

Cross-town Improvement Project Evaluation

final

report



U.S. Department of Transportation
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final report

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

Executive Summary

Even with the recent recession, the volume of freight moved through seaports and major inland ports in the United States has more than tripled over the past 25 years. The growth in urban goods movement that has accompanied this increasing trade has created a number of challenges for large cities, especially those where high volumes of intermodal transfers are taking place. These challenges include severe truck traffic delays around seaports and inland ports, general traffic congestion on urban highways and arterials, and negative regional effects related to air quality, noise, and safety. Freight delays themselves also have a negative economic impact on the private sector.

These issues have spurred considerable research towards identifying promising technological solutions to urban freight management. The FHWA Office of Freight Management and Operations (FHWA-OFM) has sponsored several research projects in this arena, the most recent of which is the Cross-town Improvement Project (C-TIP) in Kansas City. Kansas City is the second largest rail hub in the nation by tonnage after Chicago and has significant volumes of cross-town intermodal handoffs between western and eastern railroads as well as local deliveries to industry.¹ This activity requires cross-town dray truck trips between railheads and from intermodal terminals to shippers around the region. However, due to deficiencies in information sharing and business practices, this commerce also generates a significant amount of bobtail and chassis repositioning moves which generate little or no revenue for carriers while contributing to congestion and other issues in the Kansas City region.

C-TIP seeks to mitigate these problems through:

- A collaborative dispatch model (allowing freight railroads and dray carriers to easily identify load matching opportunities);
- An in-cab smart phone application that provides real-time traffic and routing information to dray truck drivers; and
- An Open Source Architecture Package (C-TIP OSAP) that provides dray dispatchers with real-time driver location data and a wireless communications platform for delivering work orders to drivers, allowing for easy identification of load matching opportunities and thereby reducing unproductive bobbails.

An initial C-TIP system was deployed by Science Applications International Corporation (SAIC) for a four-month period from October 2010 through January

¹ Missouri Economic Research and Information Center, *Missouri Freight Transportation: Economy on the Move*.

2011 in Kansas City. This evaluation was conducted by Cambridge Systematics (CS) in collaboration with RMI and Occur2Strategies. The evaluation methodology was based on an evaluation plan developed by CS.² The evaluation strategy was designed to quantify the time savings and emissions associated with C-TIP, and also to assess nonquantitative factors such as software usability and overall viability in a commercial trucking environment. The evaluation included collection of both publicly available data to assess factors such as emissions reductions as well as proprietary private sector data sets from rail and trucking industry stakeholders who were involved in the test. These data were input into RMI's Vantage software, which is a specialized performance monitoring solution used by railroads and intermodal terminals to maximize efficiency. Vantage is able to provide real-time dashboard displays of key performance metrics for the evaluation, such as emissions reductions, time savings, and bobtail reductions.

This evaluation shows that there is scope to address some of the challenges of urban freight movement with technologies such as C-TIP. A summary of test results is provided in Table ES.1:

- A C-TIP OSAP deployment by IXT in Kansas City eliminated 137 bobtail truck trips even as revenue loads remained stable.
- An automated dispatch system developed for Chicago-based Pride Logistics using C-TIP OSAP allowed Pride dispatchers to better allocate resources throughout the day, eliminating most of the manual effort involved in the dispatch operation and better identifying load matching opportunities. This helped eliminate 30 bobtails while the number of total loads grew.
- Out of 95 total trips on five intermodal lanes in Kansas City, DRG redirected trucks 30 times on three lanes, with travel time savings ranging from five to seven minutes per trip. On average, this corresponded to a 21 percent improvement in travel times.
- Through initial route recommendations at trip outset, RTTM saved drivers on one Kansas City intermodal lane an average of six minutes travel time per trip, corresponding to a 19 percent reduction in travel time.
- In Kansas City, Real-Time Traffic Monitoring (RTTM) and Dynamic Route Guidance (DRG) combined were able to achieve greenhouse gas emissions reductions of about 163,000 grams of CO₂ equivalents during the test period, and over 1,200 grams of criteria pollutants.³ This corresponds to a 10 percent emissions reduction for DRG, and a 6 percent reduction for RTTM.

² Cambridge Systematics, *C-TIP Evaluation Plan*, April 2010.

³ Criteria pollutants include diesel particulate matter, volatile organic compounds, oxides of nitrogen, and carbon monoxide.

- An Intermodal Move Exchange (IMEX) simulation found that the system could have eliminated 135 bobtail trips in Kansas City over a four-month period, thereby eliminating over 1,000 empty truck miles and saving 180 gallons of diesel fuel. The reduction in bobtails would have reduced greenhouse gases by about 2.6 million grams and criteria pollutants by almost 19,000 grams, if C-TIP were fully utilized by all stakeholders.
- Another IMEX simulation using gate move data between two railroads in Chicago found that C-TIP could have matched 1,654 loads during a four-month period, assuming a three-hour cross-town delivery window. This would save 6,864 gallons of diesel fuel, with concomitant reductions in greenhouse gas and criteria pollutant emissions.

It is interesting to note the variability in terms of bobtail reduction between the different IMEX tests. Simulated results in Kansas City and Chicago indicated that reductions of 8 percent and 17 percent respectively could be achieved. Actual results from IXT in Kansas City and Pride Logistics in Chicago found reductions of 13 percent for IXT and 52 percent for Pride. There could be many reasons for this variation, including:

- The Chicago and Kansas City simulations were limited to cross-town moves between rail terminals, whereas the IXT and Pride tests encompassed all move types including trips to and from customer loading docks. This means there were probably more opportunities for Pride and IXT to locate a bobtailing driver near a load opportunity, thus eliminating an empty trip.
- IXT and Pride are separate drayage firms that probably have different operational characteristics tailored to their own markets, as well as differing levels of IT investment. This likely explains the large difference in the results for the two tests.
- Although the prevailing cross-town rail traffic pattern in both cities is similar (western railroads to eastern railroads), it is possible that a greater proportion of trucks hauling cross-town containers in Chicago are coming back empty, leading to a greater share of matched loads in Chicago.

Table ES.1 Summary of Cross-town Improvement Project Test Results

Test	Location	Dates of Test	Description of Test	C-TIP Module Deployed	Test Results				Report Section
					Actual or Simulated	Productivity Results	Emission Reductions ^b	Fuel Savings	
IXT Drayage Optimization	Kansas City, Missouri	6/28/2011 8/31/2011	Deployment of iPhones to optimize drayage moves	IMEX WDU	Actual	137 Bobtails Eliminated	1,721,823 grams	8%	Section 3.1
Pride Logistics Drayage Optimization ^a	Chicago, Illinois	8/1/2011 9/30/2011	Deployment of automated dispatching system with Android smart phones to optimize drayage moves	IMEX	Actual	30 Bobtails Eliminated	2,296,502 grams	52%	Section 3.2
Dynamic Route Guidance	Kansas City, Missouri	12/1/2010 4/30/2011	Deployment of RTTM/DRG-enabled iPhones	IMEX WDU RTTM DRG	Actual	21% Travel Time Improvement	109,822 grams	10%	Section 2.2
Real-Time Traffic Monitoring	Kansas City, Missouri	12/1/2010 4/30/2011	Deployment of RTTM/DRG-enabled iPhones	IMEX RTTM	Actual	19% Travel Time Improvement	54,300 grams	6%	Section 2.1
Kansas City IMEX Simulation	Kansas City, Missouri	10/1/2010 1/31/2011	Simulated matching cross-town railroad container moves	IMEX	Simulated	135 Empty Trips Eliminated	2,570,597 grams	8%	Section 2.3
Chicago IMEX Simulation	Chicago, Illinois	1/1/2011 4/30/2011	Simulated matching cross-town railroad container moves	IMEX	Simulated ^a	1,654 Empty Trips Eliminated	110,231,008 grams	17%	Section 2.3

Note: IMEX: Intermodal Move Exchange.
WDU: Wireless Drayage Updating.
RTTM: Real-Time Traffic Monitoring
DRG: Dynamic Route Guidance.

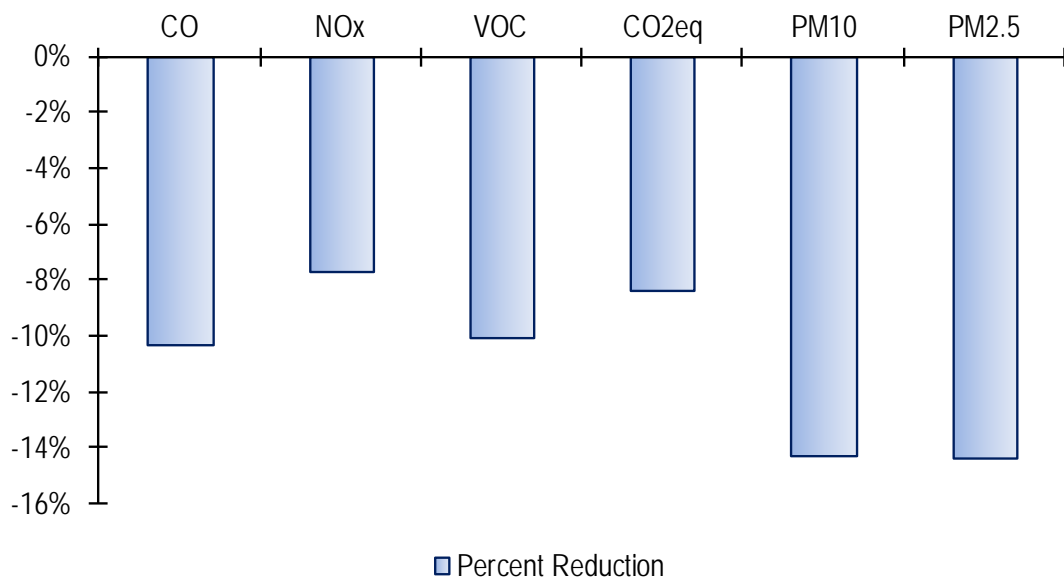
^a Results assume three-hour delivery window.

^b Includes carbon monoxide, oxides of nitrogen, volatile organic compounds, carbon dioxide equivalents (greenhouse gases), particulate matter, and fine particulates.

These efficiency improvements led to demonstrable reductions in harmful diesel emissions during the test period. As shown in Figure ES.1, RTTM and DRG combined were able to achieve significant percentage reductions in various pollutants compared to what would have happened without implementation of the technology:

- Carbon monoxide (CO) emissions were reduced by 10 percent;
- Oxides of nitrogen (NO_x) were reduced by eight percent;
- Volatile organic compounds (VOC) emissions fell by 10 percent;
- Greenhouse gas emissions were reduced by eight percent; and
- Particulate matter (PM₁₀) and fine particulates (PM_{2.5}) were each reduced by 14 percent.

