FREIGHT EFFICIENCY STRATEGIES: INFORMATION TECHNOLOGY

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A White Paper from the Freight Efficiency Strategies Development Group

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About the Freight Efficiency Strategies Development Group

In July 2015, Governor Jerry Brown issued Executive Order B-32-15, directing several state agencies to work together in developing an integrated action plan that will "establish clear targets to improve freight efficiency, transition to zero-emission technologies, and increase competitiveness of California's freight system" and that the plan should "identify state policies, programs, and investments to achieve these targets". In response, an interagency group was formed to oversee the development of the California Sustainable Freight Action Plan (CSFAP). Members of the interagency group include the California Air Resources Board, the California Department of Transportation (Caltrans), the California Energy Commission (CEC), and the Governor's Office of Business and Economic Development (GO-Biz). As part of developing the plan, the interagency group has solicited feedback from a broad range of stakeholders through a variety of engagement activities and outreach efforts. A component of this engagement was the development of the Freight Efficiency Strategies Development Group (FESDG) made up of freight experts from academia, industry, and government. The purpose and main task of this group was to produce a series of white papers that identify promising strategies for increasing the efficiency of the freight system. A series of six papers were developed over the course of six months. Each paper focuses on a specific theme for increasing freight efficiency within the larger freight system.

About the National Center for Sustainable Transportation

The National Center for Sustainable Transportation is a consortium of leading universities committed to advancing an environmentally sustainable transportation system through cutting-edge research, direct policy engagement, and education of our future leaders. Consortium members include: University of California, Davis; University of California, Riverside; University of Southern California; California State University, Long Beach; Georgia Institute of Technology; and University of Vermont. More information can be found at: ncst.ucdavis.edu.

Disclaimer

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ABSTRACT

This White Paper presents recommendations for using information technology solutions to increase the efficiency of California's multimodal freight system. These recommendations resulted from a consensus based process by working group committee members. We address two problems: information problems in the goods movement supply chain, and information problems in statewide trucking. Regarding the goods movement supply chain, we recommend the following strategies: 1) accelerate and expand the FRATIS program; 2) implement ports-wide appointment systems at the state's major ports; 3) develop and implement a transparent supply chain wide load tracking system. Regarding statewide trucking, we recommend the following strategies: 4) statewide smart parking system; 5) "push" freight information system; 6) statewide freight information platform; 7) border region ITS strategy; and 8) freight focused traffic management.

INTRODUCTION

This White Paper presents recommendations for using information technology solutions to increase the efficiency of California's multimodal freight system. We follow the Efficiency Strategies Development Group (EFDG) scope document, which states:

"This Think Tank will be focused on opportunities for Federal, State and local policies and the private sector to remove system-wide barriers to the efficient movement of freight."

The IT Group framed the problem as one of delay. There can be delay due to 1) congestion on roads or at docks, 2) uncertainty of when a load can be delivered or picked up, where a parking place may be, etc., 3) queuing at weigh stations, borders, or terminal gates, 4) limited time windows for deliveries.

Typically, delays are due to a combination of institutional problems and/or information problems. An example of institutional-driven delay is road congestion. Road traffic demand is high during the day and low at night because most businesses do not operate at night. Local truck traffic is concentrated during daytime hours in part because deliveries are constrained to those hours, either by the businesses themselves or by local regulation. Examples of information problems include the uncertainties associated with when or where a load is ready for pickup or delivery, weight or other restrictions on local roads, or unanticipated road or bridge closures.

There are numerous barriers to reducing delay, some of which cannot be avoided. For example, despite the increased prevalence of flex time for certain employment categories, the typical workday schedule is not going away. Others can be avoided or at least mitigated through policy intervention, as in the example of smart parking systems that reduce the delay associated with finding a space. Our task is to identify barriers that can be addressed, and show how IT can be used to overcome them.

In accordance with the State's goals of increased fuel efficiency and reduced GHG emissions, the IT Group focused on strategies that generate eco-efficiencies: freight system efficiency is improved while environmental benefits are achieved. We have organized our strategies around two themes: 1) Information problems in the goods movement supply chain, and 2) Information problems in statewide trucking.

Theme 1: Information Problems in the Goods Movement Supply Chain

In the goods movement system, a major barrier is the lack of information and managing the flow of information flows across the supply chain. Supply chains are systems, but in most cases there is no system manager. Each part of the supply chain has limited information and/or may not receive information early enough in the process about the other parts, and each actor is optimizing their component independently. Examples abound: terminal operators may not receive information on the incoming cargo sufficiently in advance of the vessel arriving; many BCOs have limited information on when their cargo may be available or may not be aware of where to obtain such information; the trucking community may not receive load information in a timely manner for various reasons, warehouses do not know exactly when the next load will arrive, etc. A system manager would optimize across the entire system, but such management requires information and cooperation.

A second problem is measurement and data. Different parts of the supply chain use different measures For example, "turn time" for a trucker can sometimes include queuing at the gate, but more often only tracks time spent within the terminal. It also does not capture how truck delays impact the marine terminal operator (MTO). It follows that data on 'turn time' will be inconsistent and not comparable across terminals. Even within the same segment of the supply chain, firms may use different information systems that are incompatible, and as firms or public agencies invest in new technologies, they face problems in interfacing with legacy systems.

IT makes it much easier to collect and share information. Various types of sensing devices allow for passive collection of data (e.g. cellphone GPS traces, vehicle GPS traces, tracking of containers via sensors), making the data collection far more efficient. Real-time or near real-time data systems reduce uncertainty about traffic conditions, container location, or border delays. The potential benefits of IT systems compound as data sources and linkages increase (e.g. linking vessel, container, yard and chassis data, as in some of the newer terminal operations systems software), because information problems are typically at the interface of supply chain links.

We are seeing an explosion of proprietary tools to address information problems in the supply chain. From the early days of eModal to the many tools emerging today, there are more and more choices of management tools (e.g. truck assignment and routing software, inventory management systems), and more new tools to solve specific problems (e.g. empty container matching). This proliferation of proprietary tools, mostly focused on specific problems or segments of the supply chain, will continue. IT entrepreneurs have every incentive to create software that is targeted to a specific market and captures the customer.

However, it does not appear that there is an incentive to create the equivalent of "open source" systems, or interoperable systems. Open source could reduce profits, and interoperable systems could in the short run reduce competitive advantage. Nor do system users necessarily wish to share data. Nearly every participant in the supply chain is in intense competition, and some users may be concerned about the regulatory implications of data sharing. Thus, while these tools are increasing efficiency in all sorts of ways, it is not clear that the "system manager" ideal will be achieved simply by "letting the market work."

The IT Group recommends three strategies for generating eco-efficiencies by reducing information problems in the supply chain:

1. Accelerate and expand the FRATIS program

2. Implement a system-wide appointments system at California's major seaport
3. Design a fully transparent tracking system across the supply chain

Theme 2: Information Problems in Statewide Trucking

Given that the states have primary responsibility for the highway system and the interstate commerce that takes place on the system, it seems quite appropriate for the IT Group to examine potential efficiency improvements on the state highway system. Traffic congestion is a major source of delay. Absent major infrastructure investment, there are traffic management solutions, such as signal priority for trucks in heavy truck traffic corridors, or improved real-time information and routing systems. In addition, there are many sources of delay on the highway system, aside from recurrent traffic congestion:

- Weigh stations, inspection processes, permitting
- Limited availability of real-time accident/incident/event data
- Security-related delays at border crossings
- CV parking and facility shortages

IT could play a greater role in all the above problems. California has at least one "virtual weigh station" on I-80; it would be helpful to understand whether it has improved traffic conditions in the corridor, or improved weight compliance, and hence makes a case for broader implementation. There are other issues associated with special permits, and interstate traffic. For example, California is part of PrePass, but Oregon and Washington are not, so interstate truckers need two different permits to bypass weight stations amongst the three states.

In some ways, California is at the leading edge in real-time information, but some parts of the system have better access than others. One of the most advanced FRATIS (Freight Advanced Traveler Information System) demonstrations is taking place in Los Angeles. At the same time, California does not have an advanced freight traveler advisory system. Border crossing delays are a significant impediment to commerce, yet there is currently no program in place that is taking action to reduce these delays. Finally, the issue of truck parking and rest area provision is becoming more important as a result of both constantly increasing truck traffic and restricted hours of service requirements. California has one of the most severe truck parking shortages in the US.

The IT Group recommends five strategies for generating eco-efficiencies by reducing information problems in statewide trucking:

1. Develop and implement a statewide smart parking system and increase the supply of truck parking
2. Develop and implement a "push" freight traffic information system
3. Develop and implement a statewide freight information platform
4. Implement the Border Region ITS Strategy
5. Develop and implement freight priority traffic management in high volume truck corridors

The eight recommended strategies are discussed in the following sections of the White Paper.

ACCELERATE AND EXPAND FRATIS PROGRAM

Statement of the Problem

The Freight Advanced Traveler Information System (FRATIS) has been a successful and promising program for generating eco-efficiencies. Its success has been shown in recent demonstrations, and there will be increasing benefits with a further expansion of the program. According to Butler (2014), the lack of Freight Advanced Traveler Information has negative effects on both economic efficiency and environmental sustainability. The FRATIS Program can produce society-wide benefits including promoting efficient movement of freight transportation, planning of freight daily work activities and logistics management systems. It would also help improve the environment of neighboring communities and safety of the traveling public, as well as reduce energy consumption.

For different freight movement stakeholders, FRATIS can enhance communication, improve efficiencies and reduce costs. It can help trucking companies improve productivity and efficiency of the fleet, empower dispatchers with real-time information for faster and better decisions, generate near optimal trucks itinerary with real time information and provide dispatchers access to real time terminal waiting times and turn-times. With the information system, drivers will be able to navigate to their destinations and be rerouted in case of heavy traffic, incidents and congestion in their current route (Butler, 2014).

FRATIS can help Intermodal Facilities receive pre-notifications containing details for trucks coming to perform transactions in their facilities and real time notifications of trucks heading towards their facilities with estimated time of arrival. The notifications ahead of time would help the facilities reduce waiting time, turn-around time and unproductive pickups/drop-offs by enabling better container turns and reuse. With FRATIS, intermodal facilities are able to communicate directly with dispatchers to notify about terminal closures, incidents, or any other operational status in order to mitigate congestion in their facilities (Butler, 2014).

In terms of public benefits, FRATIS can help promote better transportation planning and policy, and improve air quality by reducing CO_2 emissions and quality of life of the region. It provides a platform to support economic development in the region and contribute to better utilization of existing infrastructure and capacity. With more information about safer routes for trucking operations provided by FRATIS, local communities can effectively protect residents from truck-related accidents (Butler, 2014).

Description of the Strategy

According to Figure 1 below, the FRATIS framework has three components: 1) data collection from different public and private sources, 2) FRATIS IT Toolkit used to pull and integrate data, and 3) FRATIS data application to two basic application bundles and their value added versions. (Jensen et al., 2012).

The FRATIS system integrates data from multiple sources. Overseen by a regional public-private partnership, FRATIS will pull data from various sources using web services and/or application programming interfaces (API). Note that at this early stage, FRATIS is envisioned as a regional/urban system rather than a national one, due to the significant disparities between available ITS and freight data among regions. Data sources include Regional ITS data, truck movement data, intermodal terminal data and the future U.S. Department of Transportation (DOT) Connected Vehicle data (Jensen et al., 2012). Regional ITS data contains real-time freeway/arterial speeds and traffic volumes, incident data, truck parking locations and availability, and route restrictions. Truck movement data is from third parties such as truck speeds and position data from Global Positioning System (GPS) devices in trucks. Intermodal terminal data includes real-time queue lengths and container availability updates. The Future U.S. Department of Transportation (DOT) Connected Vehicle data includes data outputs expected from the U.S. DOT Connected Vehicle program, such as road-level weather information and probe data from Vehicle-to-Infrastructure and Vehicle-to-Vehicle technologies currently under development.

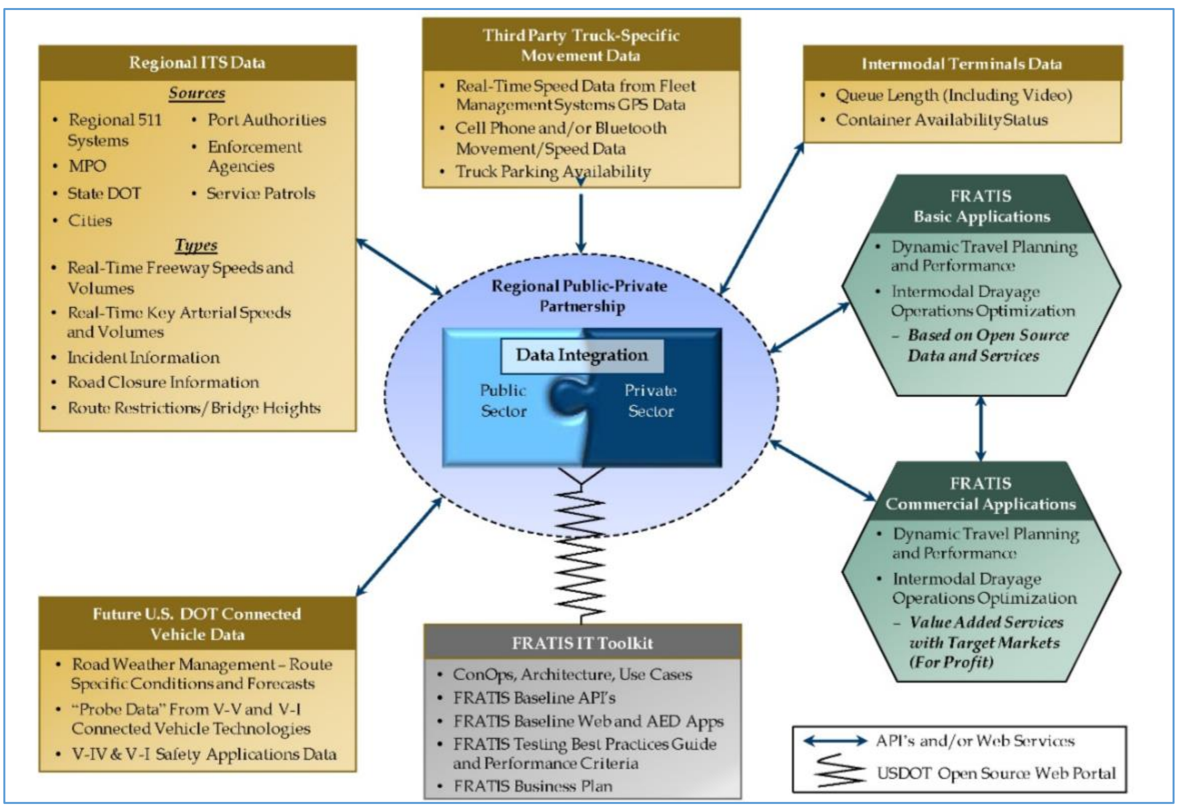


Figure 1 Proposed High-Level FRATIS System Concept (Jensen et al., 2012)

Two FRATIS application "bundles" contain Freight-Specific Dynamic Travel Planning and Performance and Intermodal Drayage Operations Optimization. The Freight-Specific Dynamic Travel Planning and Performance application bundle includes all of the traveler information, dynamic routing, and performance monitoring elements identified in the development of user needs for this project. The application will leverage existing data in the public domain, as well as emerging private sector applications, to provide benefits to both sectors. Relevant data includes wait times at intermodal facilities (e.g. ports), incident alerts, road closures, work zones, routing restrictions (hazmat, oversize/overweight). The Intermodal Drayage Operations Optimization application bundle 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. Individual trucks are assigned time windows for pick-up or drop-off. These improvements would lead to corresponding benefits in terms of air quality and traffic congestion. (Jensen et al., 2012)

For instance, Figure 2 shows a full process view of the steps involved in the used of the LA-Gateway FRATIS system by PLG dispatching staff, and including information exchange with YTI terminal.

