand the potential benefits of increased integration with other stakeholders are critical to the success not just of future FRATIS deployments but of any pilot programs relying on increased connectivity and communication.

The concept of leveraging new technology to share specific order information between stakeholders in real time and optimize and coordinate plans amongst stakeholders can create concerns related to technology integration, proprietary data and information, and a general sense of some loss of control. 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.

(7) The flexibility to adjust in real time to handle the dynamic nature of freight operations is key

As covered from a stakeholder perspective in Lesson Learned #4 in section 3.0, this pilot program proved that in order for the FRATIS system to be usable, and to provide the greatest value to drayage operators, marine terminals, and other key stakeholders, future versions of the

FRATIS optimization solution must be flexible enough to change and reoptimize the generated plans throughout the day as conditions change due to new orders, changing traffic conditions, driver incidents, etc.

(8) The U.S. DOT's new focus on Agile Development and the provision of Open Source Applications Development Portal provided value to the Demonstration Team

Application of *Agile Development* processes in the LA-Gateway FRATIS system and software development effort provided significant value to the Demonstration Team. The primary benefit of this process was to institutionalize user involvement in the FRATIS design and development activities—it created a process that resulted in a system that was more easily accepted by users, since test users had several opportunities to provide feedback during the process.

Additionally, the U.S. DOT provision of the new Open Source Applications Development Portal provided a systematic and convenient way for the Demonstration Team to upload the LA-Gateway FRATIS software that was developed during this project. In fact, the LA-Gateway FRATIS software is one of the first Dynamic Mobility Applications application bundles to be included in this portal. This portal can support the ability of other regions and partnerships to being to deploy FRATIS systems, and is key to U.S. DOT's Connected Vehicle adoption strategy for Dynamic Mobility Applications.

(9) Guidance for different types and sizes of FRATIS deployments

While estimates of the scalability of FRATIS will be covered in the IA Team's final report, based on the Demonstration Team's conduct of this small-scale test, the following qualitative guidance may be useful in planning future FRATIS deployments:

- This FRATIS test was sized for a medium-sized trucking company of 50 vehicles. Like most trucking companies of this size, PLG had a relatively modern order/dispatching back office system, which staff used to develop and modify the daily plan of pickups and deliveries (using PLG's fleet of trucks) of intermodal containers at the port terminals. To deploy the current version of FRATIS with PLG, data initially had to be manually imported from the PLG system to FRATIS; later in the test this was automated, but it took nearly a year and required additional resources to implement. Part of the problem here was the necessity to integrate the TomTom back office and in-vehicle hardware/software information with PLG's ordering system. A key lesson learned here, which has been reinforced by the FRATIS South Florida test, is that future versions of FRATIS need to: (1) have a much more flexible software approach that can be more easily integrated into dispatcher operations; and (2) be designed with an architecture that is hardware independent, and not tied to specific vendor systems such as TomTom. In fact, Productivity Apex is currently testing a "Version 2 FRATIS," which is based on these attributes, and which uses a standard tablet-based application interface. This simplified FRATIS approach should also be more applicable to smaller trucking companies/fleets.
- An open question that has not been answered yet is what level of FRATIS saturation (i.e., percentage of trucks in a port region) would be necessary for major system-wide benefits to occur. One way of looking at this would be to

examine the intermodal industry practice of using the port terminals as virtual warehouses for up to four days – current rules allow for four days free storage of a container in a terminal yard. In this business environment, most retailers/shippers/owners wait until the fourth and final day to submit an order for the trucking company to pick up the container. A future version of FRATIS could provide transparency to all parties, and could be used to provide mutually agreed upon appointments for pickups of containers across the four days. This would spread out truck trips associated with ship arrivals at the port, thereby reducing peak congestion issues and providing significant improvements in truck trip efficiency. In this case, perhaps even if only one-third of the trucks were using FRATIS, this could result in measurable efficiency benefits associated with reductions in peak truck congestion at and near the terminals.