Figure ES.1 C-TIP RTTM and DRG Kansas City Emissions Benefits



Source: CS analysis of RTTM and DRG move records.

There were some operational constraints to full utilization of C-TIP in Kansas City. For instance, the IMEX dispatch model assumed a loaded container could wait in an intermodal terminal as long as necessary to be matched as a dray backhaul. In practice, this is rarely the case as terminals typically want to move grounded containers out of the yard as quickly as possible. More broadly, the railroad and dray trucking industries may lack the collaborative mentality that would be required for a common dispatch platform to work. This contributed to the lack of railroad participation in the program, which necessitated a 'what if' simulation analysis of the IMEX component.

Nonetheless, this initial deployment of C-TIP technologies in Kansas City did prove the concept that such applications can provide public and private sector benefits, including congestion mitigation, emissions reductions, and truck travel time savings. Due to the scale of the test, the measured benefits are relatively modest. Nevertheless, it is reasonable to expect that much greater benefits could be achieved in a larger intermodal market like Chicago, where large scale cross-town container moves between rail yards occur on a daily basis. To assess this scalability, this evaluation implemented a Delphi assessment of a theoretical Chicago C-TIP deployment.⁴ The results of this assessment revealed general agreement among intermodal industry experts that substantial benefits could be achieved. For example, panelists' expert consensus was that RTTM and DRG could achieve travel time savings of 5-10 percent per trip for Chicago cross-town dray movements, and that bobtails could be reduced by more than 15 percent per day.

The positive results obtained from DRG and RTTM in Kansas City, along with drayage optimization tests in Kansas City and Chicago, suggest that future research may be best targeted towards freight information exchange, improving the truck dispatch operation, and in providing real-time information and tools to support truck routing decisions. However, use of C-TIP by the intermodal industry was more limited than expected, and a key factor here was the choice in taking a government systems engineering approach to developing a system from the ground up. This approach, while technically sound, took several years to complete, by which time both the initial C-TIP industry champions and the smart phone and information technologies available in the marketplace had changed.

The C-TIP experience points out an opportunity for future U.S. DOT tests to be based more on emerging applications being developed by the private sector. Mindful of the C-TIP experience, FHWA-OFM already is moving in this direction with the Freight Advanced Traveler Information System (FRATIS) Concept of Operations. As part of a new, more responsive private-sector-centric approach to testing and deploying freight technologies for U.S. DOT programs, this project will develop concepts for three FRATIS application 'bundles:' freight real-time traveler information with performance measures, freight dynamic route guidance, and drayage optimization.

⁴ Delphi is an analytical method that relies on a panel of subject matter experts to develop a consensus opinion on a given topic through iterative polling.

Table of Contents

- Executive Summary ES-1**
- 1.0 Introduction 1-1**
 - 1.1 C-TIP Background 1-1
 - 1.2 Evaluation Goals and Methodology 1-3
 - 1.3 Organization of Report 1-5
- 2.0 Kansas City and Chicago C-TIP Tests 2-1**
 - 2.1 Real-Time Traffic Monitoring 2-1
 - 2.2 Dynamic Route Guidance..... 2-12
 - 2.3 IMEX Analysis..... 2-20
 - 2.4 C-TIP User Interviews..... 2-31
- 3.0 Drayage Optimization Tests..... 3-1**
 - 3.1 Kansas City IXT Test 3-1
 - 3.2 Chicago Test 3-3
- 4.0 Delphi Study Results 4-1**
- 5.0 Summary of Findings..... 5-1**
- A. RTTM/DRG Intermodal Lanes and Route Maps A-1**
 - A.1 RTTM Maps A-1
 - A.2 DRG Maps A-6
- B. C-TIP User Interview Instruments B-1**
 - B.1 C-TIP Driver Questionnaire B-1
 - B.2 C-TIP Terminal Manager Questionnaire B-2
 - B.3 Pride Logistics Driver Questionnaire B-3
- C. Delphi Assessment Questionnaires C-1**
 - C.1 First Round Questionnaire C-1
 - C.2 Second Round Questionnaire C-6

List of Tables

Table ES.1 Summary of Cross-town Improvement Project Test Results ES-4

Table 2.1 EPA MOVES Dray Truck Emissions Factors2-10

Table 3.1 Kansas City Metro Area Cities Included in the IXT
Drayage Analysis3-2

Table 3.2 IXT Drayage Optimization Test Results by Month3-3

Table 3.3 Pride Logistics Test Bobtail and Driver Productivity Metrics3-6

Table 4.1 C-TIP Delphi Panel4-2

Table 4.2 Importance of C-TIP Features to Users4-3

Table 4.3 Potential Chicago Travel Time Savings4-4

Table 4.4 Estimated Daily Bobtail Volumes in Chicago4-5

Table 4.5 Estimated C-TIP Bobtail Reduction in Chicago4-5

Table 4.6 Estimated Terminal Idle Time in Chicago4-6

Table 4.7 Potential Terminal Idle Reduction in Chicago4-6

Table 5.1 Summary of Key C-TIP Evaluation Findings5-1

List of Figures

Figure ES.1 C-TIP RTTM and DRG Kansas City Emissions Benefits	ES-5
Figure 1.1 C-TIP Data Architecture.....	1-2
Figure 1.2 Sample iPhone RTTM Alternate Route Instructions.....	1-3
Figure 2.1 RTTM Route Compliance by Lane	2-3
Figure 2.2 RTTM Travel Time Performance <i>BNSF to Topeka</i>	2-5
Figure 2.3 RTTM Travel Time Performance <i>Toyota to Grainger</i>	2-6
Figure 2.4 RTTM Travel Time Performance <i>UP to Toyota</i>	2-7
Figure 2.5 RTTM Travel Time Performance <i>BNSF to Musician’s Friend</i>	2-8
Figure 2.6 RTTM Travel Time Performance <i>BNSF to NS</i>	2-9
Figure 2.7 RTTM Emissions Reduction	2-12
Figure 2.8 DRG Performance <i>Toyota to Grainger</i>	2-14
Figure 2.9 DRG Performance <i>UP to Toyota</i>	2-15
Figure 2.10 DRG Performance <i>BNSF to Musician’s Friend</i>	2-16
Figure 2.11 DRG Performance <i>BNSF to Topeka</i>	2-17
Figure 2.12 DRG Performance <i>BNSF to NS</i>	2-17
Figure 2.13 DRG Emissions Reduction.....	2-19
Figure 2.14 IMEX Trip Assignments.....	2-20
Figure 2.15 C-TIP IMEX Terminal Move Summary <i>Kansas City</i>	2-22
Figure 2.16 C-TIP IMEX Performance Metrics <i>Kansas City</i>	2-24
Figure 2.17 C-TIP IMEX Potential Emissions Reduction <i>Kansas City</i>	2-26
Figure 2.18 C-TIP IMEX Performance <i>Chicago Terminal</i>	2-28
Figure 2.19 C-TIP Potential Emissions Reduction <i>Chicago Terminal</i>	2-30
Figure 3.1 Dispatch Web Application Information Flow.....	3-5
Figure A.1 Primary and Alternate Routes by Lane.....	A-1
Figure A.2 Toyota to Grainger.....	A-6
Figure A.3 UP to Toyota	A-12
Figure A.4 BNSF to Musician’s Friend	A-18

1.0 Introduction

1.1 C-TIP BACKGROUND

The Cross-town Improvement Project (C-TIP) was first conceptualized in 2004 as an “intermodal move database” that would help coordinate cross-town drayage moves between rail terminals, thus helping to reduce empty moves. This would reduce some of the noise, emissions, and congestion impacts of cross-town truck traffic. Over the years, the C-TIP concept grew to include other features, until in 2009 a detailed Concept of Operations (ConOps) was developed which detailed five core elements:

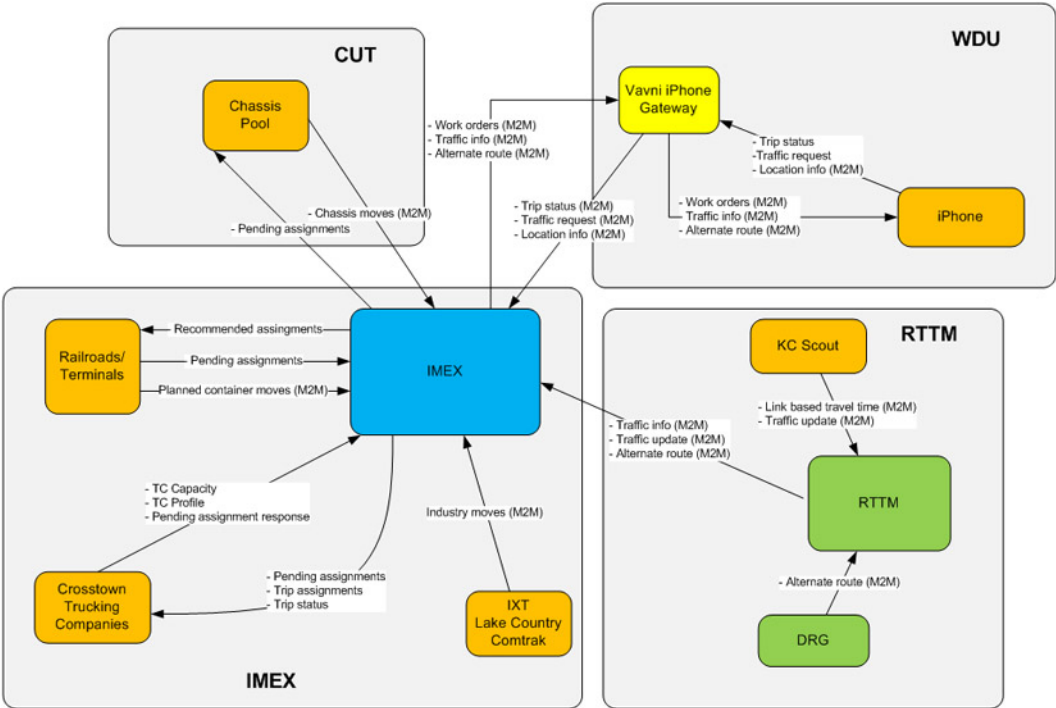
- **Intermodal Move Exchange (IMEX)** - An open architecture port that allows for a **collaborative** dispatch management model among rail lines, truckers, and facility operators.
- **Wireless Drayage Updating (WDU)** - Utilizes low-cost wireless technology as an interface between drivers and dispatchers, and between the core functions within C-TIP and its users.
- **Real-Time Traffic Monitoring (RTTM)** - Real-time monitoring and distribution of route- and location-specific travel time and congestion information and control of traffic management systems and devices.
- **Dynamic Route Guidance (DRG)** - Uses inputs from RTTM, a dedicated Geographic Information Systems (GIS) source, and specially developed simulation tools to provide truckers with real-time visual routing around congested areas.
- **Chassis Utilization Tracking (CUT)** - An application that allows for collaborative use and management of intermodal chassis among railroads and trucking companies.⁵

The C-TIP data architecture is shown in Figure 1.1, showing the relationships between the key C-TIP components and the data sources for each. Routing and trip information is pushed out to truck drivers through a specially designed iPhone app with voice command capability to avoid driver distraction problems. A screenshot of the iPhone app is provided in Figure 1.2, showing alternate routing instructions from RTTM.