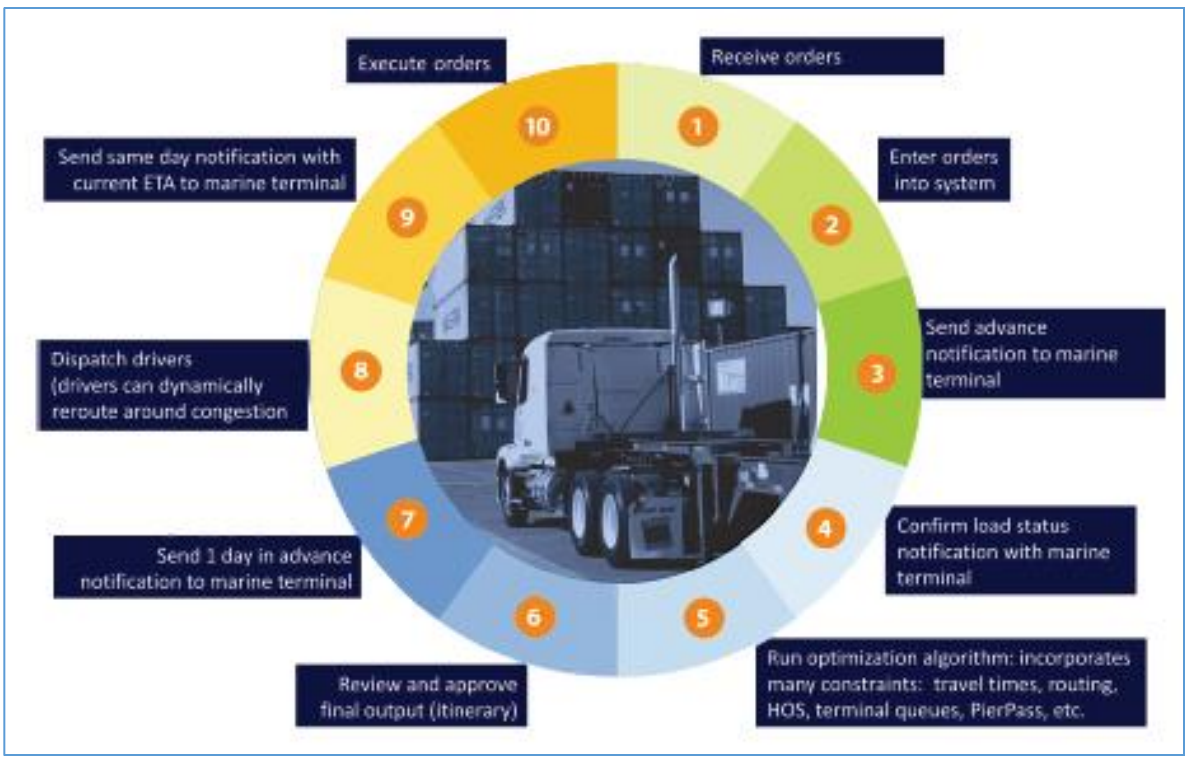


Figure 2 Overview of FRATIS system 10-step process for uses in the LA-Gateway FRATIS Demonstration (Jensen, Fayez and DeSantis, 2015)

Expected Benefits

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), Jensen, Fayez and DeSantis (2015) identify and quantify a number of benefits. The program reduced the number of bobtail trips (i.e., empty-return loads) by 10 percent, terminal queue times by 20 percent, travel times by 15 percent, fuel consumption by 5 percent and level of criteria pollutants and GHG by 5 percent. Given that the C-TIP test was of relatively small scale, the results are promising for substantial benefits on larger scale implementation.

CDM Smith along with Booz Allen and North River Consulting (Troup, 2014) provided some preliminary assessment results for LA-Gateway demonstration case. They compared test data with baseline data and calculated several indicators related to efficiency of system. Figure 3 shows the average daily miles per order before and after the installation of the FRATIS system (Jan to Feb 2014). The daily mileage per order has dropped significantly within less than one year.

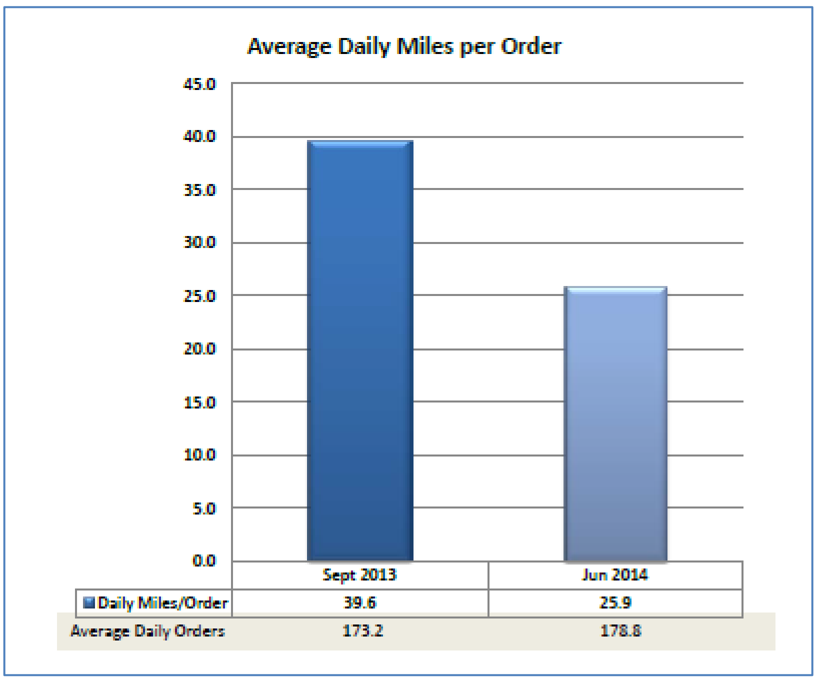


Figure 3 Average miles per order before and after the installation of the FRATIS system

Figure 4 shows the average daily miles, trip time and stop time per order before and after the installation of the FRATIS system. All the three indicators have dropped significantly within less than one year.

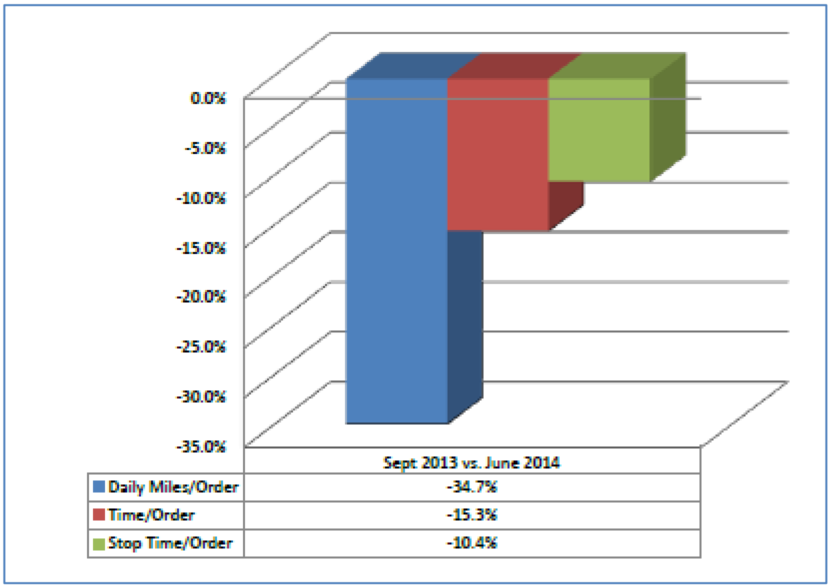


Figure 4 Daily mileage, time and stop time per order before and after the installation of the FRATIS system

Expected Costs

Operations costs will be borne by three primary entities including trucking companies, transportation agencies and fleet information private sector vendors (Jensen et al., 2012).

Trucking company dispatchers/operations managers will need to install FRATIS at both their offices and on the Application Enabled Devices (e.g., smartphones) of their drivers. Internal training will also be required for both the web and mobile FRATIS platforms. The companies may also elect to purchase value-added commercial versions of FRATIS applications that may be available from fleet management/routing/traveler information private sector vendors.

Transportation agencies will need to include a component of TMC operations dedicated to the FRATIS system data exchange. These agencies will also need to provide for implementation and continued operations and support of any freight-specific ITS sensors (e.g., key freight arterials volume/speed sensors). Agencies responsible for integrated corridor management on freight-intensive routes will need to work together to make sure all relevant data are available and feeding into FRATIS (this could include local traffic signal systems, state DOT freeway management systems, route restrictions, commuter rail train management systems, and other data streams for a particular corridor). Also, these agencies will need to operate the continuous collection and assessment of freight performance information derived from FRATIS.

Fleet management/routing/traveler information private sector vendors will need to assign appropriate internal operations resources to manage the data integration associated with open-source data exchange with the regional public sector transportation agencies. It is assumed that companies will recoup the cost of participation in FRATIS through the development and marketing of commercial value-added FRATIS applications which would likely require paid subscriptions or other pricing/cost recovery methods. For example, a fleet management vendor could conceivably develop a specialized version of FRATIS that would be designed to serve drayage reefer operations for seafood companies.

Role of the Public Sector

Taking the LA-Gateway demonstration as an example, Public-Sector Test Participants/Stakeholders mainly include LA Metro, Gateway Cities Council of Governments and Port of Los Angeles and Port of Long Beach (Jensen, Fayez and DeSantis, 2015). Among them, LA Metro is the public-sector test partner that is interested in examining FRATIS data outputs to potentially help plan for infrastructure improvements in the region to facilitate movement. LA Metro is also the major transportation agency that funds a significant portion of the County's 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 lays the institutional groundwork for the LA-Gateway FRATIS test. As the largest port complex in North America, Port of Los Angeles and Port of Long Beach are 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.

A key institutional enabling element to deploy FRATIS in a given region will be the creation or use of a Public-Private Partnership (PPP). For the FRATIS concept to succeed, public and private sector freight movement and other data will need to be integrated and managed so as to support the specific data needs of the FRATIS applications. This will require organized cooperation between public sector organizations (e.g., MPOs, DOTs, cities) and private sector companies. The FRATIS PPP will be responsible for data and system integration (i.e., "standing up" FRATIS in the region) and project development and ongoing operations (Jensen, Fayez and DeSantis, 2015).

It is anticipated that the FRATIS regional public-private partnership will administer the operations and maintenance of FRATIS, with the private partners primarily acting as data providers with public sector agencies providing labor and physical plant (e.g., server space) to stand up the system. This approach is preferred because it is unlikely private partners will do this on their own, and may need guidance/assistance from transportation agencies. Operations and maintenance may be completed using in-house staff and IT resources, or it may be performed by a government contractor (Jensen, Fayez and DeSantis, 2015).

Implementation Challenges

There are several challenges to be overcome if FRATIS or a similar system is widely deployed within the state. The first is cost. To date, the FRATIS demos have received significant funding from USDOT. It is unlikely that federal support would be provided for an ongoing program in the current federal fiscal environment. Thus state and local agencies would need to identify funding both for capital investment and the ongoing operation and maintenance of the system.

The FRATIS demonstration evaluations have generated some suggestions for addressing operational challenges (Jensen, Fayez and DeSantis, 2015; Williamson et al., 2015; Newton et al., 2015):

- Developing an early and consistent involvement of public and private freight stakeholders;
- Leveraging innovation to improve the relationship between the port trucking community and the port terminals community;
- Identifying stakeholders that see the value in innovation as a means to improve their operations is critical to maximizing the benefits of a deployment;
- Selecting appropriate partners who have the ability and willingness to participate in the optimization system;
- Setting up a framework that have the support and commitment of senior management at the onset to communicate to the organization that participation is supported and expected.
- Dealing with the fact that Small scale demonstrations, by definition, may not demonstrate enough benefit to maintain necessary stakeholder involvement.

Several operational constraints for FRATIS deployment and operation need to be overcome according to Jenson et al. (2012). First, FRATIS should be deployed on a regional basis and require a metropolitan regional-level focus. Based on the findings from the User Needs assessment, the primary target market for FRATIS applications is local and regional intermodal trucking drayage carriers, with a secondary market being small- and medium-sized local and regional truck carriers (non-intermodal). In addition, the public sector information sources that will be utilized and integrated into FRATIS by the private sector vary greatly between major metropolitan regions in the U.S., and even within some states.

Second, FRATIS relies heavily on public-private partnerships. Public and private sector freight movement and other data will need to be integrated and managed so as to support the specific data needs of the FRATIS applications. This will require organized cooperation between public sector organizations (e.g., MPOs, DOTs, cities) and private sector companies, which are expected to deploy applications based on FRATIS. Third, the geographic coverage of FRATIS will be limited. In a given metropolitan region, it would be unreasonable to expect that every single possible route that could be used by a truck would have real-time information available to it; FRATIS will need to focus primarily on critical and major freight freeways, arterials and intermodal connectors. The operational capabilities of FRATIS in a given region will thus be constrained by the data sharing/integration framework that is utilized by the public and private sector. Legal Agreements, Memorandums of Understanding, and Private Sector Return of Investment (ROI) will all need to be addressed by regional data sharing/integration frameworks.

Measuring Success

Each of the demonstration cases has developed a set of system testing framework to evaluate the effectiveness of the FRATIS system. For instance, the Figure 5 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 (Jensen, Fayez and DeSantis, 2015).

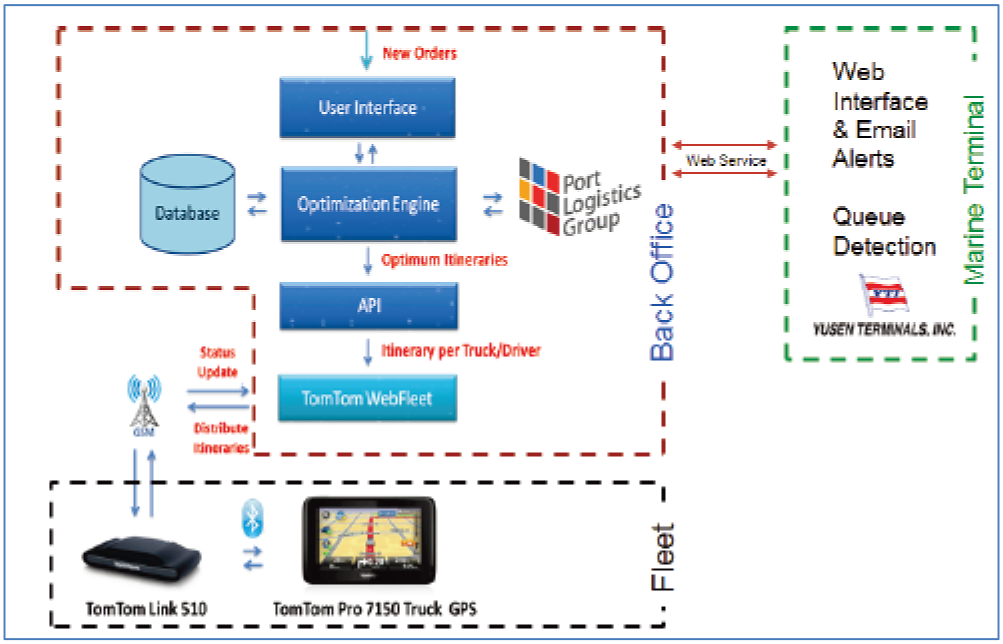


Figure 5 FRATIS system testing overview

Table 1 shows the data needed for the testing and the test hypotheses used to evaluate the success of each component of the system (Jensen, Fayez and DeSantis, 2015). However, none of the three demonstration cases has provided real data for testing the effectiveness of the FRATIS system yet.

Table 1: Data Needed for Evaluation

System	Data needed	Elements	Test Hypotheses
Drayage optimization	▪ Daily orders from the drayage company. ▪ Optimization algorithm using the order data to optimize drayage moves	▪ 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 ▪ Dynamic route guidance based on real-time traffic and route data	▪ 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 decision making.
Drayage-to-marine terminal operators communication	▪ Predictive queue-time information by drayage operators ▪ Real time route recommendation.	▪ 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: Cambridage 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.