5.0 Recommendations for Future FRATIS and Freight DMA Programs

Based on the lessons learned developed in this report, the following six recommendations are provided to U.S. DOT and regional public-private partnerships that are interested in developing, testing and deploying future FRATIS and Freight Connected Vehicle applications:

1. The Los Angeles-Gateway Cities region provides: (1) a set of highly motivated public and private-sector freight stakeholders that is now experienced in working with the U.S. DOT for over four years; (2) economies of scale related to intermodal freight movements and massive sets of vehicles and infrastructure/facilities; and (3) and has huge issues related to mobility inefficiencies and air quality problems that warrant application of FRATIS. This region remains the predominate choice for testing FRATIS—the Demonstration Team commends U.S. DOT for its recent decision to fund new FRATIS applications in this region, and it is recommended that this region be one of the primary FRATIS Connected Vehicle test bed for the Nation.
2. The LA-Gateway FRATIS project highlighted the importance of both early and consistent stakeholder engagement, especially when involvement in testing needs to include private-sector intermodal freight interests such as drayage trucking firms and marine terminal operators. Future FRATIS-like programs should either include substantial time for recruitment before the U.S. DOT proceeds with a testing program; or the U.S. DOT should target testing programs in regions where mature freight public-private partnerships already exist.
3. The Demonstration Team experience in conducting testing of the LA-Gateway FRATIS system showed how important it is to continuously retrain and reenergize test participants—particularly in the trucking company environment, which can experience high staff turnover in dispatcher staff. Future FRATIS-like programs should substantially increase the planned resources for continuous training of test users, and it is recommended that the U.S. DOT address this in future scopes that encompass freight connected vehicle technologies involving private-sector fleet and/or supply chain participants.
4. To improve both the trucking company experience with FRATIS, as well as to promote adoption of FRATIS, future FRATIS deployments need to move to a more flexible software-based version of FRATIS (i.e., versus the TomTom hardware-based solution in this test program). For example, 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. Future efforts should focus on more flexible software and integration approaches, and utilize web services, API connectivity and mobile applications for the next generation of FRATIS—the FRATIS approach needs to eventually become independent from both the back office and dispatcher-to-truck

communications platforms that trucking companies use today. Additionally, future FRATIS application of the Drayage Optimization Algorithm must be more flexible to allow for the Daily Plan to be modified by drayage dispatchers, in real time, across a given day in response to changing operational conditions and external events.

5. For future efforts that involve testing the FRATIS component on communications between trucking companies and marine terminal operators, three key recommendations are offered. First, is it important to select testing partners that that are open to new technology adoption, are less resistant to change (especially in dispatcher operations), and are invested in improving their operations. Secondly, on the marine terminal side, bringing in both Beneficial Cargo Owners (BCO) and shipping lines, would allow for the marine terminal operators to make more operational changes, which could improve both their operations, as well as the drayage fleets serving them. Finally, to achieve success in testing, participants must be selected such that there is a substantial daily number of trucks from the participating drayage firm that access the participating marine terminal—in other words, there needs to be enough traffic by trucks using the FRATIS "dynamic appointments" so that the marine terminal operations staff will have the incentive to change their operations and become more efficient.

6. It is recommended that additional flexibility be provided by U.S. DOT to future FRATIS deployers in two key areas. First, it is important that the priority needs of the freight partnership in a given region take precedent over testing program directives to have commonality across sites—the LA-Gateway region FRATIS stakeholders would have preferred to have the Marine Terminal-to-Drayage Company Communications Interface be the primary focus of the project (i.e., versus the Drayage Optimization Algorithm). Secondly, given the volatile nature of the port operations environment across U.S. seaports, flexibility needs to be provided to temporarily suspend testing during periods of severe port operations issues, such as was the case during the fall 2014 chassis and drayage crisis at the ports of Los Angeles and Long Beach—testing periods for intermodal freight ITS projects could potentially include several months of "schedule reserve" time that could applied in response to such situations.

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