⁵ Intermodal Freight Technology Working Group, *Cross-Town Improvement Project Concept of Operations: 2009 Update*, July 2009.

An operational test of C-TIP was conducted from October 1, 2010 to January 31, 2011 in Kansas City. This test involved the RTTM, DRG, and IMEX components of C-TIP. Additionally, two drayage optimization tests – one in Kansas City, the other in Chicago – were conducted to assess the potential for truck bobtail move reduction using wireless technologies. Finally, an intermodal optimization analysis was conducted using gate move data between the CSX and UP railroads in Chicago to determine the potential benefits of C-TIP IMEX in a much larger intermodal market.

Figure 1.1 C-TIP Data Architecture



Source: SAIC.

Figure 1.2 Sample iPhone RTTM Alternate Route Instructions



Source: SAIC.

1.2 EVALUATION GOALS AND METHODOLOGY

FHWA commissioned a team led by Cambridge Systematics, Inc. (CS) to evaluate the freight performance, emissions, and other benefits that C-TIP may provide to the public and private sectors. This report documents the evaluation results. C-TIP-related items evaluated include:

- The RTTM and DRG components of C-TIP in Kansas City, including driver compliance with route recommendations, travel time savings, accuracy of travel time predictions, and emissions reductions.
- An IMEX simulation test in Kansas City, including potential reductions in bobtail trips, emissions, fuel use, and empty miles had all stakeholders followed the IMEX work plan.
- The Chicago C-TIP intermodal optimization exchange model, which uses records for nearly 10,000 gate moves between the UP and CSX railroads in Chicago to develop a simulation of potential C-TIP benefits in the Chicago drayage market, including total potential matched loads, empty miles eliminated, fuel saved, and emissions reductions.

- The Kansas City drayage optimization test, which involves dispatchers from IXT Drayage Company utilizing the C-TIP Open Source Architecture Package (C-TIP OSAP) to reduce unproductive bobtail moves.
- The Chicago drayage optimization test, which involves the use of a specially developed Android app by Pride Logistics, LLC to reduce bobtails.

The RTTM, DRG, and IMEX C-TIP components (including the Chicago intermodal optimization model) are tested using the RMI Vantage performance monitoring system. Vantage is a business intelligence tool designed specifically for intermodal operations which provides the ability to monitor, measure, and manage key intermodal performance metrics in real-time. Vantage software is used at more than 80 intermodal rail terminals in North America and is widely accepted as an industry standard. Baseline and operational test data were fed into Vantage to develop dashboard displays of key evaluation metrics.

C-TIP benefits were assessed in multiple ways:

- Driver compliance with RTTM and DRG route recommendations was evaluated by comparing GPS positional records supplied by the iPhone-equipped drayage trucks to the route recommendation data collected during the operational test phase.
- Travel time savings were calculated by subtracting actual trip times (gathered via GPS time stamps) from the predicted travel times for the default route. For RTTM, the calculation was made for the entire trip from origin to destination; for DRG, it was performed from the point of redirect.
- The accuracy of RTTM and DRG travel time predictions was assessed by taking the average difference between projected and actual travel times for each predefined intermodal lane.
- RTTM and DRG emissions benefits were developed using dray truck emissions factors from the Environmental Protection Agency's MOVES model. Using known distances and projected travel times between origin and destination points, average truck speeds for intermodal lanes were calculated; emissions factors for those speed bins (in grams per mile) were then multiplied by distance and compared to a baseline (i.e., no alternate routing) to assess emissions savings.
- Potential IMEX benefits were estimated using simulation tests.⁶ Gate move data supplied by railroads in Chicago and Kansas City were used to calculate the unproductive (bobtail) trips that would have been eliminated through daily implementation of the IMEX work plan to match loads. Potential bobtail reductions are the sum of loaded containers (identified by container

⁶ Actual IMEX benefits could not be evaluated due to lack of railroad participation in the C-TIP test deployment.

ID) that could be moved sequentially by the same cross-town driver, given a set of assumptions about delivery windows and the length of time containers could remain in the rail terminal. Empty miles saved were thus derived by multiplying the number of bobtails reduced by the miles between origin and destination pairs. Fuel savings could then be calculated using average dray truck fuel economy factors, while emissions benefits were developed by multiplying empty miles saved by the same emissions factors used for the RTTM and DRG evaluation.

- The drayage optimization tests in Kansas City and Chicago used data provided by the trucking companies involved to develop bobtail reduction metrics. The IXT drayage test relies on a spreadsheet analysis of move records supplied by Profit Tools (a drayage software provider), covering IXT cross-town moves from April 1, 2011 through August 31, 2011. The Chicago drayage optimization test utilizes information provided by Pride Logistics for drivers using the Android app based on a methodology developed by Pride.

Beyond these quantitative assessments, the team also conducted qualitative research to better understand potential C-TIP benefits and limitations. This was accomplished through:

- C-TIP user interviews in Kansas City and Chicago; and
- A specially defined Delphi study of the potential benefits of a Chicago C-TIP deployment. Delphi is a research method that seeks to quantify expert opinion on a given topic through iterative polling.

1.3 ORGANIZATION OF REPORT

The remainder of this report is organized as follows:

- **Section 2.0: Kansas City and Chicago C-TIP Tests** presents the results of the RTTM/DRG test in Kansas City, the IMEX analyses in Kansas City and Chicago, and the results of C-TIP user interviews;
- **Section 3.0: Drayage Optimization Tests** summarizes the results of the IXT test in Kansas City and the Pride Logistics test in Chicago; and
- **Section 4.0: Delphi Study Results** analyzes the results of the Delphi process.
- **Section 5.0: Summary of Findings** summarizes the key points and major findings of the evaluation.

2.0 Kansas City and Chicago C-TIP Tests

2.1 REAL-TIME TRAFFIC MONITORING

RTTM provides real-time predicted travel time information via the iPhone interface for primary and alternate routes, with route recommendations when warranted. Drivers can access this information pretrip by entering their origin and destination, after which the phone returns predicted travel times on the primary and alternate routes for that origin and destination pair. Drivers then select the route they want to take based on this information, with turn-by-turn directions provided by voice command from the iPhone.

During the trip, the iPhone sent GPS positional records to the C-TIP database, enabling the evaluation of driver compliance with recommended routes as well as comparison of actual to projected travel times for each trip (to assess travel time savings).

Route Compliance

The Real-Time Traffic Monitoring application was used by six drivers on five key intermodal lanes (origin-destination pairs) in Kansas City:

- BNSF to Topeka (Comtrak Logistics);
- Toyota to Grainger (Comtrak Logistics);
- UP to Toyota (Comtrak Logistics);
- BNSF to Musician’s Friend (IXT); and
- BNSF to NS (ITS).

Maps of primary and alternate routes for each lane are provided in Appendix A. Figure 2.1 shows driver compliance with the RTTM route recommendations at origin. This measures the degree to which drivers followed the RTTM route recommendations (whether or not RTTM recommended a default route or an alternate one). As the dashboard shows:

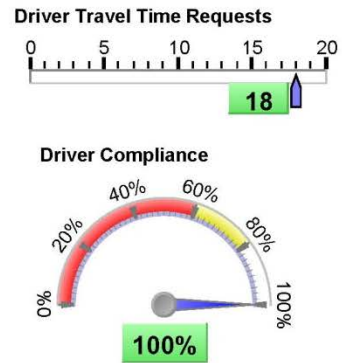
- Four of the five lanes had 100 percent compliance with RTTM route recommendations. This was the case with BNSF to Topeka, Toyota to Grainger, BNSF to Musician’s Friend, and BNSF to NS. However, on three routes (BNSF to NS, BNSF to Topeka, and UP to Toyota) RTTM never offered an alternate route, which implies that the primary route as defined in the application was always the best route from a travel time perspective. On the

other lane (BNSF to Musician's Friend), an alternate route was offered every time a driver made a travel time request at origin, and the driver proceeded to follow that route.

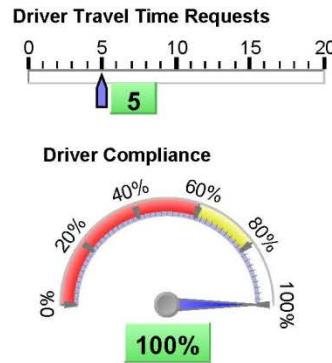
- The remaining lane (UP to Toyota) had zero percent compliance with the RTTM route guidance. However, this is owing to the fact that the true point of origin for these shipments was not the UP yard but a terminal consolidation point five miles away from the yard – a fact of which RTTM was not aware.