SYSTEM-WIDE APPOINTMENTS AT MAJOR SEAPORTS

Statement of the Problem

There are many delays in the drayage process: congestion on roadways, queuing at terminal gates, queuing or waiting to drop off or pick up, queuing or waiting at the destination. Appointment systems are intended to reduce truck queuing, increase velocity of container movement, and reduce container dwell time. Appointment systems target productivity and efficiency at port terminals via the implementation of information and communication technologies (Giuliano, et al. 2008; Morais & Lord, 2006).

Description of the Strategy

An appointment system provides time windows for drayage transactions (pick up, drop off). The basic system would have an information platform that informs shippers of container, chassis and space availability. Shippers select a time window for the transaction, and a truck is dispatched to arrive during the time window.

Appointment systems have potential benefits for both terminal operators and truckers and shippers. Appointments allow terminal operators to optimize utilization of resources. If terminal operators know in advance which containers are being picked up or dropped off, they can better manage truck flows and container moves within the terminals. This information is particularly useful during the evening and on weekends when labor costs are higher. The ability to predict gate moves allows for the more efficient ordering and use of longshore labor. Appointments would also translate to shorter turn times for truckers, as less time would be spent waiting for a container to be available. Appointments could also be used to meter truck arrivals to prevent congestion on the dock.

The Ideal Appointment System

In order to generate maximum benefits, an appointment system would have the following attributes:

- A universal system consistently applied across all terminals in the port complex
- A single information platform accessible to all users
- Priority gates at each terminal so that truck incurs no delay at gate
- Coordination of gate entries and dock transaction (e.g. container fully ready for pickup at the time of truck gate entry)
- The capability to generate appointment windows and fill them at least one day in advance
- High rate of compliance

There are many actors involved in an appointment system, including ports, terminal operators, shippers, drayage truckers, and BCOs

There are several examples of appointment systems planned or in operation. We describe examples from North America and Australia.

Appointment Systems in Response to AB 2650, California

In 2002 AB 2650 sought to reduce vehicle emissions and highway congestion by reducing truck queuing at marine terminal gates and distributing truck traffic over a greater period of time throughout the day. The legislation permitted terminals to adopt either gate appointments or off-peak operating hours as a means of avoiding fines for truck queues. Given the costs and difficulties of implementing off-peak operating hours, most terminals chose to implement appointment systems. An evaluation found that 1) use of the appointment system depended upon operating policies of individual terminals; 2) perceptions of the appointment system's effectiveness differed across user groups; 3) there was no evidence that the appointment system affected queuing at marine terminal gates; 4) while a majority of the terminals did implement an appointment system in response to the legislation, most did so in order to avoid paying the high labor costs associated with extending operations to off-peak hours, and hence had little incentive to develop an effective system (Giuliano et al, 2008).

APL Terminal, Los Angeles

APL terminal implemented an appointment system and expanded gate hours in response to a container volume surge that made it necessary to shift from an all "on wheels" pickup system to a partial stack system (JOC, 7/31/14). The terminal did not have sufficient cargo handling equipment or longshore labor to manage stack moves. The system required truckers to make a container appointment 24 hours in advance with a four-hour window to account for possible delay. Containers were assured to be on chassis when truckers arrived at the terminal. Having the container ready for pickup guaranteed expedited treatment, and hence incentivized compliance by drayage truckers. As a result, the average transaction time decreased from 100 to 60 minutes.

Port Botany, Sydney, Australia

Port Botany implemented a "vehicle booking system" (VBS) in 1999 in order to maintain a "high level of terminal efficiency and maintain acceptable turn times for trucks" (Davies, 2009). The VBS has been a success. The percentage of trucks processed within a 60 minute turn time (measured from in-gate to "truck complete" – truck loaded or unloaded) increased from 73% in 2005 to 85% in 2006. (Davies, 2009, p. 13) Davies (2009) reports that the average in gate to out gate time was 51 minutes from January 2001 to June 2007, much less than was experienced in the early 1990's before introduction of the VBS.

Napoleon Avenue Container Terminal, New Orleans

Napoleon Avenue container terminal at the Port of New Orleans, LA, adopted the appointment system in 2003 in order to better use terminal space and reduce gate congestion. Similar to APL terminal's case, it is designed to intervene and solve problems before trucks arrive at the terminal. The terminal is relatively small; It handles 1,100 gate moves per day.

Port Metro Vancouver

Port Metro Vancouver: The Vancouver port has implemented a number of strategies to reduce truck queuing and improve port operations efficiency. An appointment system began in 2001 and has been continuously refined since. The appointment system is part of a suite of strategies, including a rigorous truck licensing policy, fines on terminal operators if turn times exceed a specified maximum cap, and a PierPass like off-peak congestion management fee (Heaver, 2009).

Ports of Los Angeles and Long Beach

The operator of PierPass has initiated an effort to organize a ports-wide appointment system. As of August 2015, 10 of the 13 container terminals "adopted a trucker appointment system action plan with the goal of establishing a system of appointments throughout the harbor beginning in 2016." (JOC, 8/27/15). As currently envisioned, each terminal would have its own system, but will comply with 3 rules: (1) appointments will be mandatory; (2) they will apply to imports only; (3) the appointment system will be operated via links from the PierPass website. Appointments are seen as part of a comprehensive program of efficiency improvements at the ports.

Although many appointment systems are either operating or being planned, none of them have the full list of attributes required for a maximally effective, system wide appointment system as described in the previous section. The Port Authority of New York and New Jersey (PANYNJ) is scheduled to launch a common portal appointment system in 2016 that may provide guidance on development of the California systems.

Expected Benefits

There are many potential benefits from a ports wide appointment system. The literature identifies increased throughput, reduced wait and turn times, increased gate efficiency, increased equipment utilization, and the capacity to plan truck moves across the day (Moras and Lord, 2006; Huynh and Walton, 2008; Namboothiri and Erera, 2008; Huynh, 2009)

Most studies of appointment systems are based on various types of simulation, and these studies consistently show productivity benefits. The only comprehensive empirical study is Giuliano et al. (2008). The Giuliano et al study in not likely to be transferable, due to the conditions under which appointment systems were implemented.

Simulation Studies

With a simulated model based on queuing theory, Zhao and Goodchild (2013) tested the effectiveness of a truck appointment system and truck appointment information on container terminal yard efficiency. The model quantified the interaction between arriving trucks and a yard crane when trucks retrieve containers. The model tested the appointment system configuration – duration of appointment time window, container dwell time, and appointment lead time – in terms of the import container retrieval operation and container re-handling. The authors report an increase in terminal yard operation efficiency. The appointment system improved yard crane productivity and truck transaction time. The terminal could enhance system performance in these cases: (1) a longer appointment lead time (two days vs. one day) could ensure better scheduling of yard crane, (2) in case of a short container dwell time, reduced duration of appointment window could enhance yard efficiency, but the effect diminishes as the dwell time increases, and (3) the yard crane performance could be resilient against the use of inaccurate information or missing appointments if the early/late arrival is within the 4 hour window. It is because the yard crane operation algorithm makes a container location decision in a way that minimizes re-handing of containers.

Huynh and Walton (2008) combine mathematical formulation and computational simulation to seek a solution that optimizes the number of trucks entering the container yard with respect to truck turn time and yard crane operation efficiency. The optimum solution must benefit both the terminal and the truckers and be robust against late or missing appointments. The authors conducted experiments using data collected in May, 2003 at the Barbour Cut Container terminal, Port of Houston. The simulation and experiments documented that the appointment system could allow terminals to plan truck moves per day based on capacity and resources. Smoothing – reassigning of trucks that exceed the terminal cap in the next hour period – is beneficial in that it could enhance yard crane utilization and decrease truck turn time.

Using a drayage operations planning approach, Namboothiri and Erera (2008) develop an integer programming heuristic to evaluate the container pickup/delivery sequences that minimize transport costs in order to test the potential productivity gain of the appointment system. A minor change in gate appointment configurations can significantly affect the productivity of drayage firms. Terminal operators should provide enough appointment capacity for effective drayage. According to the authors, a 30% increase in appointment capacity brings about 10-24% improvement in vehicle productivity. An improper selection of appointments could result in up to 4% decrease in the number of serviced customers. A 50% reduction in the appointment window duration necessitates a 4% increase in total terminal capacity.

Using data from field observations, Guan and Liu (2008) develop and test a multi-server queuing model to evaluate gate congestion and its impact on the truck waiting cost. Data were drawn from a terminal at Port of NY-NJ. The optimization model aims to minimize terminal gate congestion and truck waiting time/costs, and does not consider transaction time within the terminal. If optimized, a small increase in gate capacity could 'drastically' reduce truck waiting time. An appointment system could be 'the most viable way' to increase system productivity and decrease terminal gate congestion, because it does not require a large expenditure or adjustment of manpower and land expansion. Coordination among shipping lines, shippers, terminal operators, and trucking companies, and all stakeholders is necessary.

Huynh (2009) uses a simulation model to test scheduling rules that might affect truck turn times and ultimately system resource utilization. He also evaluates factors that might influence scheduling performance. The scheduling rules are adopted from the health care sector: individual appointment system (IAS) and block appointment system (BAS), and compared to a no scheduling baseline. Relative to no scheduling, IAS does not increase productivity of yard cranes, but reduces internal yard turn time by about 44%. BAS increases crane productivity, but imposes longer turn times on truckers. IAS is superior to BAS because IAS is robust in the case of walk-ins, late or missing appointments. IAS benefits both the terminal operator and truckers. With caution, the terminal operators must minimize the number of walk-ins, as IAS is sensitive to it. Or an increased spacing between the appointments is necessary.

Empirical Study

Using data from 3 terminals, Giuliano et al. (2008) examined use of appointments, compared turn times with appointments, and used data from 2 terminals to estimate turn time savings at different levels of appointment use. . Use of appointments varied greatly across terminals and reflected practices of the individual terminals (see figure 6 below). On average, about 63% of appointments were kept by truckers, with the most frequent reason for missing appointments being delays at the marine terminal. There was no significant difference in turn times between those using appointments and those not using appointments. There was no data available to quantify impacts on terminal operations. Potential total turn time savings (including gate queue time) for imports only was estimated based on data from two terminals. Depending upon the amount of queue and transaction time savings associated with appointments, and on the extent to which appointments are used, savings range from 2% to over 10% of total turn time across all daily transactions (see figure 7).

The Giuliano et al. study is not likely to be transferable, due to the conditions under which appointment systems were implemented. Appointment systems were implemented in response to state legislation which required terminals to either extend gate hours or implement an appointment system in order to reduce emissions from drayage trucks waiting at gates or in terminal yards.

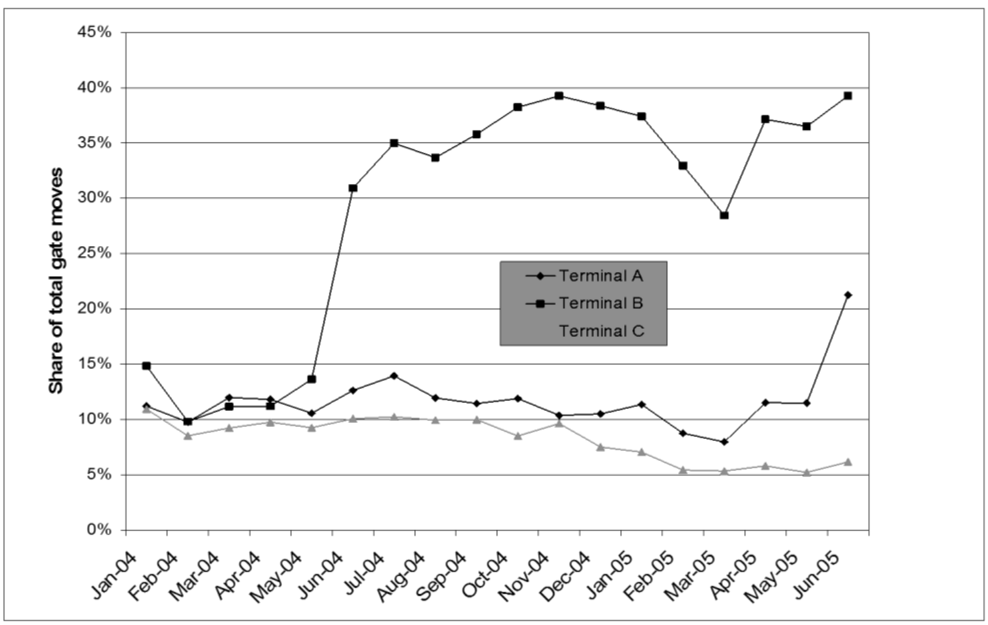


Figure 6 Appointments as share of gate moves (Giuliano et al, 2008)

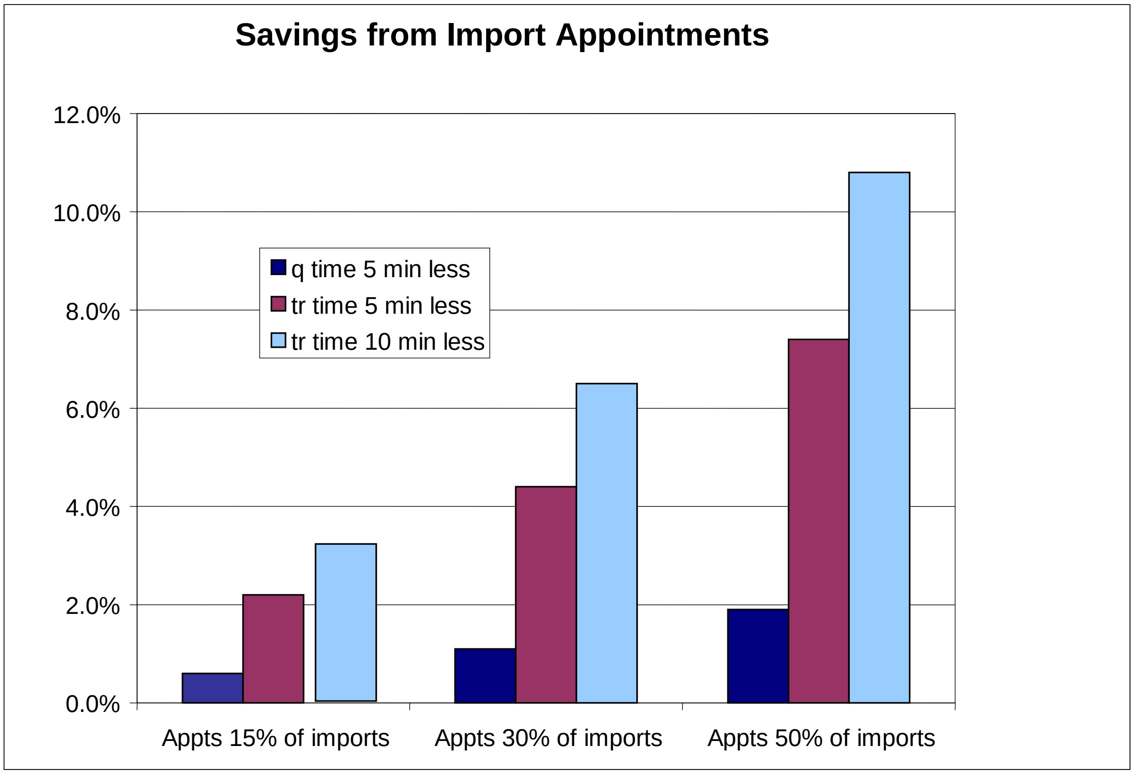


Figure 7 Estimated turn time savings under different assumptions (Giuliano et al, 2008)

Expected Costs

There is no information on the financial costs of developing and operating an appointment system. In the case of a ports wide system, there would have to be an information and communications system to collect data from terminals, generate appointment windows, and allocate windows. The system would need real-time capability to adjust to unanticipated delays (trucker stuck in traffic, trucker delayed at previous stop, container not located, etc.).

A system wide appointment system would involve substantial transactions costs to design a system that would be acceptable to all stakeholders.

A system wide appointment system would generate winners and losers. Some shippers/truckers would not get preferred time windows, and appointments that are optimal for the terminals are not necessarily optimal for shippers/truckers. Although some research has been done on joint optimization, whether such tools are sufficiently developed for large scale implementation is uncertain.

Role of the Public Sector

Appointment systems at the individual terminal level have been implemented in ports around the world. We have fewer examples of port wide systems, with Vancouver one notable case in North America. In Vancouver the government has played a strong role via regulation of the drayage industry (e.g. the truck licensing policy) and of the terminals (e.g. the fine system for long gate wait times or turn times). In California, the port authorities, as managers of the port, would be a logical entity to manage a port wide system. Port authorities understand port operations and have interactions with the key stakeholders that would be involved in developing and operating an effective system. Another possibility is a multi-terminal group such as PierPass, with the port authorities setting policy and framework, and the terminal group implementing the program. The argument for a terminal group is that direct market participants who receive the benefits and costs have more incentive to develop an effective program.

The public sector may play a key role in incentivizing participation, serving as a "neutral forum" for developing an appropriate and effective appointment system, and possibly funding the upfront information infrastructure that would be required.

Implementation Challenges

There are many implementation challenges to a port wide appointment system. First, there is a "supply side" and "demand side" of appointments. From the MTO perspective, the objective is to use equipment, labor, and terminal space as efficiently as possible. Ideally the MTO would issue a series of "calls" (time windows for specific pickups) that would maximize the total number of daily pickups. From the shipper/trucker perspective, the objective is to use the fleet as efficiently as possible (typically using optimal route sequencing). It is not necessarily the case that both objectives lead to the same outcome. That is, the appointment problem is a multi-objective optimization problem subject to constraints. Under such conditions, although the "system" outcome is the best possible, it will not be the best possible for at least some TOs or shippers/truckers (from their individual perspectives). Some form of compensation would likely need to be developed in order to achieve full participation in the system.

Second, benefits of the appointment system must be evident to all participants. MTOs must be convinced that appointments will lead to efficiency gains, or they have no incentive to implement or operate an effective system. Shippers/truckers must be convinced that appointments will lead to shorter and more reliable turn times, or they have no incentive to use or keep appointments.

Third, a port wide system requires some common infrastructure and operational practices. A port wide appointment system would require a common information platform. Currently, there are several different information exchange platforms, and they are not interoperable. Also, an effective appointment system requires coordination of gates and yard, which may require priority gates, new logistics practices, and other changes in terminal operations. MTOs vary in the type of product, a number of ships served, customer requirements, dock space, etc. It, therefore, would be difficult to implement a uniform system across all MTOs. At the same time, however, shippers/truckers operate across multiple terminals. Thus, the basic structure of the appointment system would have to be common, and the extent of variation in appointment practices (e.g. policies for selecting appointments, variability of turn times, etc.) would need to be limited. These issues are evident in the current PierPass effort.

Fourth, the extensive road congestion that prevails in both Los Angeles and the San Francisco Bay Area generates significant unreliability in truck travel times. While shorter time windows increase the effectiveness of appointment systems, the uncertainty generated by road congestion will force longer time windows, especially during daytime hours.
Morais and Lord (2006) conducted terminal operator interviews in 2005. Participating stakeholders included Port Authority of the Port of Montreal, Cast Racine Terminals at Port of Montreal, Port of Long Beach, Port Authority of New York-New Jersey, Port of Oakland and TransBay Container Terminal, Vancouver Port Authority, and Port of Seattle. The authors made the following observations.

First, the integration of the appointment system into the terminal operating system – that manages information of all container location, schedule of terminal operation, and the business rules – is critical. Second, it is essential that the system provides clear incentives and benefits for terminal operators and truck drivers, such as productivity enhancement via faster turnaround time. Terminal operators regard it important that they be capable of planning container moves on a daily basis according to their capacity. Third, extended gate hours (e.g. PierPass) and technologies (e.g. OCR, RFID, and CCTV camera) operated along with the appointment system significantly improved success rates. Fourth, successful implementation is critical in order to overcome human reluctance to new business practices. Lastly, a system based on the container is preferable to one based on reserving time, due to duplicate appointments on a container and/or greater cancellations. The former system allows better flexibility for truck drivers and shorter lead time between the moment truckers make appointment and the actual pick up. It eliminates the chance to overbook a container pickup.

The authors suggest several requisites for a working appointment system: it handles and reassigns cancellations; it allows appointments arranged during the day; it allows a short arrangement lead time prior to picking up; it prevents overbooking for the same container; it levies a penalty for a missed reservation (no-show); it allows tolerance for delayed show-up; it makes appointment based on containers, rather than on trucks; and it allows telephone reservations.

There are many aspects of a port wide system that would have to be worked out. Issues include 1) scope of the appointment system (e.g. pickups only, all container moves, or all truck moves, and over what part of the day); 2) how to integrate with other efficiency strategies such as “peel off pile” operations; 3) how and to what extent should each MTO determine system rules; 4) how to discourage missed appointments.

Measuring Success

Conceptually, measuring success is straightforward, as a before/after analysis could be done, provided the necessary data are available. A baseline would be needed in order to measure success. This would require a substantial data gathering exercise before implementation. The data to measure gate-to-gate turn time is available from MTO records. Queuing outside the gates is more difficult; it requires some form of truck tracking system, or some form of field sampling.

It will be important to develop metrics for both MTOs and truckers so that stakeholders on "both sides of the gates" have information on the progress and benefits of the appointment system.

LOAD TRACKING SYSTEM

The concept of a system-wide load tracking system is to make the status (location, contents, origin, destination) of every shipment transparent, meaning readily available in near real-time to all relevant supply chain participants, including ocean carriers, ports, MTOs, rail and trucking, BCOs, etc. We present this as a "stretch goal" that would take several years to accomplish. If accomplished, such a system could generate significant efficiency benefits, and reduce fuel consumption and GHG emissions.

Statement of the Problem

It is difficult to improve freight efficiency without knowing where freight is in the supply chain. Investments to improve supply chain efficiency, such as improved berths, roads and railroads are intended to make the supply chain more efficient and more reliable, yet without understanding the experience of individual loads, it is difficult to determine the extent to which such investments are actually improving the situation. A small minority of errant loads tend to cause a disproportionate degree of delay within the supply chain. When loads are missing, when they are misidentified, or when they arrive earlier or later than expected, delays can accrue not only for the problematic load but also for the other loads within the system.

While brokers and 3PLs arrange each leg of cargo's journey, they have traditionally had little control or insight into the exact routes chosen by transportation providers in moving from origin to destination. Through tracking technologies, most of which are currently cell phone based, brokers for the first time have the ability to know with precision how a load moves from origin to destination. This may allow 3PL's to more reliably optimize routing as they will have a better understanding of weaknesses within the supply chain by studying each load's "bread crumb path". Tracking can provide documentary evidence of the net effect of congestion on individual loads which can be useful evidence for policymakers who are considering options for improvement.

At present, a system to track cargo from end to end exists, however it exists in a piecemeal fashion and in most cases has yet to be stitched together. There is evidence that greater supply chain coordination is now occurring at all levels in order to expedite clearance for terminals that are capacity constrained. For example, steamship lines now coordinate vessel stowage of individual containers at the port of origin and port of departure to expedite unloading and processing. (Mongelluzzo, 2016) On the next step of the supply chain, vessel unloading of individual boxes (or, alternatively, blocks of containers) can be coordinated to expedite on-dock rail deliveries. This technique has been used in Seattle-Tacoma. (Mongelluzzo, 2015)

Description of the Strategy

To date, there has been no coordinated national effort to track cargo in a systematic way. A number of proprietary programs have been developed by the private sector that utilize driver's cell phones to track cargo. Some use apps and thus can only be used with smartphones whereas others can be used with any mobile phone. As these technologies proliferate, a major concern is avoiding redundancy. At present, as cargo travels through the supply chain, it is tracked in different ways by multiple parties, to varying degrees of precision. One question is whether the proposal should advocate a single method of tracking that would stay with the cargo through multiple steps.

The ideal concept is an end-to-end system with information available to the relevant supply chain participants: ocean carriers, ports, MTOs, BCOs, rail and trucking, etc. With technology allowing for ever smaller and cheaper sensors, it is technically feasible to add a "sensor ID" to every shipment. The sensor would have communications capability with information on contents, origin, destination, and other essential data. It would have GPS-type capability, so that its location could be tracked in real- or near real-time. The conceptual model is based on Fedex or UPS, expanded to include multiple users.

The load tracking system would require a common information platform that includes a central server that stores the data, database tools to manage and update data; a streaming capability to receive and process data in real-time, and APIs (application program interface) for interacting with the database to allow for web service querying of the data. It would require a manager and set of protocols regarding what data are stored and for how long, who gets access to the system, protection of proprietary data, storage of the data, data security, who pays to develop, maintain and operate the system, and other operating considerations. It would need a host acceptable to and trusted by all parties.

Another possible approach is to connect and integrate the various specialized information systems that are being developed and sold by private vendors. There would be many challenges to integration, including incompatible data structures and software, differences in data, lack of control over software and hardware changes, difference in access policies, etc.

Expected Benefits

Cargo transparency by itself does not provide direct benefits, but there are many instances in which time savings could be realized if this information is intelligently acted upon. For example, a load tracking system tied to individual containers could allow dispatchers to know when a container has been moved from the stack and will likely be ready for pickup. This would allow a driver to be dispatched as soon as the cargo is available, thereby lowering dwell time on the yard. It would also facilitate an effective appointment system.

If patterns of shipments are evaluated, it could lead to more effective load matching both for LTL trucking options as well as for train assembly. Load tracking would increase the predictability of shipments which would potentially benefit the slower and more carbon efficient modes of freight transportation such as rail.

As most current tracking technologies are tied to individual drivers, technologies used for transparent load tracking can be used to better utilize existing trucking capacity and better match loads with transportation providers. Technologies such as Cargo Chief can notify dispatchers if drivers divert from their routes (Cassidy, 2015). This is not a new concept, but has been discussed since the introduction of Electronic Data Interchange (EDI) in the 1980s (Siedeman, 1989). The following is a description of a system currently under evaluation at the Ports of Seattle and Tacoma.

> …"there's the rugged, portable *tracking* device, battery-operated and weighing about five or six pounds that was designed by Safefreight originally for truck trailers and vehicle fleets. The SecurityGuard SG212 uses *GPS*, wireless and Internet technologies to provide data on location, speed, direction, starts, stops and other measures. The port can trace the exact location of a container, virtually in real-time, through a Web map portal that's similar in appearance to Google Earth. It measures 5 inches by 3 inches by 3 inches deep and transmits data wirelessly through cellular communications to a Safefreight server" (Dibenedetto, 2009).

The main immediate benefits from load tracking include the elimination of "check calls" that are basically aimed at gauging an ETA from the driver. There are few estimates that attempt to quantify the net gains from automated load tracking, however the following quote seems to suggest that savings could be significant:

> "We expect to gain over 50% in efficiency in our Traffic Management and Dispatch operations. (from installation of Geotracking software) " - John Huggins, Chief Commercial Officer at FX Logistics. (Fleetowner, 2016)

Load tracking could also aid in inventory management. Increased predictability reduces uncertainty, which in turn reduces the need for extra stock. Problems further upstream in the supply chain, such as a customs delay, could be transmitted to downstream receivers in time to make adjustments and hence avoid shortages.

Expected Costs

The costs of implementing cargo tracking depend in large part of the extent to which such a system is truly "universal". For certain loads, the costs of cargo transparency have already proven to be justifiable given the precious status of the cargo, yet for low valued non-time sensitive shipments this calculation will produce a different result. As cargo tracking becomes more widely available, the cost of the service is expected to decrease, particularly for areas of the country that have reliable 3G coverage.

Given the fact that the tracking technologies work off software based on a smartphone or cell phone platform, their cost to enter the market can be quite low. In some cases, tracking solutions are even provided for free. For example, a firm called FourKites CarrierLink will provide load tracking for up to 2500 loads per month for free. (Fleet Owner, 2015) It bears noting that a sensor-based tracking system would go beyond the truck or rail trip, provided information on where the load is at the terminal or at a distribution center.

In addition to start ups, the major institutional players are also developing their own proprietary tracking technologies. For example, in late 2014 JB Hunt launched JB Hunt 360. The smartphone based app allows real time load tracking for any JB Hunt customer. This adoption shows that real time tracking is no longer a niche application for specialty loads but is becoming a standard feature for all types of cargo. (JB Hunt, 2016) The JB Hunt 360 application works for multimodal shipments as the rail carrier transmits location data to JB hunt which displays this information on the same dashboard used to track truck shipments. In this sense, the JB Hunt 360 application comes closer to the concept of a universal system.

Role of the Public Sector

In most cases, the data collected by load tracking software is private and proprietary. As noted earlier, there might be numerous benefits that would emerge from compiling this data into a single database to give a complete real time picture of the flows of freight shipments on the various networks (road, rail and river systems). If a system could be developed that would delay release to governmental agencies until the information is no longer considered sensitive, release only a sample (akin to the carload waybill sample) or release in real time with certain elements of the data (such as ownership) suppressed. Furthermore, as the collection of real time data on cargo status and location becomes more commonplace, the tendency of freight providers to view the location or status of their assets as proprietary may partially abate.

With the advent of companies such as Cargomatic, more 3PLs are viewing cargo visibility as an essential productivity tool (Cargomatic, 2016). Unlike most cargo visibility applications that target long haul trucking, Cargomatic has focused on the drayage industry and has coordinated its efforts with the Ports of Los Angeles and Long Beach to improve cargo visibility within the terminal. (Cargomatic, 2016) While the government has not yet mandated any type of in terminal tracking technology, this may change if the technology proves to shows overall efficiency gains, particularly in terms of gate productivity.

Implementation Challenges

A major implementation challenge is how to translate the long term management of the load tracking information system into economic benefits, which requires acting upon the information. Supply chain actors will need to be convinced that information sharing generates benefits to them, and incentives may be required to promote acting upon the information.

Any system of universal load tracking will necessarily develop as a phased implementation. As illustrated above, there are a number of technologies that are already being implemented at different levels of the supply chain. Given the proliferation of technologies, it may be too late in the game for a government imposed mandate that would specify a single technology and system of information gathering to be feasible. On the other hand, as noted above, there would be significant challenges in integrating disparate systems.

If the government hopes to use the wealth of data that is currently being gathered for broader freight planning purposes, it must develop incentives to induce the private sector to share the data. In certain areas, for example when load tracking correlates with a potential national security concern, there may be a stronger case for compelling shippers to turn over data on load tracking. The major incentive, however, is the benefit to the data owner in making his/her business more efficient.

Different governmental agencies have to determine what constitutes “Universal” for their purposes. The standard will likely differ depending on whether transportation logistics professionals or security parties are setting the criteria. If transportation planners are setting the terms, the definition would likely be looser, i.e. the point where marginal cost would exceed marginal benefit would occur sooner. Conversely, if the determination is made for security purposes, they will be more likely to insist on a 100% scanning criteria, however if they deviate from this standard they would be more likely to not require tracking for domestic shipments, cross border shipments from Canada and from any other foreign party that is considered secure.

One clear area where tracking may dovetail with security is the ongoing effort to scan and secure imports of containerized trade entering the US. The US Congress has repeatedly delayed implementation of 100% container scanning. In July of 2014, the Department of Homeland Security announced another two-year extension of the deadline for scanning all containers bound for the United States at the port of origin, as was originally mandated by 2007 modifications to the 2006 SAFE Port Act. The legislation has produced controversy since the time of its passage due to uncertainties regarding its technical feasibility and impact on international trade.

There must be provisions for sharing data between private and public sector and the risk of data security. For the purpose of security, it is important for the data to be made available in close to real time. However, if the data is for transportation planning purposes, it could be received much later and partially redacted.