Figure 2.1 RTTM Route Compliance by Lane

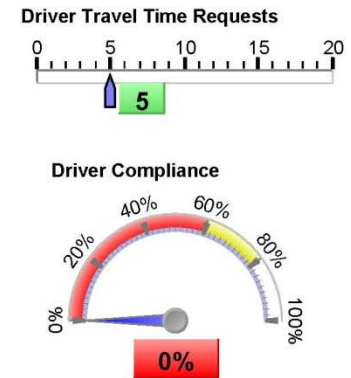
Comtrak - BNSF to Topeka



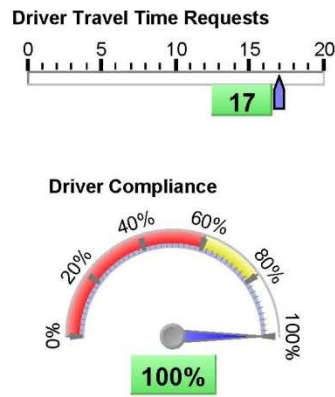
Comtrak - Toyota to Grainger



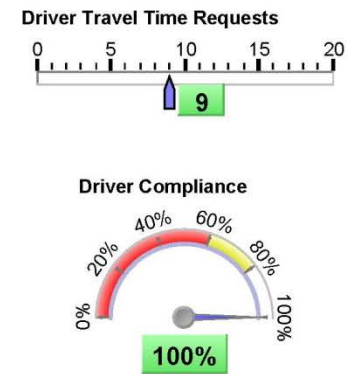
Comtrak - UP to Toyota



IXT - BNSF to Musician's Friend



ITS - BNSF to NS



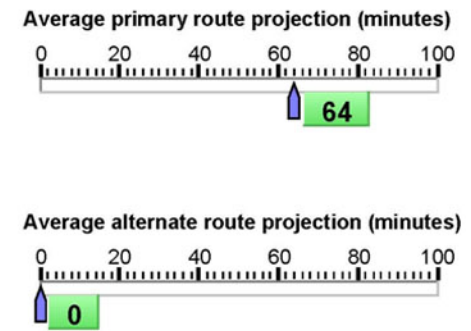
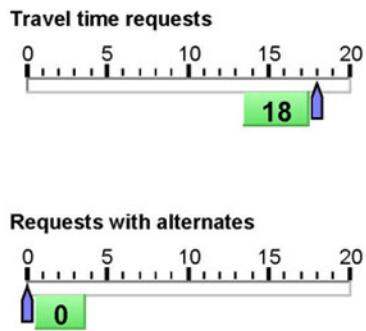
Time Savings by Lane

Vantage dashboards also were developed to evaluate travel time performance on individual lanes. Figures 2.2 through 2.6 display travel time information by lane:

- **BNSF to Topeka (Figure 2.2).** There were 18 travel time requests on this lane, however RTTM never offered an alternate route. This is because the only alternate route defined in RTTM for this lane was a secondary road to the outskirts of Kansas City, which then reconnected with Interstate 70 to Topeka. During the test, however, there was never enough congestion on I-70 to make the alternate route faster. In fact, none of the trucks on this route actually went all the way to Topeka – they all stopped at points between the BNSF terminal and Topeka instead. Therefore, it is not possible to evaluate travel time savings or the accuracy of the RTTM projections.
- **Toyota to Grainger (Figure 2.3).** There were five travel time requests on this lane, all of which yielded an alternate route recommended by RTTM. Trucks took the alternate route on all five of these occasions. However, the primary and alternate projected travel times are the same (26 minutes). In any event, none of the trucks that requested travel times on this lane sent positional data. This could be due to several factors, including drivers turning off the iPhone after requesting travel time, or drivers and other fleet staff “testing” the app to learn about its functionality.
- **UP to Toyota (Figure 2.4).** There were five requests for travel time during the test period on this lane but RTTM never offered an alternate route here either. As noted above there was zero compliance with RTTM recommendations on this route because the actual origination point was not the same as the one assumed by RTTM. The average primary route projected travel time was 33 minutes, but it is not possible to evaluate this against actual travel times because of this routing issue.
- **BNSF to Musician’s Friend (Figure 2.5).** RTTM received 17 requests for travel time information on this lane, for which the system recommended an alternate route all 17 times. Moreover, the drivers actually followed this alternate route 100 percent of the time. On average, RTTM predicted the primary route travel time to be 31 minutes and the alternate route to be 24 minutes. Actual travel time varied from projected by an average of five minutes, and actual times were within 10 percent of projected times 22 percent of the time.
- **BNSF to NS (Figure 2.6).** There were nine travel time requests on this lane, but RTTM never offered an alternate route. Route compliance was 100 percent since drivers always took the default route which also was recommended by RTTM. Travel time accuracy was fairly good on this lane, with an average variance of three minutes between projected and actual travel times. Actual travel times were therefore within 10 percent of projected times 57 percent of the time.

Figure 2.2 RTTM Travel Time Performance
BNSF to Topeka

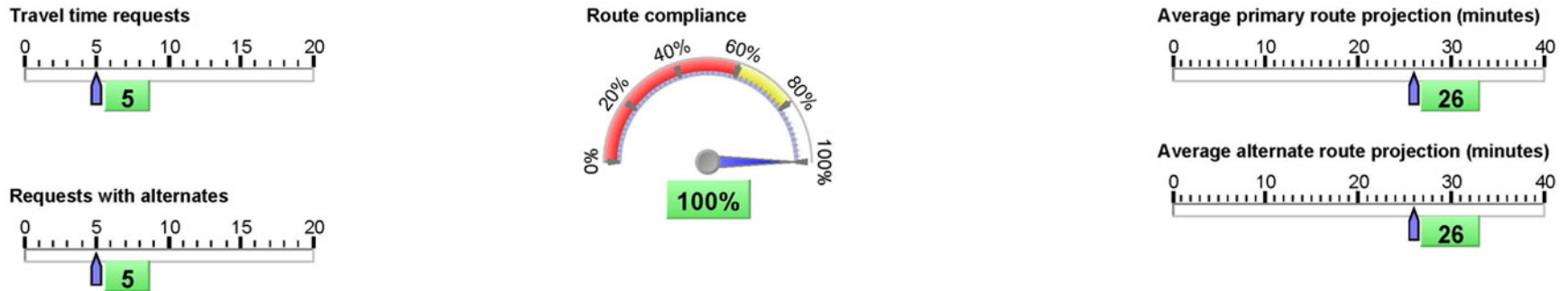
Comtrak - BNSF to Topeka



Actual time comparisons are not valid for this route.
None of the actual truck trips went nonstop from BN to Topeka.

Figure 2.3 RTTM Travel Time Performance
Toyota to Grainger

Comtrak - Toyota to Grainger



Actual time comparisons are not valid for this route.

None of the trucks requesting travel time sent position locations

Figure 2.5 RTTM Travel Time Performance
BNSF to Musician's Friend

IXT - BNSF to Musician's Friend

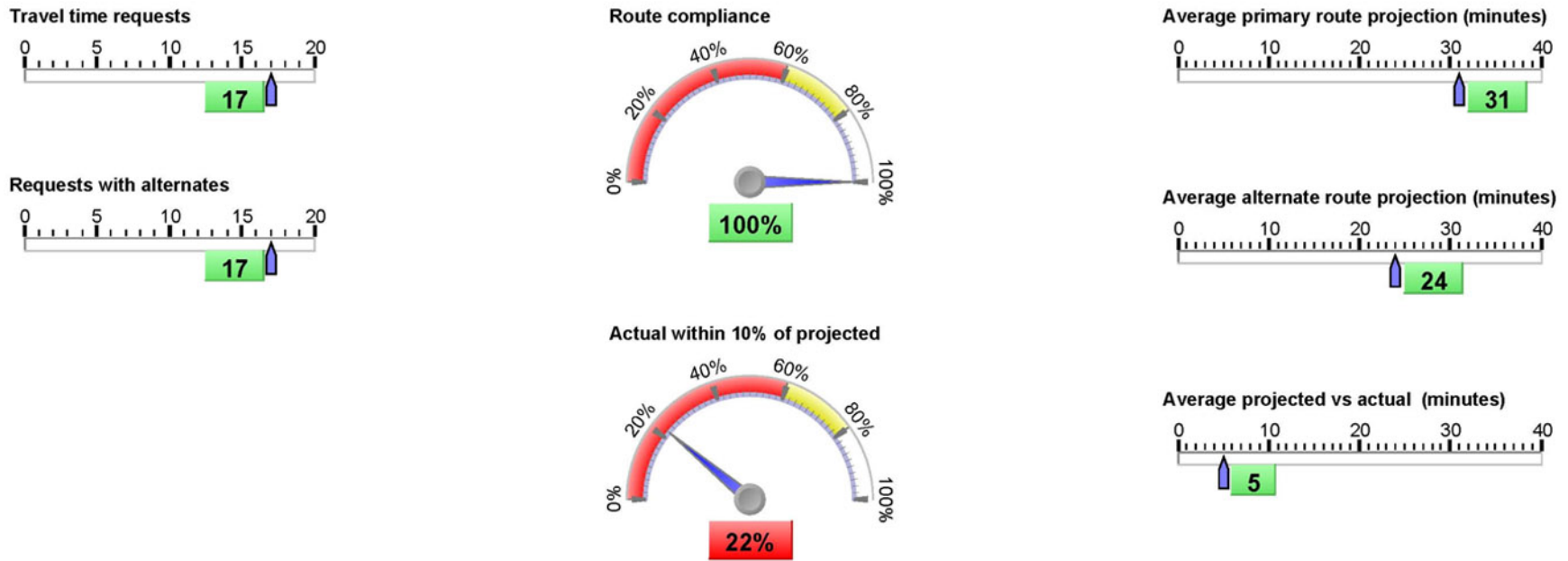
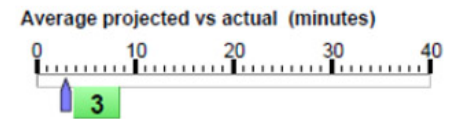
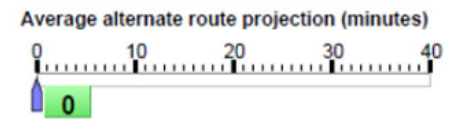
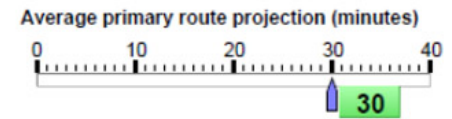
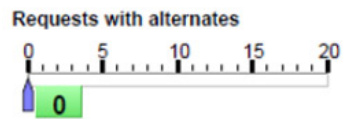
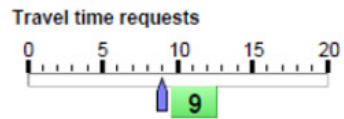


Figure 2.6 RTTM Travel Time Performance
BNSF to NS

ITS - BNSF to NS



Emissions Reduction

Diesel emissions are a function of distance traveled and speed. Therefore, if a route recommended by RTTM is shorter in distance than the default route, there could be an emissions reduction associated with it. The evaluation team therefore used common emissions factors to convert RTTM distance and delay savings to reduction in diesel emissions.

RTTM was able to achieve modest reductions in greenhouse gas and criteria pollutant emissions during the Kansas City test period.⁷ For this evaluation, CS estimated the emissions reductions that would be achieved for five EPA-designated criteria pollutants, including carbon monoxide, oxides of nitrogen, volatile organic compounds, and diesel particulate matter. Particulate matter is broken down into two categories: PM₁₀ (particles less than 10 microns but more than 2.5 microns in diameter) and PM_{2.5} (particles less than 2.5 microns in diameter). Reductions in greenhouse gas emissions (measured in carbon dioxide equivalents, or CO₂eq) also were estimated.