At present the vast majority of investment is going into smart phone GPS apps. Yet, this strategy has many limitations. Currently approximately a third of drivers carry smart phones (Macropoint, 2016). In addition, most technologies are aimed at long haul carriers. When cargo is handed off to multiple drivers, a cell phone-based tracking system could be difficult to sustain - particularly in the drayage sector which (outside of the San Pedro ports) tends to operate using older trucks and more basic IT.

Another complication in load tracking is its role in multimodal shipments. For rail, the delays in shipment delivery time can occur for multiple reasons that are not encountered by trucks. In addition, rail yard dwell time is a major concern for truck competitive cargo. Even if the rail operator is able to provide information to the beneficial cargo owner (BCO) that the load is “in yard", there is still a question of whether or not that information is useful to the BCO in determining when a load will make it to its eventual destination.

Another issue comes from the question of "load integrity", i.e. what is the smallest unit of cargo that can be tracked? While there has been some attempt to track containers separately from the vehicles that escort them, it is difficult to track cargo through the transloading process as the load is subdivided or moved from a container to a trailer.

Measuring Success

As the benefits do not derive directly from load tracking but are based on what is done with this information, it is premature to determine specific metrics. In the beginning, provided a system could be implemented, anecdotal evidence on supply chain efficiency enhancements could be publicized. In addition, if the data was used to support infrastructure investments, this could be seen as another measure of success.

STATEWIDE SMART PARKING

Statement of the Problem

Truck parking has been a problem of particular seriousness in California. According to a 2011 survey by the American Transportation Research Institute (ATRI), hours of service was identified as the 2nd most pressing trucking issue. In 2012, California was ranked 1st in commercial vehicle parking shortage among all states in the U.S., as demand exceeds capacity at all public rest areas and 88% of private truck stops along 34 of California's corridors with the highest volumes of truck travel (California Department of Transportation, 2012). FHWA data suggests that in 2015, California has only 55 truck parking spaces per daily 100,000 truck VMT, which is the 3rd worst shortage in the nation only behind Hawaii and Rhode Island; the problem is most significant on the I-5 (Sells, 2015).

The results of a survey conducted on the I-5 suggest that most truck drivers frequently encounter parking shortage and have expressed need for improved service (Martin and Warner, 2012). 51% of respondents indicate truck stops were full or too crowded when they liked to park, mostly for overnight parking. The frequency of parking shortage experience was generally high, which nearly 1/3 of respondents encountering shortage situation on a daily basis. It is also worth noting that 48% kept going in such situations. In terms of attitude towards 72% of respondents believed that smart parking would definitely or probably be useful in finding parking at truck stops, while 81% believed smart parking would definitely or probably be useful to the trucking industry overall.

Additionally, studies show that often times even when parking is available, drivers have no knowledge of the availability due to unfamiliarity with the area or previous experience (Sells, 2015).

Some of the most critical issues related to delay of truck parking include: trucker safety, as fatigue is a factor in 16% of truck crashes and 8% of fatal crashes; Illegal parking; air quality and public health issues related to extra diesel emissions; driver productivity lowered due to time lost searching for parking.
(Martin and Warner, 2012)

Description of the Strategy

There are two smart truck parking projects currently in California. One is the Smart Truck Parking (STP) project conducted by Caltrans; the other is the Reduced Emissions through Efficient Parking for Trucks (REEPT) recently launched by CARB. The two projects are described below. We recommend a more ambitious and coordinated program that would include the entire state and address the truck parking shortage.

Smart Truck Parking (STP) Project

The following paragraphs are taken from the research notes of "Program Steering Committee (PSC): Transportation Safety and Mobility" by Hanson M. (2014). It appears that Caltrans was granted FHWA funding to develop a prototype smart truck parking system in California focusing on the I-5.

Brief Description of Project & Parties Involved

The Smart Truck Parking (STP) project is a collaborative implementation and research effort among the Federal Highway Administration, Caltrans, the University of California, Berkeley, and other partners. The project, sponsored by the Federal Highway Administration, is designed to demonstrate real-time parking availability at truck stops. The premise is that if you give truckers access to timely accurate information, they will make better travel decisions. Better information will discourage the use of highway ramp idling, enhance safety, and reduce lost time and fuel while truckers search for available parking. Truck drivers will be able to check for real-time parking availability at selected truck stops that are participating in this project on a website or using a mobile device, such as a smart phone or tablet.
The project is a five-year pilot with an initial focus on the I-5 corridor in California.

There are three phases to the project:

1. Systems Engineering and development and deployment of a prototype smart truck parking system that includes truck parking availability from two sites;
2. Expansion of the system to six additional sites;
3. Evaluate system performance and economic sustainability

The overall goal is the development of truck parking system that will help to better manage existing truck parking spaces by providing accurate and timely information to truckers.

What Does It Do & How Does It Do It

This project will demonstrate and evaluate an ITS-based solution to address parking shortages that exist for long haul truck drivers, provide truckers access to real-time parking availability and the options to make parking reservations, and investigate and develop a self-sustaining business model that can be scaled and made available at truck stops across the country.

The smart truck parking system has four major components:
Truck parking space availability information systems at truck parking facilities;

1. An aggregator that collects and stores the truck counts and space availability for the sites that generate this information;
2. A database of truck parking facility attributes for the truck stops and rest areas along the I-5 corridor including SR 99; and
3. A web-based user interface that allows truck drivers and fleet operators to access truck parking information from a computer or mobile device such as a smartphone

Reduced Emissions through Efficient Parking for Trucks (REEPT)

In November 2015, Truck Smart Parking Services, Inc. submitted a pilot project to the California Air Resources Board. Similar to the Smart Truck Parking (STP) project, Reduced Emissions through Efficient Parking for Trucks (REEPT) will locate on the I-5 initially at ten locations. REEPT will target these problems and costs through a strategy that builds on existing and proven intelligent transportation technologies and services (ITS), and installs a network that connects locations where trucks park to meet HOS regulations. This network will serve as the backbone for a statewide service that will optimize commercial vehicle productivity, meet HOS requirements, and reduce GHG emissions. The network will achieve the following:

1. Enable delivery of real-time parking availability and reservations;
2. Incorporate real-time information with HOS requirements to predict parking location availability for truck drivers and routes;
3. Connect to ports and terminals to alert drivers of parking opportunities, and;
4. Ultimately, provide an optional trip planning service for shippers and truckers using big data analytics.

REEPT will collect and transfer real-time parking availability, real-time traffic, trucker HOS requirement, terminal queuing, and trucker/shipper origin and destination data to the cloud. Real-time parking availability and traffic information will be wirelessly communicated to variable message signs (VMS), websites, and/or smart phone apps. Big data analytics will produce a number of services including parking reservations, predictive parking, predictive traffic, and terminal arrival times. All the data and services integrated by REEPT will provide truckers guaranteed parking to ensure adequate rest AND the shortest possible travel times, including routes, departure times, and avoided queuing at terminals (Sells, 2015).

Statewide, integrated smart parking

In order to be as effective as possible, a smart parking system must be statewide, use common technology, and address the state's parking shortage. The I-5 survey results document a serious safety problem, if nearly half of all truckers who reach the HOS limit continue driving because there is no place to park. If there is no parking and truckers abide by the HOS rules, they have little choice but to park illegally, often on highway shoulders. A comprehensive study to determine how to address this problem and an implementation plan, if not done already, should be a top priority. The study should include the entire state, meaning within and outside the major metropolitan areas. Within metropolitan areas, port-area satellite parking and staging areas should also be considered.

Integrated smart parking requires a common information and technology platform so that truckers will need only one "app" to access all parking options, public or private. It would appear that currently there are at least two platforms in development. If truckers must invest in learning and using multiple systems, they are less likely to use them at all. Integration is important as the heavy duty vehicle fleet changes; it will be important to distribute power stations, etc., according to demand, and to make such information easily accessible.

Given the extent of implementation in other states, it appears that California could accelerate its current programs, moving much more quickly to statewide scale.

Expected Benefits

Potential benefits of smart truck parking are reflected mainly in three aspects: safety benefits, economic benefits, and environmental benefits. With regard to safety benefits, smart truck parking allows for safe parking decisions while reducing fatigue related crashes. It also removes trucks from ramps and shoulders to avoid illegal parking and related safety hazards. In terms of economic benefits, since drivers and carriers are more efficient, profitability of companies are likely to increase. In addition, business for truck stops would also grow. Last but not least, the greatest environmental benefit would be reduction in greenhouse gas emissions and energy consumption, as 2 gallons of diesel can be saved with 15 minutes less of truck driving (Miller and Morris, 2015).

A smart truck parking precedent in Michigan along the I-94 suggests considerable economic and environmental benefits. In that specific case, with the average operating cost of a truck nearly $120 per hour, saving each truck driver 15 minutes during their regular parking routine could save $4.4 billion each year across the 400,000 parking events that occur daily. Moreover, each driver could save two gallons of diesel and reduce greenhouse emissions by nearly 45 pounds per parking search, more than 3.3 million tons of CO_2 each year (O'Connell J., 2014).

In the specific case of California, a smart truck parking system can also help improve the state's competitive edge in freight transportation. With one of the highest truck volumes and one of the worst parking shortages in the U.S., California incurs over $1 billion in yearly costs from parking-search travel, fatigue-related truck crashes, and terminal queuing and idling, which significantly reduce the competitiveness of California ports. . In order to keep freight transportation competitive, it is necessary to invest in new technology and services to optimize routing and parking options for trucks to maximize the use of existing resources and minimize truck transportation costs to both the industry and society (Sells, 2015).

Expected Costs

As reported in the Mid-America Freight Coalition TPMS Synthesis (Perry, Oberhart and Wagner, 2015) 2015), the costs to implement truck parking management systems ranged between $2.04 million (Minnesota) to $4.4 million (Michigan) and $4.8 million (I-95 corridor). Detailed costs of the Michigan include: $1,711,055.00 for detection, $616,450.00 for communication, $2,080,719.00 for other costs. The project's annual maintenance cost include: $247,500.00 for detection, $20,315.00 for communication.

In the proposed REEPT project for California, the expected total cost is comparable to that of the Michigan project. It will cost $4.8 million at 10 locations over 3 years to install REEPT, establish the network; provide system enhancements, operate and maintain the system and network for two years after launch, develop and perform third party evaluations, and recruit users through an aggressive public relations and outreach campaign. In addition, REEPT will provide in-kind support of between $1 and 2 million in licensing and labor. Additional data services defined and developed during years two and three will support operational expenses (Sells, 2015).

Role of the Public Sector

A major role of the public sector, in particular the federal and state authorities, is to provide leadership in establishing a regional smart truck parking system. All previously mentioned examples (proposed or implemented) of statewide smart truck parking required the leadership from state transportation authorities (MDOT-Michigan, Caltrans-California, etc.) and the support from FHWA. It may be the most effective and efficient for the government to lead such projects. Although installation, operation and management of a smart truck parking system can be done by a private firm with the expertise (TSPS, ParkingCarma, etc.), it is still necessary for the public sector to be involved in the process.

Another important role that the public sector plays is to provide funding. For instance, USDOT announced in October 2015 a $25 million grant to the Regional Truck Parking Information and Management System Project to implement technology that alerts drivers to available truck parking in eight Midwestern states (CCJ Staff, 2015). In the case of REEPT in California, it also notes that the proposed project needs government funding for initial installation and operations. The level of funding could be reduced by support from interagency partners to assist with outreach and the marketing of system availability. REEPT will become the foundation for other services that generate revenues. Signs on any government facilities will be the responsibility of the agency to acquire and install. REEPT will provide connectivity and data feeds (Sells, 2015).

Implementation Challenges

There are several implementation challenges to a statewide smart truck parking system. First, California currently has a mix of public and private truck parking facilities that are managed and operated differently. A statewide system would require establishment of standards and oversight, as well as participation in a single information system, or interoperable systems.

Second, there is a question regarding the state's capacity to lead and contribute to funding a major technology development and implementation project.

Third, the truck parking shortage is so severe, especially near or within the major metropolitan areas, that increasing the supply of parking would have to be part of any smart parking plan. There are innovations emerging in response to the shortage, such as logistics facilities providing overnight parking; these would have to be incorporated into the smart parking information system. Fourth, charging for parking is likely to be necessary to generate the funds to operate a smart parking system. Truckers may be reticent to pay for parking, and without sufficient enforcement may park illegally rather than pay. Thus incentives would need to be developed, for example security and specialized services.

Measuring Success

At the moment, most states only collect data about crashes and fatalities. The handful of states that already collect customer satisfaction information could easily develop a customer segmentation approach to address truck operator satisfaction and use with a truck smart parking system. States wishing to pursue such a system should establish measures prior to system design and implementation. Baseline levels for these measures should be collected before a system is implemented.
Recommended performance measures include:

- Level of awareness of facilities
- Acceptance and use of parking information system
- Changes in search time and difficulty in locating parking
- Changes in truck-related crashes
- Changes in illegal parking
- Changes of utilization of parking facilities

Table 2 below provides a more detailed explanation of the metrics.

Table 2 Truck Parking Performance Measures (Perry, Oberhart and Wagner, 2015)

Measure	Importance	Data Requirement	Collection Strategy	Difficulty
Level of awareness, acceptance and use of TPMS	★★★★	Truck drivers' attitudes toward system	Questionnaires at parking facilities	★★★★
Change in parking search time and difficulty	★★★★★	Parking search time	Questionnaires at parking facilities	★★★★
Changes in truck-related crashes and fatalities	★★★★	Truck-related crash and fatality records	Police crash reports	★★
Changes in amount of illegal parking	★★★	Number of illegally-parked trucks	On-road observations	★★★
Change in utilization of facilities in system	★★★	Count of trucks parked	Automatic counting via detection tech	★★★★

★★★★★–most important or difficult, ★–least important or difficult

PUSH FREIGHT TRAFFIC INFORMATION SYSTEM

Statement of the Problem

Freight shipment reflects positive growth, and through the last few years, globalization, competitive industry trends, and new technologies are all pushing freight volumes up in throughout the U.S. For example, in Washington, freight has grown twice as fast as its overall population and traffic growth (Washington State Department of Transportation, n.d.). California (especially Southern California) is home to the nation's largest container port complex, a major air cargo center, a West Coast rail hub, and numerous regional distribution centers.

As the second largest metropolitan area in the U.S., Southern California also represents one of the largest local markets for freight services in the country. Regional and local distribution, domestic trade and national distribution, and international trade all contribute to the increasing volume of freight movement in the Greater Los Angeles area: Based on the Freight Analysis Framework, FHWA estimated that over 223 million tons of freight were shipped internally within the Southern California region – approximately 30 percent of the total freight shipped in the region; Southern California is also one of the leading manufacturing centers in the nation, generating shipments for domestic trade with the rest of the U.S; Shipments between Southern California and the rest of the country account for 447 million tons, or over 60 percent of freight shipped in the region. Southern California is also a large gateway for international trade. Over 11 percent of the nation's trade (by value) passes through the region and it collects over 37 percent of the nation's import duties.

As a major population and employment growth region, Southern California is facing great demand growth for freight transportation services, too. According to the Southern California Association of Governments, freight transportation demand is expected to grow by 80 percent between 1995 and 2020, which would further lead to congestion and air quality issues. (Federal Highway Administration, n.d.)

At the same time, freight has its own travel difficulties: truckers are faced with many restrictions like height, weight, length, width, roundabouts, etc. and their travel affected by weather and construction conditions. Real-time or near real-time traffic information is widely available, but most of the time there's no specific sites for truckers to obtain freight-specific information, not to mention that access usually requires action on the part of the traveler. As a result, the trucking community is not fully aware of the available traveler information that is already available. (Freight Mobility Strategic Investment Board and Washington State Department of Transportation, 2008)

Description of the Strategy

A push information system is a subscriber system: All trucks licensed to do business could enroll in a "freight advisory service", which would push out relevant traffic information as it becomes available, rather than having the trucker "pull" or seek out such information. A push system seeks to reduce travel time by alerting truckers on rail crossing, accident or other delays, and on road closures, weather alerts, etc. A more sophisticated system that allows for real-time truck location communication could also provide alerts for oversize trucks and loads regarding routes. Some states have set some good examples in providing freight-specific traveler information and taking the lead to develop “push information systems” for truckers.

Washington developed “Freight Alerts”, which is an automated e-mail and text message system that sends notification to subscribers about high value predictive information that allows them to plan their routes, staffing and equipment needs, and stage inventory. This system informs freight shippers and carriers on what will happen to freight corridors during planned construction disruptions, and during unplanned, emergency disruptions. (Washington State Department of Transportation, 2013)

WSDOT developed this system in 2007 and implemented it in 2009. Individuals can sign up to receive e-mail on the status of closures and other activities affecting freight, and by 2014, 30000 people have signed up. The alert system has been an effective practice for enhancing communications within this distinct and important sector. (Baglin, 2014) The following information is covered by this notification system: Permits for oversize and overweight vehicles; Information related to the legal weight limits and calculators to determine truck weights; Information to obtain a transponder to bypass state weight stations through the Commercial Vehicle Information System and Networks (CVISN); News related to major construction; Links to traveler information for the three-state I-5 Corridor. (Freight Mobility Strategic Investment Board and Washington State Department of Transportation, 2008)

Minnesota has a one-stop-shop site for truckers to get restriction information specifically tailored for freight. It is imbedded in the 511 website (http://tr.511mn.org/index.jsp), and includes information on winter driving, road reports, restrictions, and weather stations. It has a similar feature of a “push information system” called “Personalize Your 511”that allows users to create up to 20 various routes and get e-mail and text message alerts.

CommuterLink is Utah’s Intelligent Transportation System (ITS), which is a network of resources designed to maximize the efficiency of transportation in the state and help residents “Know Before You Go” a transportation services information program designed to keep travelers updated about road conditions and delays (Cisco Systems Inc., 2004). It enables registered users to receive notification alerts of incidents on freeways. The alerts can be sent to any device capable of receiving e-mail or text messages, such as personal computers, cellular phones, PDAs, and text pagers. Users can customize their alert profiles by indicating the type of incidents they are interested in and the time of day they want to receive alerts. (Kimley-Horn and Assoc., Inc. and Cambridge Systematics, Inc., 2009)

Components of a push information system are as the following graph shows (Figure 8). The information source provides new data for a specific channel to the broadcaster. The broadcaster applies filters on the data to limit data transfers and sends the data (in parallel or iteratively) to a set of repeaters (for scalability reasons) for which the filters succeeded. The repeaters then redistribute the data to receivers. For higher scalability, additional levels of repeaters may be necessary. Every broadcaster can send to multiple channels and every receiver can receive from multiple channels. In Figure 8 some of the arcs representing channels and backchannels cut through components of the transport system to motivate that these components are necessary for scalability purposes but are transparent to the channels and the dissemination process. (Hauswirth and Jazayeri, 1999)

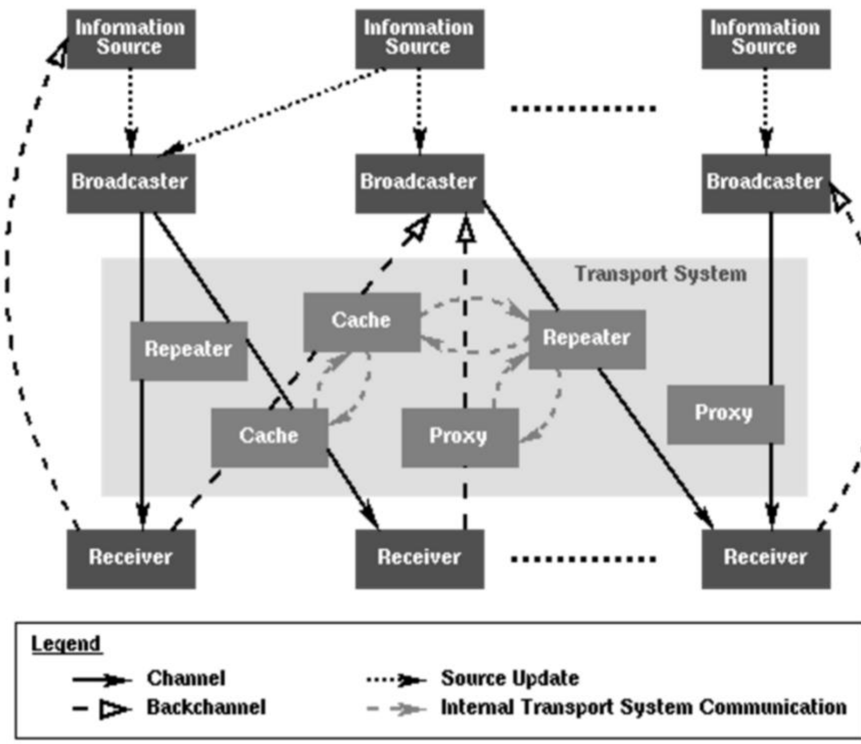


Figure 8 Components of Push Information System (Source: XXXXX)

To build such a freight push information system, the following data would be necessary: Location of roads; Status of roads (e.g., road quality or temporary construction on the roads); Types of vehicles that can utilize the road; Limitations and congestion; Real-time information (congestion, accident, etc.). (Ranaiefar, 2012)

Expected Benefits

A push information system for freight is beneficial: It provides easier access for truckers with relevant information; It minimizes traffic by helping freight avoid construction areas; It also minimizes additional traffic disruptions by avoiding oversize/over-height/over-width loads that might add more delays or problems; It improves truck mobility by increasing knowledge of construction activity, incidents, and border congestion that allows trucks to plan routes and schedule travel; It reduces local impacts; It also improves safety by increasing compliance with weight and permitting restrictions. (Washington State Department of Transportation, 2008)

Based on ITS successes in other cities, UDOT developed three primary goals for the 'Know Before You Go" initiative. First they wanted to reduce freeway delays by 20 percent, increase peak-hour freeway speeds by 15 percent, and reduce signal stops and intersection delays by 20 percent. Second, they wanted to enable emergency personnel to identify and respond quicker to traffic incidents. And third, they wanted to provide traffic, weather, and accident information to Utah travelers via radio, television, the UDOT Website, electronic message signs, and a toll-free telephone travel information line. (Cisco Systems Inc., 2004)

Expected Costs

Washington State's Freight Alerts system's cost estimate is $380,000, and it requires 1 Full-time Equivalent (FTE) to consolidate and maintain web-based information, and 1⁄2 FTE to develop and implement training program for trucking industry. (Washington State Department of Transportation, 2008)

Utah DOT spent approximately $1 million initially to develop the ATMS and ATIS software that form the core of CommuterLink. Annual software support costs for CommuterLink are approximately $50,000. The 511 phone system costs approximately $275,000 annually in usage charges. UDOT has six full-time staff dedicated to operating and maintaining CommuterLink at UDOT‟s TOC. UDOT periodically implements enhancements to CommuterLink. The cost of designing and implementing these enhancements varies, but it is typically in the $200,000 to $300,000 range. UDOT spent $50,000 setting up the mobile web capabilities and has a $25,000 annual maintenance contract. (Kimley-Horn and Assoc., Inc. and Cambridge Systematics, Inc., 2009)

Minnesota's Trucker Info's upfront cost is $150,000, and annual maintenance and operations cost is $10,000.

Role of the Public Sector

The state government has the responsibility to ensure the provision of traveler information to the public, especially information that will assist in preventing, avoiding or minimizing travel-related crashes and incidents, and make sure that the transportation system operates efficiently, especially in terms of reducing congestion and delay. (Minnesota State Department of Transportation, n.d.) The State DOT should also encourage the development of public/private sector partnerships, for example, WSDOT is currently contracting with a third-party subscription alert system that could be used to disseminate truck information. (Washington State Department of Transportation, 2008) The State DOT should provide funding for development and operations for the strategy, too. And finally, the government should also plan an outreach and public information effort to inform the trucking industry of the tools and information available.

Implementation Challenges

The freight push information system is a relatively simple concept, and there are examples in other states to help guide an implementation plan. The state of California, through Caltrans, state highway patrol, and state emergency services have the information that would be part of a push system. Most of this information is available now on websites or via 511 services. Thus the main challenge would be developing the system and finding the funds to pay for it. Longer term, the system could be expanded beyond the state highway network. In addition, the push system could become of a larger freight information platform, as discussed in the next strategy section.

Measuring Success

Several metrics could be used to measure the success of this strategy. Travel Time Delay is an important measure, as the main purpose of this strategy is to provide better access to information and reduce congestion. Connectivity is another useful measure, since the ultimate goal is to increase connectivity and efficiency. Crashes – Truck and Reliability is also a good measure as it is focused on safety issues. Emission measures the eco-efficiency of the strategy, and is meaningful in the long run. (Alameda County Goods Movement Plan Task 4B: Strategies Evaluation)

STATEWIDE FREIGHT INFORMATION PLATFORM

Statement of the Problem

Freight trucks serve the important function of delivering goods to communities. Often these communities plan their transportation networks without freight in mind. Conflicts with land use and design burden the trucking industry in regards to routing. (United States Department of Transportation, 2012) Communities want to separate freight activity from residential uses. They also design roads for personal vehicles, bicycles, pedestrians, and even transit but disregard freight compatibility. As a result many roads are not suitable for large trucks. Communities legislate which roads truck are and are not permitted to navigate. There is pressure on the industry side as well, for example the Port of Los Angeles has language on their concession agreement requiring licensed motor carriers to abide local truck route and prohibitions. (Port of Los Angeles, 2016) Carriers in violation could face penalties that can have devastating impact on their already thin margins.

The process of avoiding restricted routes can be costly as well. Searching for legal routes has many of the same drawbacks of searching for parking. Delay in delivery because of route searching increases VMT and emissions compared to an optimized route. (Suzuki, 2011) Time lost searching is a burden for multi-destination freight trips. Even when a route is not labeled as restricted a driver may find that the design of the road geometry may not be suitable due to clearance over head or at intersections. Oversight in signage or policy on part of the community may lead to damaged property due to inadequate turning radius or low clearance on bridges. This uncertainty can hinder real time routing efforts if the data on which it is based is not reliable.

Institutional and Informational barriers to truck route data exist. In California CALTRANS hosts state level trucking information for the state as a whole. However they can only advise to contact local municipalities regarding the existence and location of legal truck routes through municipalities. (CALTRANSa, 2016) Even then, many cities in California do not have easily accessible route maps or information on their websites. (CALTRANSb, 2016) The only method available is to confirm the existence of a truck route on-site which leads to inefficiencies.

Description of the Strategy

Resolving the local route dilemma will require a statewide effort. Other states have already pioneered efforts to resolve these issues. Illinois and Connecticut for example have centralized truck route information. Florida passed legislation that ensure land use and design compatibility of local tuck routes. Lessons can be learned from these states to develop a strategy for California.

In Connecticut the state legislates truck prohibitions. (CTDOT, 2012) The head authority on this matter is the state traffic administration OSTA. They have jurisdiction over every city, town or borough within the state in regards to freight traffic. Municipalities must request non-delivery truck prohibitions from the Executive Director of the OSTA for review and consideration. OSTA initiates an investigation and informs the municipality of their findings. The municipality must be in agreement before a through truck prohibition is enacted. The state maintains a list of roads with truck prohibitions in pdf format. (OSTA, 2012)

In 2012 Illinois required local public agencies to report all local truck routes under their jurisdiction to the state DOT. (Illinois General Assembly, 2012) The DOT is responsible for the collection and publishing of the data. Currently the DOT displays the data on their website in the form of an ESRI hosted map. (Illinois Department of Transportation, 2016) This map contains permitted truck routes at the state and local levels all in one location.

Florida took another approach to protect existing truck routes. In 1995 the state passed legislation requiring the creation of corridor management plans. (The Florida Senate, 2016) These plans are administered locally and require the city to map and protect truck routes by checking developments/road improvements for compatibility. Any changes to the transportation corridors that could negatively impact freight compatibility were to be reported to FDOT. (Williams & Frey, 2003) While this only applied to major truck routes it demonstrates a method by which local municipalities were made accountable to catalog and ensure exiting routes stay accessible.

California could adopt a hybrid strategy that can take portions of what these states have done. The state of California does have the challenge of a large population and geography. Data gathering will likely be best carried out at the regional level. In order to be cost effective, the data gathering should be coupled with an existing data gathering process. An existing practice that could incorporate truck route data could be through Regional Transportation Plans. The guidelines for RTPs call for a Goods Movement element. (California Transportation Commission, 2010) This element could incorporate plans on preserving and identifying truck routes. A map of local truck routes would be a natural addition. Lead agencies would then pass the data to the state, specifically CALTRANS.

It may be noted that the information platform for routes could be extended to other types of information and could be linked with the push information system described in the previous section. Should these recommendations be implemented, coordination would be helpful.

Role of the Public Sector

Local municipalities will need to dedicate some effort into collecting their truck route regulations into a deliverable format. Currently, cities have publicly available data in various formats. Some have it only in their municipal code as text, others as a pdf image in their general plan. The standardization could take place at the local level or the lead agencies over RTPs can take on that task. Shapefiles with attributes specifying restrictions details such as weight, type, height, or axels would be adequate.

Once the local data is centrally located along with the state level data there are a couple of strategies that can be taken to distribute it. The simplest approach is taking the open data approach. The hope is that private entities take the raw data and incorporate it into applications that can be used by freight carriers in routing. Alternatively CALTRANS could develop the routing platform themselves or bundle it with other freight services.

Expected Benefits

Having local route information will effectively address the issues of route searching and re-routing. Carriers can confidently optimize their routes and minimize VMT. Efficient routes could have modest emissions reductions. (Robinson & Foytik, 2014) Reduction in violations fines will reduce operating costs. Additionally hazardous freight can be safely navigated through proper routes.

Expected Costs

Expected costs can be kept to a minimum. By appending the data gathering process to an existing practice, only additional labor hours will be needed to meet the objective. Conversely legislating a new mandate could be costly in time and drafting. Data hosting costs are variable depending on the format. FTP would be cost effective while having a visual tool to go along with it would be less so. A hosted map with visual capabilities, similar to the one Illinois has, cost varies depending on the licensing agreement CALTRANS has with mapping services. Developing a custom routing application again varies depending on software development contracts but certain types can cost hundreds of thousands. (USDOT Intelligent Transportation System Joint Program Office, 2016)

Implementation Challenges

There are a few challenges to implementation. First, providing data for public use requires reliability. Information that is outdated, incorrect or incomplete undermines the goal of the endeavor. There could be legal liability where carriers following route data provided in good faith but are fined for a local violation. A disclaimer should be provided similar to that of Illinois web service. (Illinois Department of Transportation, 2016) Second, the data must be consistent. Municipalities may have differing definitions in their legal codes as to permit vehicle types. Having a unified statewide coding convention for truck routes can reduce errors and mistakes in routing. Third, given the fiscal constraints facing local governments, cities may resist a mandate from the state, and/or seek reimbursement for any costs associated with providing the information.

Measuring Success

To measure the success of the effort we can look at a couple of metrics. This system is expected to improve efficiency. Those saving should be evident in the financial saving of freight carriers. Optimal routing reduces VMT and travel time while increasing productivity. Tracking these changes in the financials of trucking firms could provide insight. Alternatively we can track the loss revenue of cities due to increased truck compliance. However possibly the best way is to use GPS technology to measure impacts before and after implementation. There are priors to using such a method to measure the success of freight infrastructure improvements. (McCormack & Hallenbeck, 2006)

BORDER REGION ITS STRATEGY

Statement of the Problem

The San Diego Association of Governments (SANDAG), working in partnership with U.S. Customs and Border Protection (CBP), the U.S. Department of Transportation (USDOT), the California Department of Transportation (Caltrans) and the U.S. General Services Administration (GSA), is undertaking the State Route 11 (SR11) and Otay Mesa East (OME) Port of Entry (POE) project. Mexican government agencies are advancing the companion project known as Mesa de Otay II POE and connecting roadways, which will develop a border crossing facility in Mexico as a partner to the new OME POE.