Emissions factors in grams per mile specific to short-haul combination trucks in the four-county Kansas City area were obtained from the EPA MOVES model (see Table 2.1). Factors are divided into speed bins from 2.5 mph to 75 mph.

Table 2.1 EPA MOVES Dry Truck Emissions Factors
In Grams per Mile

Speed (MPH)	Carbon Monoxide (CO)	Oxides of Nitrogen (NO _x)	Volatile Organic Compounds (VOC)	Carbon Dioxide Equivalents (CO ₂ eq)	Particulate Matter (PM ₁₀)	Fine Particulates (PM _{2.5})
2.5	21.99685	54.16616	6.041066	9651.828	3.337922	3.237911
5	10.99843	27.08309	3.020535	4825.908	1.66896	1.618954
10	6.336506	16.69532	1.56982	3097.472	1.071154	1.039059
15	4.99147	14.53054	1.080162	2830.331	1.019193	0.988655
20	4.153309	13.09162	0.825059	2576.837	0.94696	0.918586
25	3.735008	12.00771	0.697809	2402.457	0.888957	0.862322
30	3.403155	11.7275	0.608871	2362.748	0.859345	0.833596
35	2.955478	10.14686	0.553779	1982.124	0.646784	0.627405
40	2.755327	9.910763	0.510617	1943.435	0.604152	0.586051
45	2.599646	9.727128	0.477047	1913.348	0.570996	0.553888
50	2.439501	9.416561	0.449968	1825.176	0.499143	0.484189
55	2.29002	9.073868	0.427016	1719.147	0.415935	0.403474

⁷ Criteria pollutants are six common air pollutants for which EPA sets National Ambient Air Quality Standards following requirements of the Clean Air Act.

Speed (MPH)	Carbon Monoxide (CO)	Oxides of Nitrogen (NO _x)	Volatile Organic Compounds (VOC)	Carbon Dioxide Equivalents (CO ₂ eq)	Particulate Matter (PM ₁₀)	Fine Particulates (PM _{2.5})
60	2.191812	8.968768	0.404485	1690.702	0.379639	0.368266
65	2.124675	9.477438	0.383504	1802.04	0.396157	0.38429
70	2.067133	9.913411	0.36552	1897.47	0.410317	0.398025
75	1.959225	9.605677	0.344137	1842.103	0.396435	0.38456

Source: EPA MOVES model. Note that these factors use national default MOVES input data and are not allowed to be used for SIPs or conformity analysis.

Emissions benefits were calculated using the average projected speed in miles per hour (based on projected travel time and known distance) for the longer and shorter routes in each lane. Emissions factors for the appropriate speed bin were then taken from Table 2.1 and used to calculate expected emissions for each pollutant on the primary and alternate route. The difference between these two calculations is the estimated emissions reduction associated with C-TIP RTTM.

It is only possible to evaluate emissions reductions on two cross-town lanes since alternate routes were not offered on the other three. Figure 2.7 highlights the results for the two lanes that could be evaluated:

- On the Toyota to Grainger route, RTTM is estimated to have reduced greenhouse gas emissions by about 13,600 grams of CO₂ equivalents (CO₂eq). Carbon monoxide was reduced by 11 grams; nitrogen oxide by 78 grams; and VOCs by 1 gram. There was no measurable improvement in particulate matter emissions.
- On the BNSF to Musician's Friend route, RTTM reduced GHG emissions by about 40,000 grams. Carbon monoxide was reduced by 107 grams; oxides of nitrogen by 168 grams; PM₁₀ by 36 grams; PM_{2.5} by 35 grams; and VOCs by 21 grams.

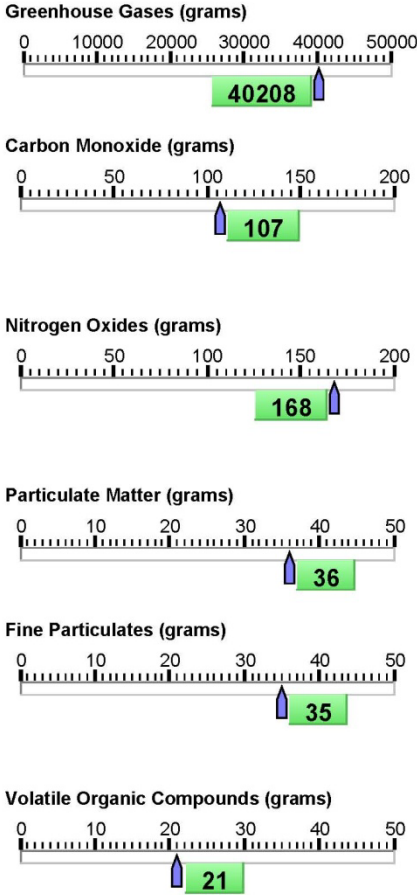
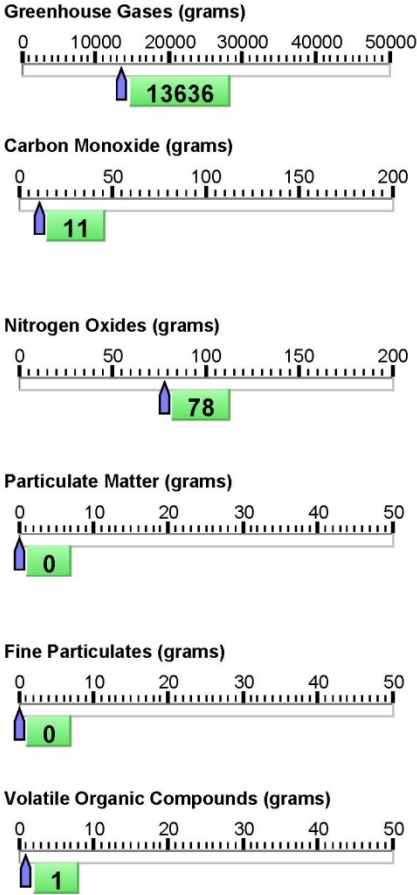
Although these reductions are rather modest due to the relatively small number of trucks involved in the test, emissions benefits would presumably be greater if the system were deployed more widely, especially in a larger intermodal market like Chicago. This would help mitigate some of the known public health problems associated with goods movement. For instance, nitrogen oxide (NO_x) is a precursor to ozone, which has been linked to respiratory problems, skin irritation, asthma, and other ailments. Particulate matter has been linked to heart disease and cancer. Diesel engines are significant sources of both NO_x and PM pollution.⁸ Reductions in greenhouse gases, meanwhile, help mitigate global climate change.

⁸ Federal Highway Administration, *Freight and Air Quality Handbook*, May 2010.

Figure 2.7 RTTM Emissions Reduction

Comtrak - Toyota to Grainger

IXT - BNSF to Musician's Friend



2.2 DYNAMIC ROUTE GUIDANCE

Dynamic Route Guidance (DRG) provides truckers with real-time travel time information for key cross-town intermodal routes and can reroute them around congestion through in-cab voice commands, thus eliminating potential driver distraction issues. In the Kansas City test, redirections could occur whenever trucks approached a predefined “decision point” along a given lane. Prior to reaching the decision point, DRG would recalculate the predicted travel time based on current information; if it found a delay ahead (due to a traffic accident or similar event), it would verbally instruct the driver to take the alternate route with turn-by-turn directions. Whenever DRG redirected a truck, the GPS positional data was used to assess whether the driver followed the redirection and also to compare the projected travel time on the original route from the

decision point to the actual travel time on the diverted route, also from the decision point.

During the test period, there were 95 total trips with DRG route guidance on the five Kansas City intermodal lanes, of which 30 were redirected to avoid congestion. DRG provided en-route redirections on three lanes:

- Toyota to Grainger (Comtrak Logistics);
- UP to Toyota (Comtrak Logistics); and
- BNSF to Musician's Friend (IXT).

Maps showing the DRG redirects on each of these three routes are provided in Appendix A. There were no redirects on the BNSF to NS and BNSF to Topeka routes during the test period.

Route Compliance and Time Savings

Figures 2.8 to 2.12 show the route compliance and time savings results of the DRG test.

- **Toyota to Grainger (Figure 2.8).** There were 13 en-route redirects on this lane during the test period out of 18 total trips. Drivers followed the recommended reroute 77 percent of the time. DRG recommended a reroute essentially at the outset of these trips (zero minutes from origin until change). The average projected travel time on these redirects was 27 minutes, saving drivers an average of five minutes. Actual travel times were at variance with projected ones by an average of three minutes, and the DRG projected time at the decision point was within 10 percent of the actual time on half of these trips.
- **UP to Toyota (Figure 2.9).** There were 29 total DRG trips on this lane. Of these, there were 11 redirects, all of which the drivers followed. The average time from trip origin to DRG redirect was six minutes, and the average projected travel time on the reroutes was 16 minutes from the decision point. These reroutes saved drivers six minutes of travel time on average, but the average difference between predicted time and actual time also was six minutes - leading to low travel time accuracy on this lane since the trips were so short.
- **BNSF to Musician's Friend (Figure 2.10).** There were six DRG redirects on this lane during the test period (out of a total of 19 trips), and drivers followed the redirection 83 percent of the time. DRG recommended a reroute, on average, just two minutes into the trip. The average projected travel time for the reroutes was 23 minutes. The DRG redirection saved drivers seven minutes of travel time on average. In terms of travel time accuracy, the average variance between actual and projected travel time was four minutes, and DRG projected travel time was within 10 percent of the actual travel time for about two-thirds of the trips during the test.

- **BNSF to Topeka (Figure 2.11).** There were 20 total trips on this lane; however DRG never redirected drivers to an alternate route, so it is not possible to measure DRG travel time projections or time savings on this route.
- **BNSF to NS (Figure 2.12).** There were nine trips on this route during the test period but no DRG redirects, so it is not possible to measure DRG benefits on this route either.