The purpose of this project is to decrease wait times, alleviate border traffic congestion, and reduce emissions by adding capacity to the regional border-crossing infrastructure[1]. This project would create a link between the U.S. regional highway system and roadway system in Mexico. This link will ensure the continued flow of $39B in cross border trade (2014) through the California/Baja California region. The need for this project is clear since trade and travel in this area is forecasted to continue to grow rapidly in the region and border delays are expected to increase correspondingly. These delays have economic impacts at the regional, state, and national levels.

The SR11 Project

The goal of the project is to reduce delays caused by traffic congestion and associated impacts while also accommodating projected trade and travel demand. This project will subsequently stimulate economic growth and job opportunities on both sides of the border.
To meet this goal, the vision for the project, is to develop a new cross-border facility and associated transportation facility, SR11, which will be a “state-of-the-art” border-crossing

[1] There are currently three ports of entry in the region: San Ysidro, Otay Mesa and Tecate. Otay Mesa East will be the fourth.

facility. The proposed POE facility will be located approximately two miles east of the current OME POE and will ultimately be the third border crossing along the San Diego region's border with Tijuana, as well as the fourth crossing between Mexico and San Diego County.

Key objectives of the proposed POE include:

- Optimizing the efficiency of the new POE by using state-of-the-art ITS and cutting-edge operating concepts.
- Financing the facility through self-sustaining cash flows derived primarily through tolls.
- Integrating a toll-pricing demand management model at the border that is based on crossing time and focused on congestion management and emissions reduction.
- Designing the project as a national model of public/public partnering.
- Developing a project that serves as an example for both environmental and economic benefits.

Description of the Strategy

The ITS strategy will serve three primary purposes.

- First it will provide the underlying infrastructure and hardware and software applications to support entire toll collection system for the new port of entry. This will be developed through a Concept of Operations (ConOps) and establishment of system requirements to feed into the project alternatives analysis, design and implementation stages.

- Second, the ITS strategy through the ConOps and system requirements, will provide the required process and suggested applications (a "blueprint") to be integrated into a Regional Border Management System (RBMS). The RBMS will provide for binational communication and coordinated traffic management between the existing Caltrans Transportation Management Center (TMC) and a new Tijuana/Mexico Regional TMC.

- Lastly, the ITS strategy will involve multiple facets related to enhanced traffic flow (reduced congestion) goals for U.S./Mexico port of entry operations including the management of the lanes used to approach the port of entry and advanced traveler information to be made available directly for users. Advanced technologies to facilitate flow will include license plate reader (LPR), Wi-Fi, RFID, among others with the capability to serve the needs of Customs operations for both the U.S. and Mexico, as well as inform passenger and commercial users about wit times. Other flow enhancements include automated signage and/or changeable constructed barriers to allow for optimal management prior to entering the port of entry.

Other Similar Sustainable Freight Applications Using ITS Advanced Technologies

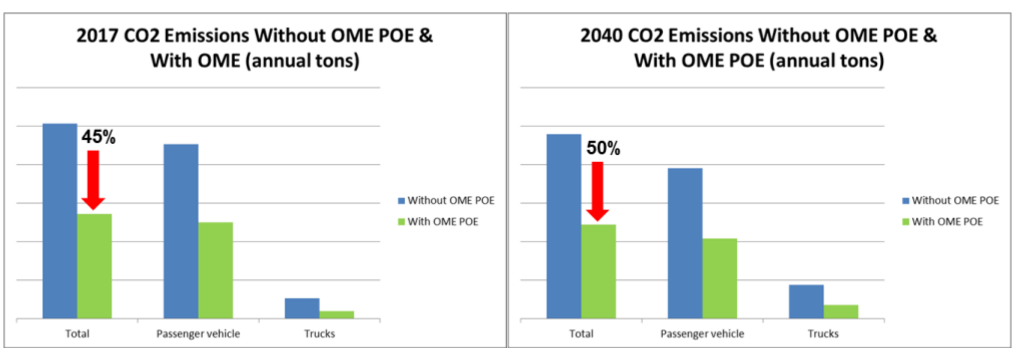
Two examples that relate to the Border Region ITS Strategy include the FRATIS demo (greater Los Angeles) project and the existing Interstate 15 Express Lanes in San Diego County. Similar to the FRATIS system, The Border Region ITS Strategy will rely upon the exchange of data and information between the Caltrans TMC, and newly developed RBMS and Tijuana/Mexico TMC. Concepts as a part of this include traveler information for both passenger and commercial users, messaging signage for all users, as well as potential integration into shipping industries where dispatchers may be involved through the process for commercial activities.

The Interstate 15 Express Lane facility currently utilizes a variable toll system which is priced to facilitate demand management. The I-15 toll road toll transponder technology is integrated with other Southern California regions by the FastTrack technologies. The toll rates vary with traveler demand, and have proven to be effective with congestion management in the region. Users of the system are able to access information to determine the value of their trip based upon a variable toll. This system also serves as part of the region's Integrated Corridor Management System (ICMS) which has dynamic routing for incident management. Additionally, this I-15 system is integrated into the Caltrans TMC with all other Interstate/Highway facilities. The combined experience of SANDAG and Caltrans District 11 for tolling and TMC operations will be leveraged for the regional border systems directly through the Border Region ITS Strategy.

Expected Benefits

The travel environment that exists in the San Diego border region is unpredictable and time consuming with wait times as long as over two to three hours. The Border Region ITS will serve as a critical component for the goal of achieving a 20-minute wait time at the new Otay Mesa East border crossing. The added capacity of a new border crossing incorporating the ITS strategy will provide users with an option to efficiently use this extra capacity.

In addition to congestion relief at the border, reductions in greenhouse gas emissions and particulate matter pollutants will potentially be a resulting benefit as passenger and commercial vehicles spend less time idling on the approach roads leading to the POEs.



Anticipated CO2 Reduction Benefits by Border Region ITS Strategy (Source: SANDAG)[2]

[2]The difference between CO2 emissions is primarily driven by assumptions from implementing the SR 11 facility and OME new border crossing. This is due to the fact that the Traffic & Revenue Study assumes a rate of traffic diversion that occurs once the new POE is operational. This diversion rate reduces the number of passenger and commercial vehicles crossing at San Ysidro and Otay Mesa which reduces the respective existing delays at those crossings. The SR 11 OME border crossings provides new capacity, which is managed by a toll system which generates a wait time much lower than the existing border crossing delays. In addition to the diversion and estimated travel time savings, idling emission rates were used from the 2008 EPA report below. Combined there is a systemwide reduction of CO2 emissions.

Other benefits over the long-term include having a more integrated regional traffic management system that includes all border crossings and the collection of information related to wait times at each border crossings allowing users to make more informed travel decisions. The end goal is maximizing the capacity efficiency for border crossers.

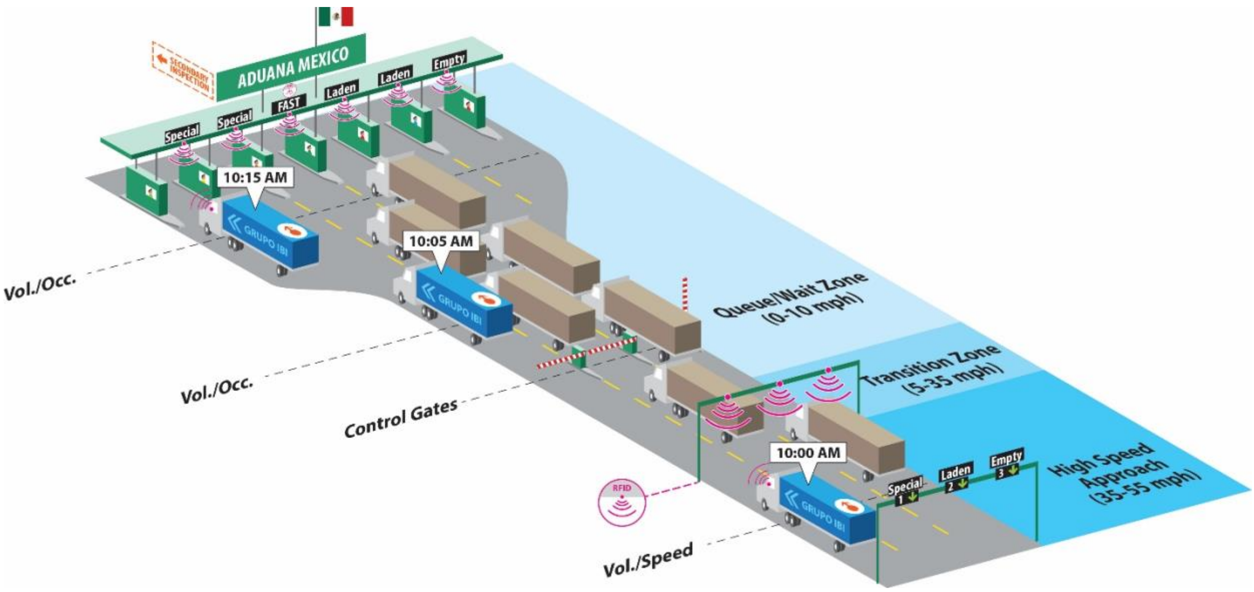


Figure 9 Approaching OME/Mesa de Otay II POE, queue, Aduanas northbound/outbound primary inspection (Source: IBI Group, 2014)

Expected Costs

The preliminary cost estimate is around the level of $40 million as outlined in the Concept of Operations (part of the on-going federally funded Pre-Deployment Strategy).

Role of the Public Sector

The lead public sector implementing agencies involved in this process include SANDAG and Caltrans District 11. Together, these agencies are the project sponsors, while other US federal partners include Customs and Border Protection (CBP), the General Services Administration (GSA) and the U.S. Department of Transportation (USDOT) play varying roles in the project's development. These include staffing and operational and maintenance, and primary use of the port of entry by CBP, ownership and development of the port of entry by GSA, and financing support from the USDOT. Both CBP and USDOT are also involved in providing important support for diplomatic relationships with Mexico's comparable government agencies.

At the binational level there is a Memorandum of Understanding signed in July 2014 between Mexico and California and binational, multi-agency oversight committee has been formed to expedite the Border Region ITS Strategy and ultimate construction of the SR 11/Otay Mesa East Project. The committee held its first meeting in November 2014 and meets regularly to work on key project milestones.

Terms of the federal ITS Pre-deployment Study (USDOT Sponsored) indicate that all the ITS Border Strategy should fully scope intelligent systems on both the US and MX side of the border; it must be fully integrated and coordinated in order to improve traffic flows. Border traffic optimization must occur with bi-national authorities.

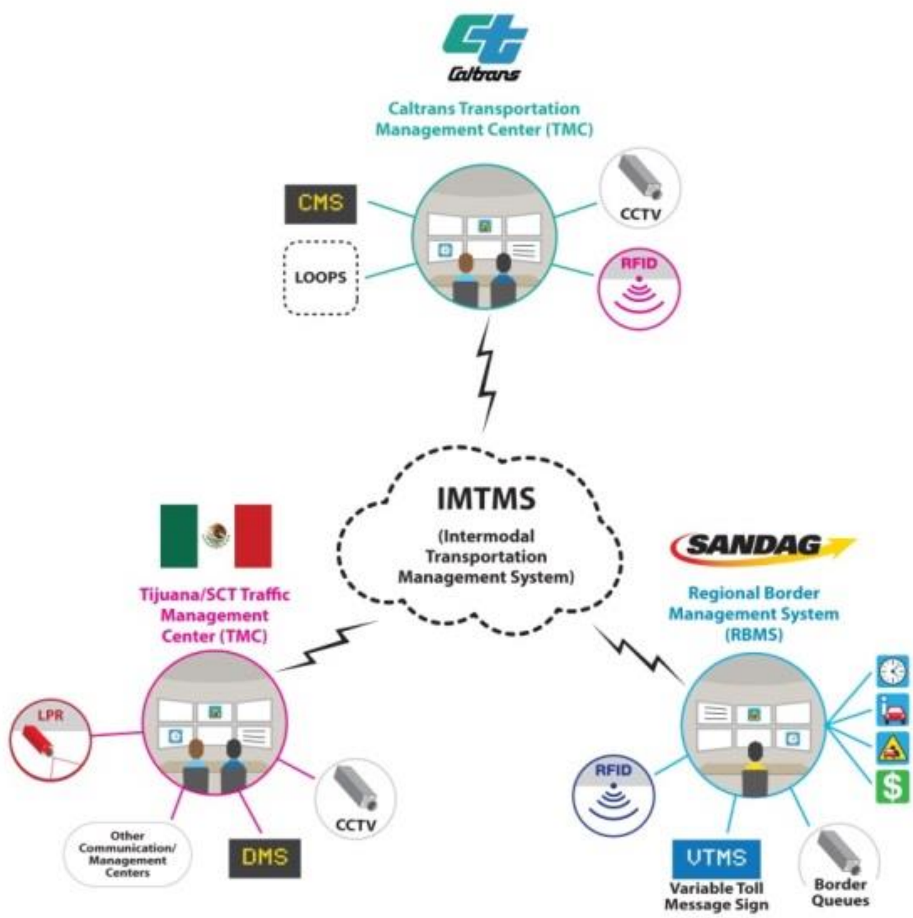


Figure 10 Basic operation and coordination concept between Regional Border Management System and Traffic Management Centers in US and MX (Source: IBI Group, 2014)

Implementation Challenges

As a binational project, there are implementation challenges for the project. These include coordination with local, state and federal partners in the United States, coordination with local, state and federal partners in Mexico, integrated data collection and information sharing across two different countries, and timely execution and implementation of the project based upon toll revenue generated financing.

Working through all levels of government within the United States is no easy task and the project has many responsibilities to ensure that this process is successful. Duplicating all processes with Mexico is a substantial undertaking and requires significant resources. The bilateral coordination across 30 border related agencies the border requires significant time and resources.

The project has been elevated to the High Level Economic Dialogue at the federal level with support from both the State of California and Mexico; so for all purposes this project has become federalized by both the US and MX. Despite major achievements to date, the remaining schedule of the project will require the same level of effort as the project progresses towards implementation. These risks will be managed until the project is constructed and opened to traffic. The project sponsors will look to build on past success to continue moving the project forward.

Measuring Success

These strategies are aimed at achieving the State's Sustainable Freight objectives (GHG reductions, emissions reductions, economic competitiveness and application of advanced technologies).

The Border Region ITS Strategy will provide for a reduction in travel times which will allow for the opportunity to reduce GHG emissions, while improving the throughput of both passenger and commercial users providing for economic competitiveness. The wait time information which will be provided through the ITS strategy will be able to accurately measure the time it takes users to cross through the border crossing; including from Mexico to the California State Highway system. This information will inform economic competitiveness directly as SANDAG has multiple studies that provide information of the economic impact from border wait times.

Additionally, SANDAG is close to updating the economic impacts from border wait times and will also be looking impacts to GHG. So an updated border wait time study is being launched to provide information for analyzing wait times and their impacts on to both economic competitiveness and GHG emissions.

FREIGHT-FOCUSED TRAFFIC MANAGEMENT

Statement of the Problem

The majority of freight movement in California is made by trucks, which account for a significant portion of traffic on the state's highway systems, especially along major freight corridors such as I-710 and I-5. These freight trucks both cause and suffer from delays due to traffic congestion on highways. They also contribute to and experience traffic congestion on surface streets on their way to pick up and make delivery, especially in urban areas.

There are several traffic management strategies that can mitigate traffic congestion, reduce travel delay, and improve trip time reliability. Most of the strategies in use today are focused on the general needs and characteristics of passenger cars. However, the physical characteristics and operational needs of freight trucks are different from those of passenger cars. Therefore, there are opportunities to improve existing traffic management strategies by giving more consideration to the needs and characteristics of freight trucks, and to develop new freight-focused traffic management strategies that can be deployed in areas where the share of truck traffic is high.

Description of the Strategy

Freight-focused traffic management strategies consider the physical characteristics and operational needs of trucks, and place greater weight on reducing their travel delay for, for example, in signal timing at intersections and ramp meters. Doing so would increase travel efficiency, save fuel, and reduce emissions for both the trucks and the overall traffic. Some freight-focused traffic management strategies can be implemented in the near term with the use of existing technologies. Others that look to take advantage of Connected and Automated Vehicle technologies may take longer time to develop and deploy. Examples of freight-focused traffic management strategies are given below.

Freight Signal Priority

Freight signal priority (FSP) allows freight vehicles approaching a traffic signal, at signalized intersections and ramp meters, to request signal priority. It considers the vehicle's location and speed to determine whether priority should be granted. With the Connected Vehicle technology that enables communications between vehicles and infrastructure (e.g., traffic signal), information collected from freight vehicles approaching the traffic signal, such as the vehicle's adherence to its delivery schedule, weight carried, vehicle type (e.g., alternative fuel vehicles), and its fuel consumption and emissions may also be considered in granting priority (see Figure 11). If priority is granted, the traffic signal would turn green sooner or staying green longer, allowing the freight vehicle to pass through more quickly.

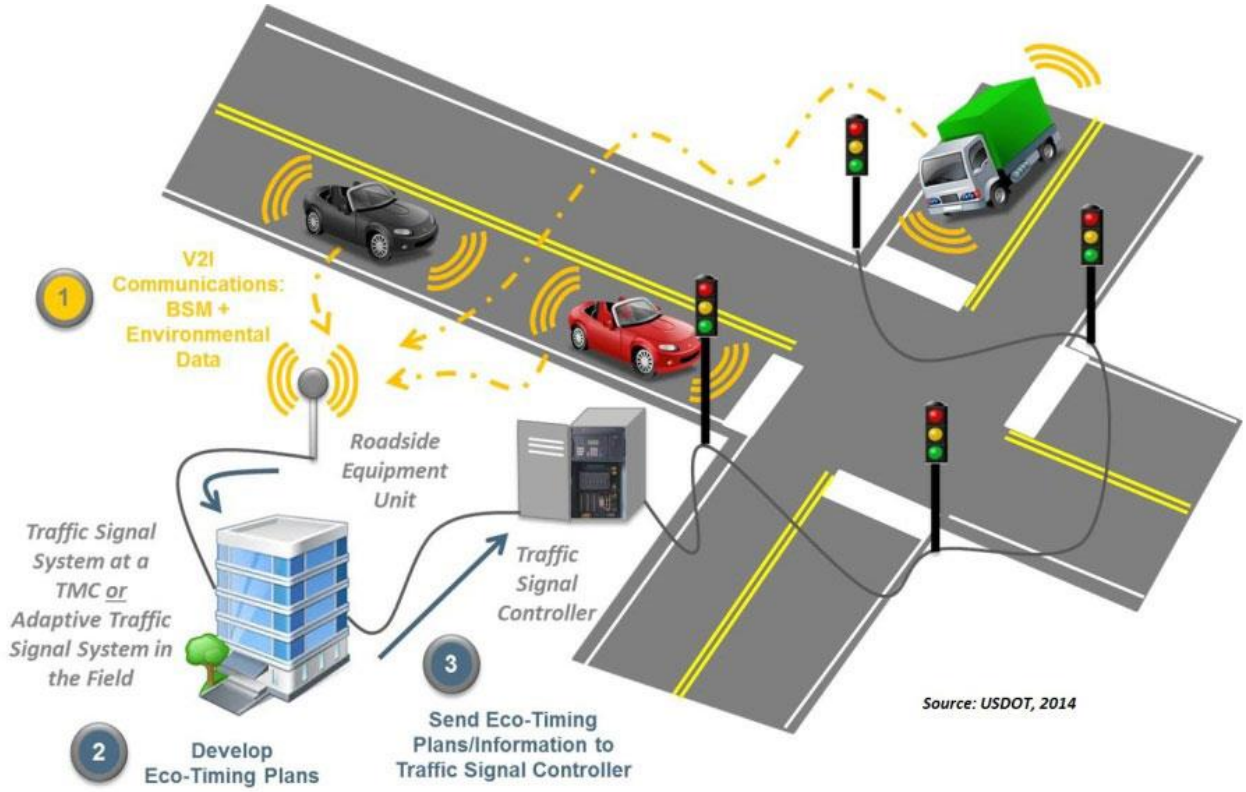


Figure 11 Freight Signal Priority in Connected Vehicle environment (USDOT, 2014b)

Truck Eco-Routing

Many existing fleet management systems utilize route planners that minimize travel distance or travel time. A shortest or fastest route is often not the route with lowest fuel consumption or emissions, particularly in areas with hilly terrain or heavy traffic congestion. On the other hand, truck eco-routing calculates the most environmentally friendly travel route for a truck considering its engine size, weight carried, road grade, and real-time traffic condition (Scora et al., 2013). If applicable, it can also take into account time window to ensure that the pick up or delivery will be made on time. Truck eco-routing provides trucking companies and truck drivers with an additional route planning option (see Figure 12), which they can use to improve the efficiency of their trucking operations.

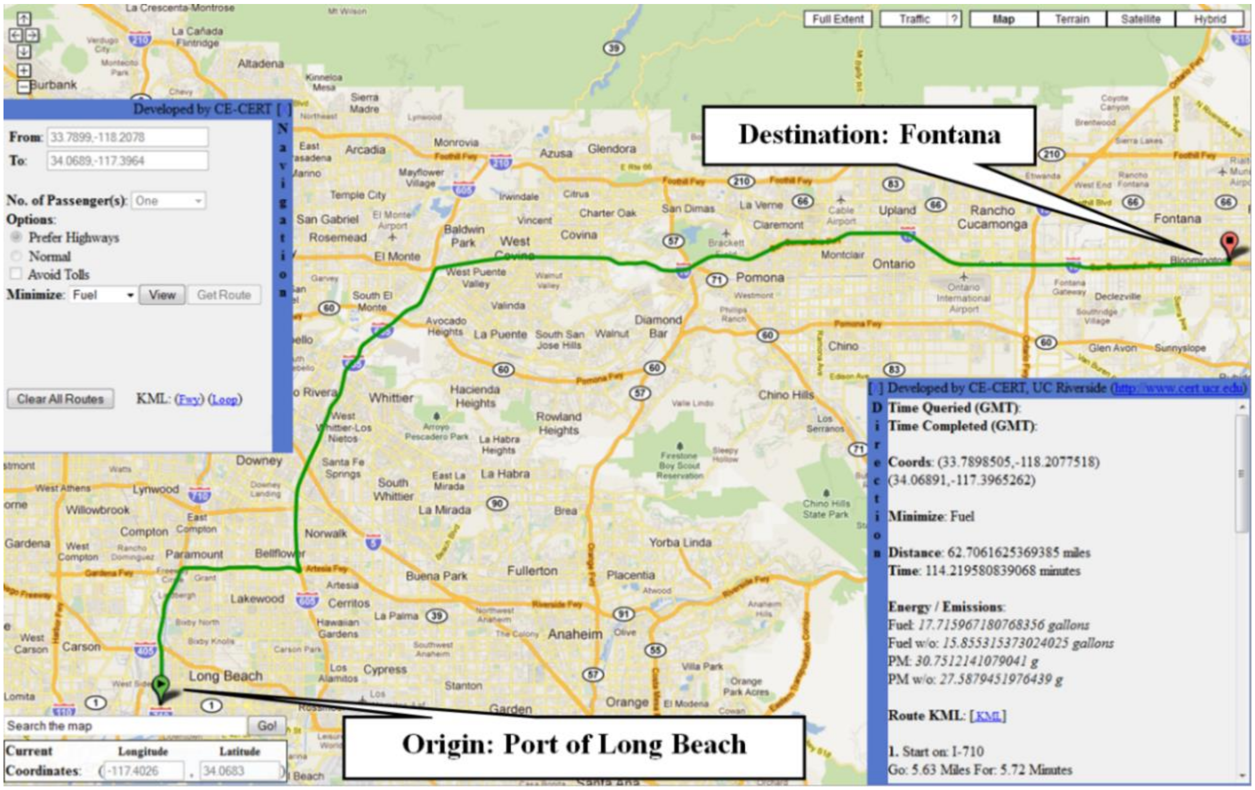


Figure 12 Truck eco-routing application

Expected Benefits

In the case of FSP, a simulation modeling study (Yelchuru et al., 2014) shows that a FSP scheme that is geared towards reducing fuel consumption (referred to as "Eco-FSP") provides up to 4% fuel savings for freight vehicles that are equipped with Connected Vehicle technology. This is equivalent to $649,000 annual savings for a fleet of 1,000 delivery vehicles driving 30,000 miles on arterials each year. Another simulation modeling study (Kari et al., 2014) show that Eco-FSP reduces travel delay of freight vehicles equipped with Connected Vehicle technology by up to 26%. This study notes that passenger vehicles and unequipped freight vehicles also gain fuel saving benefits, resulting in a system-wide fuel reduction in the order of 5%-10%.

In the case of truck eco-routing, a comparative evaluation of route options for truck (Scora et al., 2015) shows that on average the most fuel-efficient route could save fuel by 9%-18% compared to the fastest route, but taking 16%-36% longer travel time. Despite such tradeoff, the eco-route option may make economic sense if the truck will still arrive at the destination within the required time window (if any). The eco-route option is especially attractive when the truck carries heavy loads or when the fuel prices are high. Thus, truck drivers or fleets can strategically choose to use truck eco-routing for parts of their operations depending on circumstances.

Expected Costs

FSP can be implemented with existing technologies that are used in a similar system called transit signal priority, which costs $8,000 to $35,000 per signal depending on system design and functionality, and type of equipment (USDOT, 2002). Note that these estimates were made in 2002 and the technology costs may be much lower at present. Also note that these estimates include the costs for necessary equipment both at the traffic signals and on the vehicles, which in the case of transit signal priority, are typically paid by the transit agency implementing the system. If FSP is to be implemented with Connected Vehicle technology that utilizes Dedicated Short-Range Communication (DSRC) devices, the capital costs would range from $48,000 to $51,600 (in 2013 dollars) per traffic signal (USDOT, 2014c) while the annual operations, maintenance, and replacement costs would range from $1,950 to $3,050 per traffic signal (USDOT, 2014a). These infrastructure-related costs would likely be paid by the public agency responsible for the traffic signal. On the vehicle side, the capital costs would be around $4,150 while the annual costs would vary (USDOT, 2014d). These costs are presumably the responsibility of the vehicle owner.

For truck eco-routing, the implementation costs are expected to be minimal. Most truck drivers and truck fleets are already using some forms of route planning system. The eco-routing option would likely be offered by developer as an added feature to the existing route planning system.

Role of the Public Sector

Government agencies at all levels have a significant role to play in the freight-focused traffic management strategies in the same way as in the existing traffic management strategies. As owners of roadway facilities, state and local transportation agencies will manage their facilities in a way that achieves their safety, mobility, and sustainability goals. They will serve as the entity responsible for the planning, design, and implementation as well as the operations and maintenance of the freight-focused traffic management strategies. The federal government will lead research and development of new strategies, coordinate technology transfer activities, and provide financial and technical support for the deployment.

Implementation Challenges

Challenges to the implementation of freight-focused traffic management strategies may include:

- *Finance* – Implementing these strategies will require financial outlays. In the operating environment of many transportation agencies where resources are limited, it may be difficult for freight-focused traffic management projects to compete with other agency needs, especially if freight traffic in the area is not high.
- *Perception* – Since these traffic management strategies are geared towards freight vehicles, there could be perceptions by the general public that their personal mobility is sacrificed. Managing these perceptions could be a challenge.
- *Private-Public Partnership* – Some freight-focused traffic management strategies such as FSP also require an investment by vehicle or fleet owners. Transportation agencies will need to get their buy-in before the implementation.

Measuring Success

Key performance metrics in measuring the success of freight-focused traffic management strategies include:

- Reduction in travel delay
- Increase in trip time reliability
- Reduction in fuel consumption
- Reductions in vehicle emissions

Data needed for the calculation of these performance metrics will be collected in real-world before and after the implementation of any specific strategies. Note that the performance metrics should be calculated for both freight vehicles and all vehicles in the traffic. It is important that improvements for freight vehicles are not at the cost of other vehicles in the same traffic stream.

CONCLUSIONS

This white paper has presented eight possible IT strategies to address the Governor's order to increase the efficiency and sustainability of California's freight system. Our approach was to frame the problem as one of delay from congestion or uncertainty. Our goal was to identify strategies that generate eco-efficiencies; strategies that both increase efficiency by reducing delays and generate environmental benefits (reduced fuel consumption and GHG emissions). We organized our strategies around two themes: 1) Information problems in the goods movement supply chain, and 2) Information problems in statewide trucking.

We identified eight strategies that are recommended for consideration of implementation. Because of the short time frame of this study, we relied entirely on the existing literature. Some strategies have been tested and studied more than others, hence the information presented here varies from one strategy to another. In no case was there sufficient information to quantify the costs or benefits of implementing the strategy as discussed in this paper. All strategies require additional study before their contribution to efficiency or GHG reduction can be estimated.

Our assessment of the eight strategies are summarized in Table 3 below. Our assessment criteria include cost, implementation time frame, degree of difficulty, potential for efficiency gains, and potential for GHG reductions. We use general rankings of high, medium, and low, except for implementation time frame. All assessments are relative to one another (e.g. "high" means high relative to the other strategies). We stress that these are highly subjective ratings based on very limited information. In general, the highest cost strategies have the longest time frames, the most challenges, and the greatest potential gains. The lowest cost strategies are easier to implement, but due to their limited nature are not expected to have major impacts on efficiency or GHG reductions. These strategies provide a useful starting point for developing a statewide freight efficiency program to achieve California's efficiency goals.

Table 3: Assessment of IT Strategies

Strategy	FRATIS	Appts	Load tracking	Smart parking	Push info system	Info platform	ITS border	Traffic mgmt
Criterion								
Cost	M+	M-	H	H	L	M-	M+	H
Time	3-5	1-3	5-10	5	1-3	1-3	3-4	5-10
Difficulty	M	M	H	M	M-	M-	M+	M+
Efficiency	H	M	M	M	M	M-	M+	M+
GHGs	M	M	H	M	M-	L	M+	M

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Appendix

From the presentation "Smart Truck Parking – Improving the Parking Experience" (Caltrans, University of California, Berkeley, Parking Carma and NAVTEQ, 2011)

PRECEDENTS IN CALIFORNIA (As of 2011)

Goal – to provide truckers with:

- Truck stop attributes.
- Real-time information of parking availability.
- Capability to make advanced parking reservations.

The Team:

- **UC Berkeley TSRC** will provide data collection for evaluation (including focus groups, surveys, and outreach) and the evaluation of the system performance. TSRC will research and highlight the energy and environmental benefits of the project.
- **NAVTEQ** will maintain a database of public and private truck parking with features of importance to truckers.
- **ParkingCarma** will integrate real-time truck parking availability & reservation capabilities with NAVTEQ's customized truck parking mapping & routing services. The company will also customize an interface for truck drivers to access truck parking information as well as directions to parking facilities by VOICE (511 or 800 number), internet (PC or mobile devices), and possibly satellite radio.
- **Caltrans** will provide overall project management and coordination, grant access to public roads and public parking facilities, and provide recruiting support for public outreach.

Two Precedents:

Logistics Terminal, Lathrop CA (sensor testing)

- A drop and hook depot for trucks to deposit and pick up trailers.
- Has spare parking capacity usable by trucks, but is currently not known as an overnight truck parking facility.
- An ideal environment for testing sensor performance for having a single secure gate used for bot entrances and exits.

Flying J (Pilot), Lodi, CA

- Private truck stop with two entrances and 187 spaces that frequently fills up at night.
- Multiple sensing systems would be used and evaluated side-by-side.