Figure 2.8 DRG Performance
Toyota to Grainger

Comtrak - Toyota to Grainger

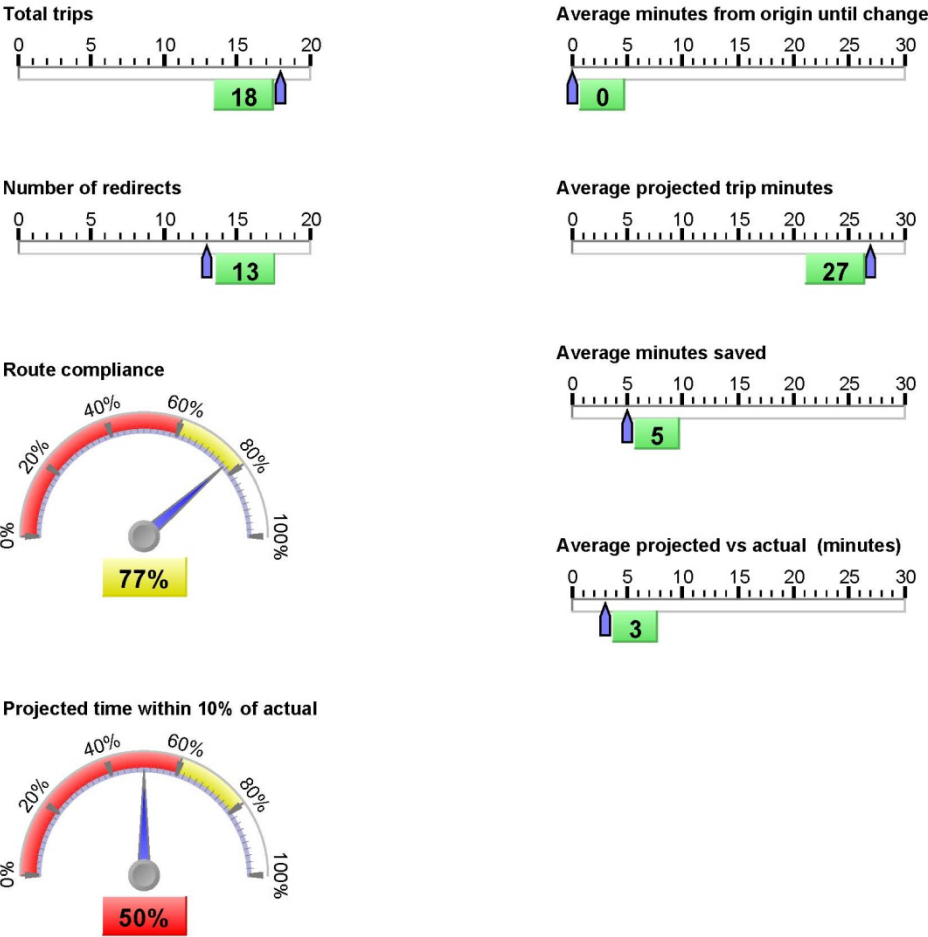


Figure 2.9 DRG Performance
UP to Toyota

Comtrak - UP to Toyota

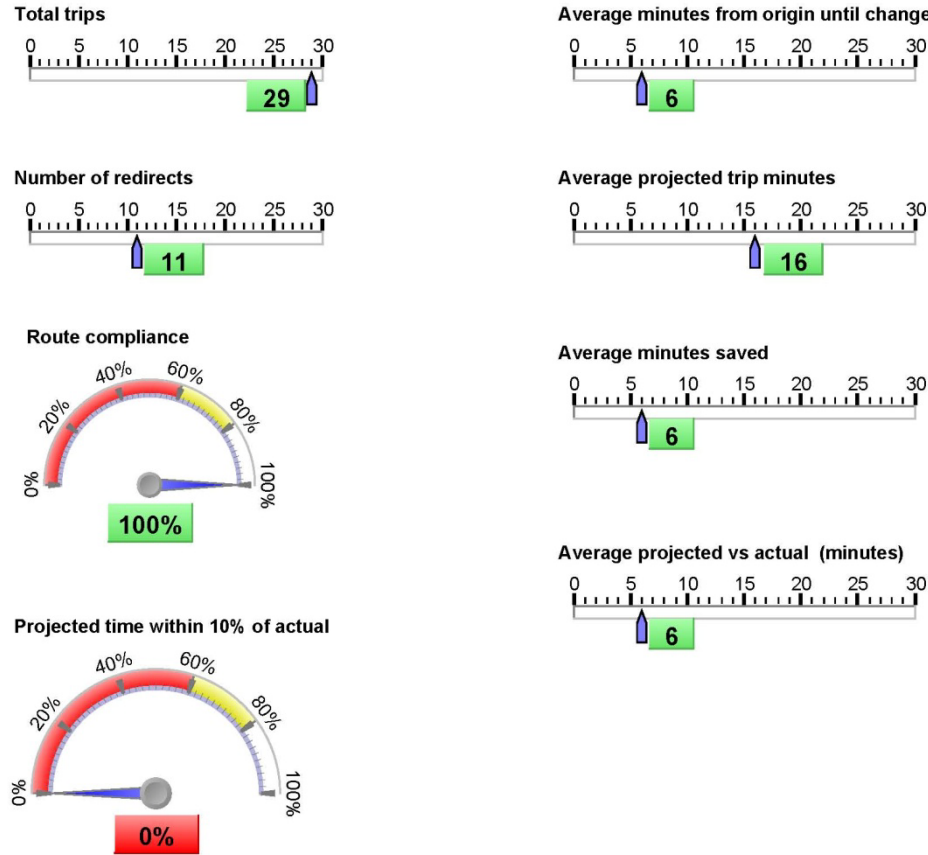


Figure 2.10 DRG Performance
BNSF to Musician's Friend

IXT - BNSF to Musician's Friend

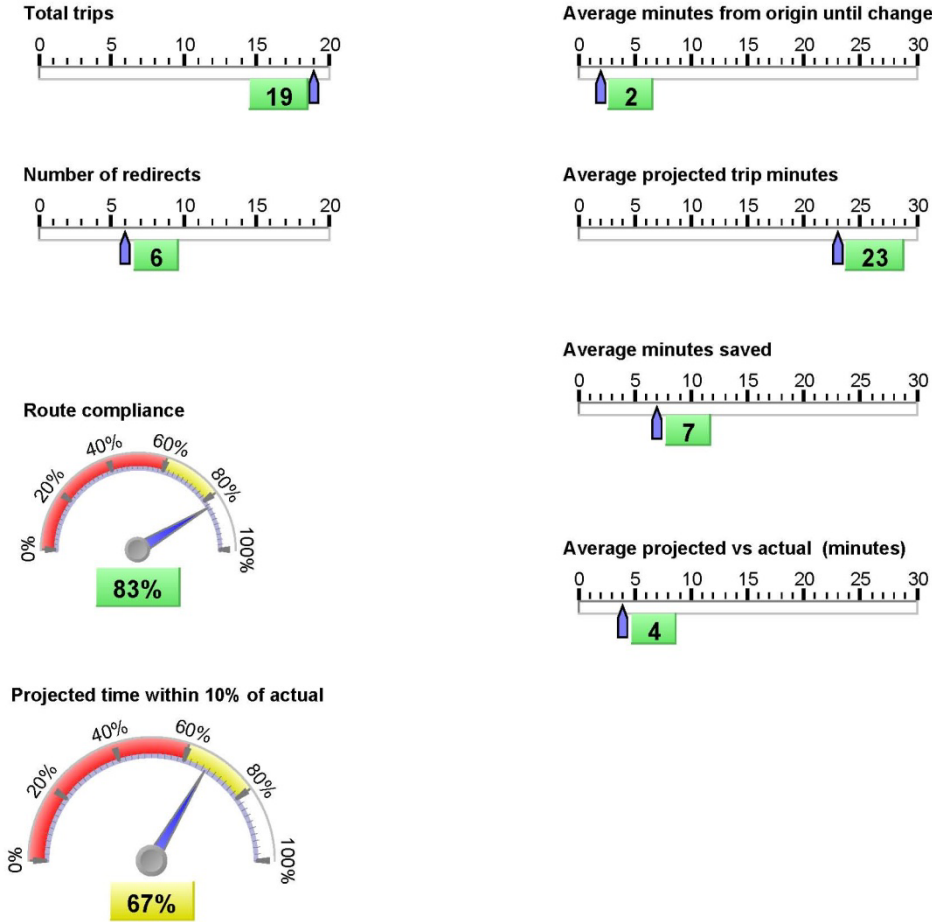


Figure 2.11 DRG Performance
BNSF to Topeka

Comtrak - BNSF to Topeka

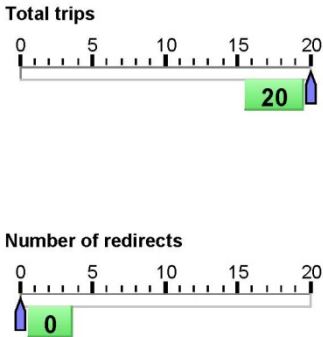
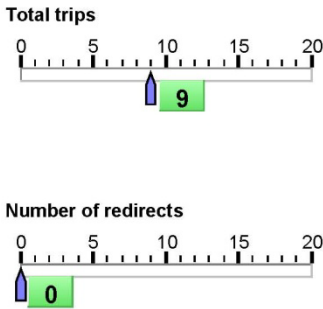


Figure 2.12 DRG Performance
BNSF to NS

ITS - BNSF to NS



Emissions Reduction

DRG emissions reductions also were assessed on these three cross-town lanes. The calculations were performed the same way as for RTTM, except the speed and distance calculations were determined from the point of redirection for each route rather than the point of origin. The same EPA emissions factors shown in Table 2.1 were used to assess DRG emissions savings. Figure 2.13 presents the estimated emissions reductions by lane.

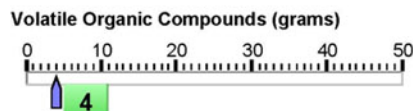
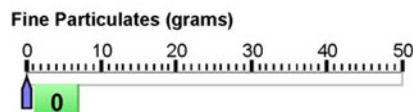
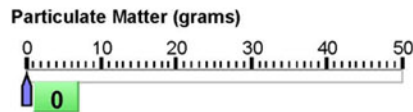
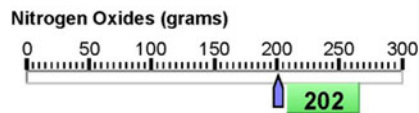
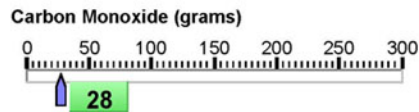
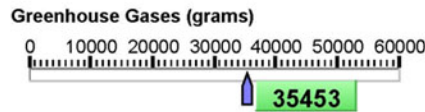
- On the Toyota to Grainger lane, DRG is estimated to have reduced total GHG emissions by more than 35,000 grams, nitrogen oxides by 202 grams, and carbon monoxide by 28 grams during the test period. There was no reduction in particulate matter, and reductions in volatile organic compounds were negligible.

- For the BNSF to Musician's Friend lane, GHG emissions were reduced by about 14,000 grams. NO_x was reduced by 59 grams, while CO was reduced by 38 grams. Other pollutants had more modest reductions, including 13 grams of PM₁₀; 12 grams of PM_{2.5}; and seven grams of VOCs.
- The UP to Toyota lane had the greatest emissions reductions under DRG. GHGs on this lane were reduced by nearly 60,000 grams of CO₂eq. Nitrogen oxides fell by 271 grams and carbon monoxide by 89 grams. PM₁₀ and PM_{2.5} were reduced by 28 grams and 27 grams, respectively, while VOC emissions fell by 16 grams.

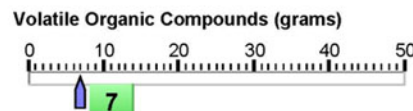
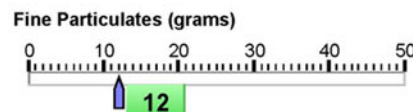
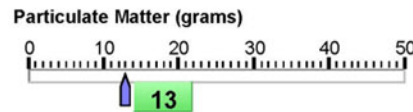
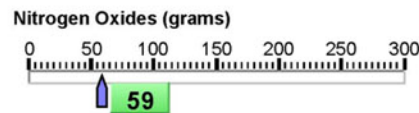
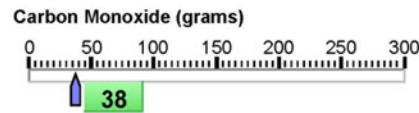
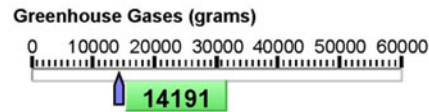
Overall these savings are modest but not unexpected given the scale of the deployment. The test did show, however, that there is scope for emissions reduction through freight dynamic mobility applications.

Figure 2.13 DRG Emissions Reduction

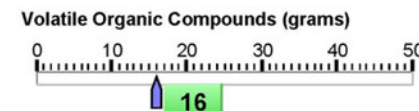
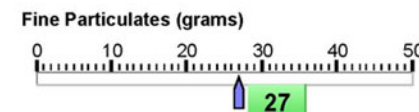
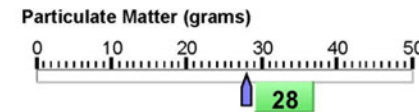
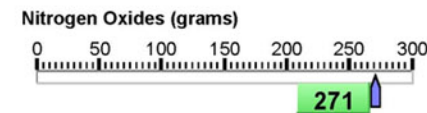
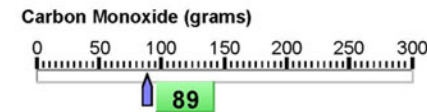
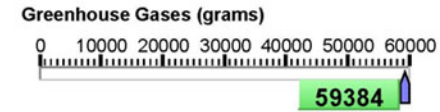
Comtrak - Toyota to Grainger



IXT - BNSF to Musician's Friend



Comtrak - UP to Toyota



2.3 IMEX ANALYSIS

IMEX is a collaborative on-line dispatch model designed to facilitate information exchange between intermodal rail terminals and the dray trucking community, with the goal of reducing unproductive moves to the greatest extent possible. Using data feeds from trucking firms and railroads, IMEX produces a daily work plan that optimizes container and chassis moves between cross-town railroads. The work plan is designed to accomplish the necessary moves with the fewest possible bobtail trips. IMEX proposes a carrier for each cross-town (either ITS or Greer). Railroads can view this plan and assign work orders accordingly, as shown in Figure 2.14.

Figure 2.14 IMEX Trip Assignments

The screenshot shows the 'TRIP ASSIGNMENTS' section of the C-TIP system. It features a table with the following columns: Type, ID, Proposed, Assigned, Status, From Terminal, To Terminal, Availability Date, Est Loaded, Est Outgate, Est Ingate, and Est Unloaded. The table lists several cross-town moves, including those for carriers ITS and Greer, with specific terminal and time slot assignments. A 'Linked Moves' section is also visible below the main table.

Type	ID	Proposed	Assigned	Status	From Terminal	To Terminal	Availability Date	Est Loaded	Est Outgate	Est Ingate	Est Unloaded
Crosstown	HJCU437905	ITS	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 22:03...	9:15	9:45	10:30	10:45
Crosstown	MOAU20647	ITS	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 16:37...	12:15	12:45	13:30	13:45
Crosstown	MOFU73108	ITS	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 05:55...	12:15	12:45	13:30	13:45
Crosstown	MOTU51748	Greer	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 16:50...	6:15	6:45	7:30	7:45
Crosstown	MOTU51748	Greer	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 16:50...	6:15	6:45	7:30	7:45
Crosstown	MOTU51748	Greer	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 16:50...	6:15	6:45	7:30	7:45
Crosstown	SLSU900777	Greer	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 22:05...	9:15	9:45	10:30	10:45
Crosstown	TCLU400059	Greer	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 05:19...	6:15	6:45	7:30	7:45
Crosstown	TGHU737576	Greer	---	UR	UP Neff	NS Voltz	Sat May 15 2010, 05:49...	9:15	9:45	10:30	10:45
Crosstown	TRLU648948	Greer	---	UR	UP Neff	NS Voltz	Sun May 16 2010, 07:04...	12:15	12:45	13:30	13:45
Linked Moves: BSU402990 (5 Items)											
Crosstown	BSU402990	ITS	---	OA	NS Voltz	UP Neff	Sun May 16 2010, 08:00...	6:15	6:45	7:30	7:45
Crosstown	CLHU907834	ITS	---	UR	UP Neff	NS Voltz	Sun May 16 2010, 07:28...	6:15	8:45	9:30	9:45
Crosstown	CRXU925809	ITS	---	UR	UP Neff	NS Voltz	Sun May 16 2010, 07:31...	12:15	12:45	13:30	13:45
Crosstown	DFSU229777	ITS	---	OA	NS Voltz	UP Neff	Sun May 16 2010, 08:00...	10:15	10:45	11:30	11:45
Crosstown	HJCU811798	ITS	---	OA	NS Voltz	UP Neff	Sun May 16 2010, 08:00...	14:15	14:45	15:30	15:45

Source: SAIC.

Due to several external factors, including a decline in freight volumes brought about by the recession and the retirement of a key C-TIP champion at a Class I railroad, Kansas City railroads did not participate in the C-TIP operational test. This made it impossible to evaluate the actual benefits of C-TIP IMEX since the railroads did not use the system. Therefore, the evaluation team instead conducted a simulation test to estimate the potential benefits of IMEX.

Kansas City

The Kansas City IMEX simulation test, conducted from October 1, 2010 to January 31, 2011, provided a total of 1,663 cross-town drayage moves for

analysis. These moves included cross-town transfers between the Union Pacific Neff Yard and the Norfolk Southern Voltz Yard, and between the BNSF Argentine Yard and NS Voltz Yard. The railroads provided gate move data, including the date and time a container was unloaded; the origin and destination terminals; and a container ID number.

Figure 2.15 provides a summary of terminal move activity during the Kansas City test period and IMEX matched moves. The vast majority of moves originated at either the BNSF Argentine or UP Neff yards. This is because the prevailing traffic pattern for cross-towns in Kansas City is from western railroads (e.g., BNSF or UP) to eastern railroads (e.g., NS). The BNSF and UP railheads accounted for 1,588 of the cross-towns in the test period, or 95 percent of the total. The total number of matches averaged about 30 per month except for November when it rose to 71 matches.

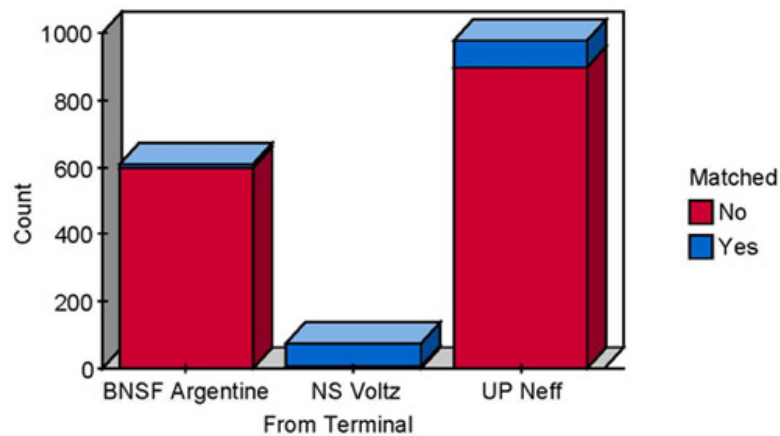
Of the 1,663 moves, IMEX identified 163 potential “matches,” or containers that could be sequentially matched and moved by the same driver, thus eliminating a bobtail. A potential match in IMEX occurred whenever the same terminal had a container destined to it and also had a container move originating from it. In that event, the same driver could theoretically bring the first container to the terminal, drop it off, and load up the next container without making a bobtail move. For purposes of distributing matched loads, it was assumed that each driver could handle five containers per day. However, in practice there were never enough matches in one day to require more than one driver.

Figure 2.15 C-TIP IMEX Terminal Move Summary
 Kansas City

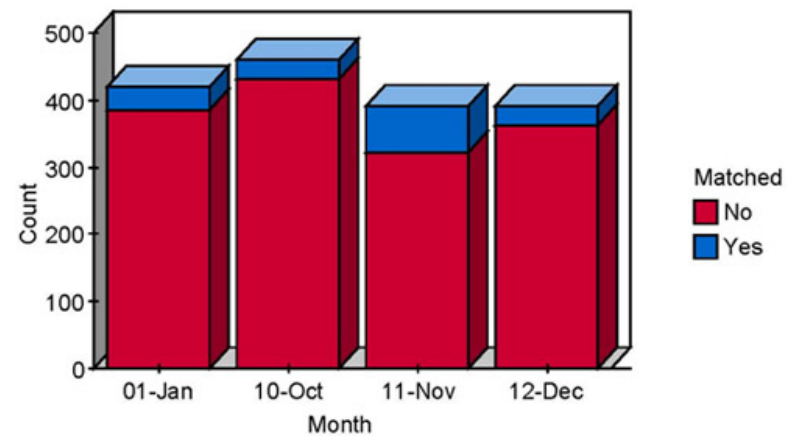
Terminal Move Summary

Month ▾	BNSF All	BNSF Matched	NS All	NS Matched	UP All	UP Matched	Total All	Total Matched
01-Jan	168	2	16	14	236	19	420	35
10-Oct	154	2	12	12	295	16	461	30
11-Nov	116	4	33	31	243	36	392	71
12-Dec	171	3	14	11	205	13	390	27
Total	609	11	75	68	979	84	1663	163

Moves by Terminal



Moves by Month



It is important to note that not all IMEX matches correspond to actual matches. Of the 163 matches identified by IMEX, only 28 could be verified as cross-town moves that were performed in sequence by the same driver. Railroads and dray carriers did not always match loads for a variety of reasons:

- The IMEX dispatch model assumed that boxes can sit all day in a terminal if necessary in order to be matched; however, in practice this is rarely the case as railroads typically want grounded containers out of their yards as soon as possible.
- Draymen in Kansas City do not plan their entire day far enough in advance to take advantage of matching opportunities, and in any event the railroads typically don't give dray carriers notice until a unit is on the ground anyway – all of which makes it hard to coordinate moves across the space of many hours.
- Overall, truckers may view it as too much trouble to pick up a matched load when doing so would only save them about 15 minutes (at least in the Kansas City context). In Kansas City, the rail terminals are close enough together to allow a trucker to drop off a box, bobtail back to the originating terminal, and deliver another box within one hour – thus minimizing the potential time savings associated with picking up a matched load.

Additionally, overall volumes and traffic patterns changed dramatically just prior to the test period due to the recession and changing railroad operational strategies, leading to drastically reduced load matching during the C-TIP deployment phase. These cumulative factors contributed to low overall participation in the program amongst railroads and dray carriers.

Nonetheless, this initial IMEX deployment did prove the concept that a specially designed technology could address the known inefficiencies associated with cross-town rubber tire interchanges between railroads. It is possible that greater benefits could be achieved in a larger rail market such as Chicago.

Figure 2.16 is another Vantage dashboard describing key C-TIP IMEX performance metrics. The top row of gauges shows total moves, total C-TIP matches, and actual matched moves. The bottom set of gauges describe the potential empty trips/miles eliminated and fuel saved if all stakeholders had followed the IMEX work plan during the test period. Empty mileage and fuel savings were calculated using the following assumptions:

- Distance between terminals is eight miles (UP Neff to NS Voltz; there were no matches from the NS back to the BNSF during the test); and
- Dray truck fuel economy averages six miles per gallon (a commonly accepted value in the trucking community).

The number of empty miles saved is thus the distance between the terminals multiplied by 135 trips. Fuel savings are then derived by dividing average fuel economy into total miles saved.

Figure 2.16 C-TIP IMEX Performance Metrics
Kansas City

C-TIP Performance 10/1/2010 - 1/31/2011



Total number of cross town moves between BN, UP and NS in Kansas City



Number of moves identified by CTIP that could be sequentially matched and moved by the same driver



Cross town moves that were moved in sequence by the same driver



Number of empty trips that would have been eliminated if CTIP was fully utilized



Empty miles that would be eliminated by CTIP



Fuel that would be saved by eliminating empty trips

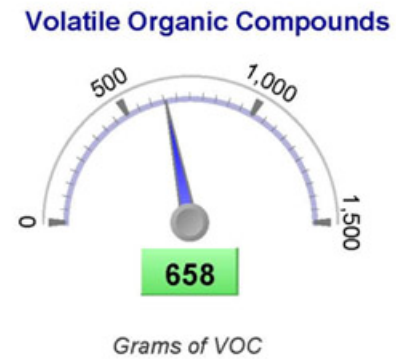
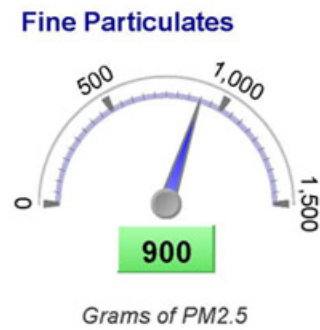
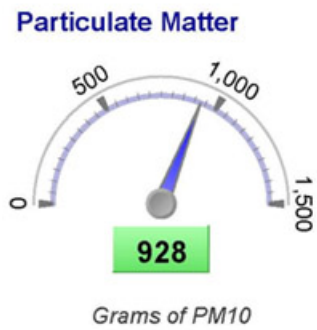
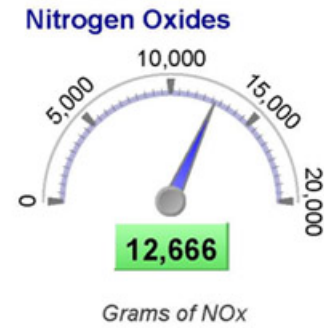
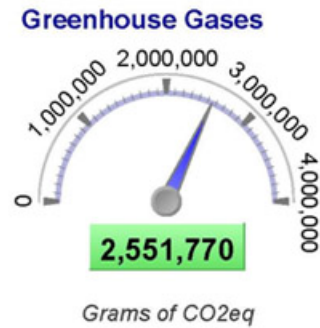
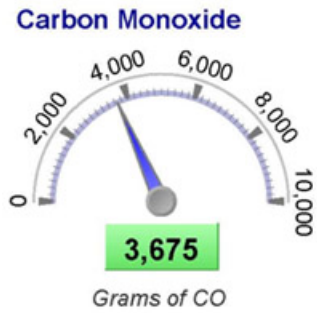
Using these assumptions, if C-TIP had been fully utilized during the period, it would have eliminated 135 empty truck trips (163 C-TIP matches minus 28 actual matches). This would have eliminated 1,080 empty miles and saved 180 gallons of diesel fuel.

These potential mileage and fuel savings also would lead to emissions reductions. CS estimated the potential IMEX emissions reductions using the same EPA emissions factors used in the RTTM/DRG analysis. For analytical purposes, it was assumed that trucks traveling between the two terminals would average 30 mph. (Google Maps reports a travel time of 18 minutes between the two points, which is about 27 mph.) Therefore, emissions factors for the 30 mph speed bin were chosen from Table 2.1 for the analysis.

The results are provided in Figure 2.17. As the Vantage dashboard shows, given this set of assumptions, C-TIP IMEX would have reduced carbon monoxide emissions by 3,675 grams, greenhouse gases by about 2.5 million grams of CO₂eq, oxides of nitrogen by 12,666 grams, PM₁₀ by 928 grams, PM_{2.5} by 900 grams, and VOC by 658 grams.

Figure 2.17 C-TIP IMEX Potential Emissions Reduction
Kansas City

Emissions Reduction 10/1/201 - 1/31/2011



Chicago Terminal

A similar ‘what if’ analysis was conducted for intermodal transfers in Chicago, which is by far the nation’s largest rail hub. The Chicago test relied on gate move data provided by the UP and CSX railroads. The data includes 9,890 intermodal moves between these two railroads in Chicago, made between January 1, 2011 and April 30, 2011. These moves involved four UP terminals and two CSX terminals in the Chicagoland region. These data were loaded into IMEX, which then provided a daily optimal work plan as in Kansas City. The work plan used the same logic as the Kansas City test, except that the gate move data were analyzed in one batch rather than on a daily basis since four months’ worth of data were received all at once.

The following assumptions were used:

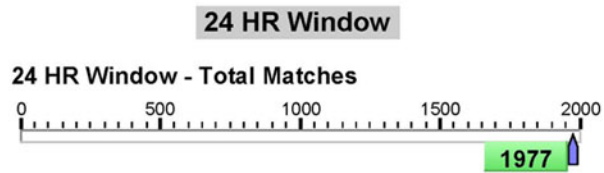
- The average dray distance between terminals is 25 miles;
- The cutoff for cross-town deliveries is 5:00 p.m. each day; and
- Dray truck fuel economy averages 6 mpg.

Results were stratified into 24-hour, 12-hour, 3-hour, and 15-minute ‘windows’, where each time window represents the total time available to make the cross-town delivery from container de-ramping at the originating terminal to the 5:00 p.m. cutoff at the receiving terminal.

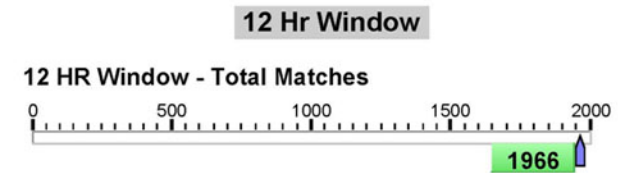
Figure 2.18 shows theoretical C-TIP IMEX performance for the Chicago terminal under these assumptions. Clearly, the potential is much greater in a large intermodal market like Chicago. Under the 24-hour window, there are nearly 2,000 matches; if all of these matches actually occurred it would save more than 49,000 empty truck miles and about 8,200 gallons of diesel fuel. Interestingly, under a 12-hour delivery window the potential matches, miles saved, and fuel saved do not decrease that much. Even under the 3-hour window, the system finds more than 1,600 matches which would save 41,000 empty miles and cut fuel use by nearly 7,000 gallons. This suggests that substantial benefits could be realized even under real-world operational constraints such as tight cutoff times for cross-town freight.

Figure 2.18 C-TIP IMEX Performance
Chicago Terminal

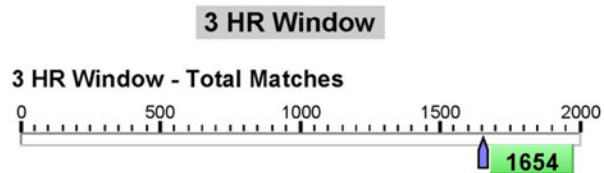
Chicago Study Performance and Fuel Savings



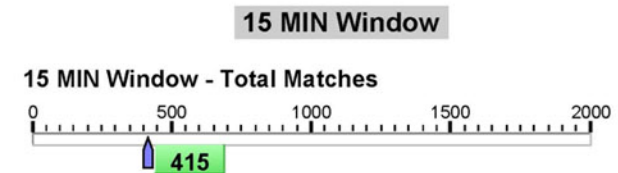
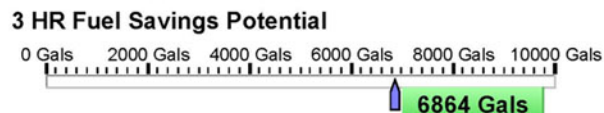
24 HR Empty Miles Savings Potential 49,425 Miles



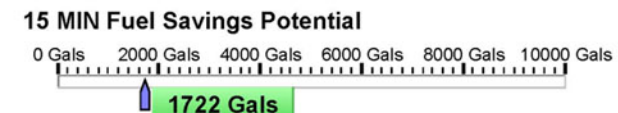
12 HR Empty Miles Savings Potential 49,150 Miles



3 HR Empty Miles Savings Potential 41,350 Miles



15 MIN Empty Miles Savings Potential 10,375 Miles



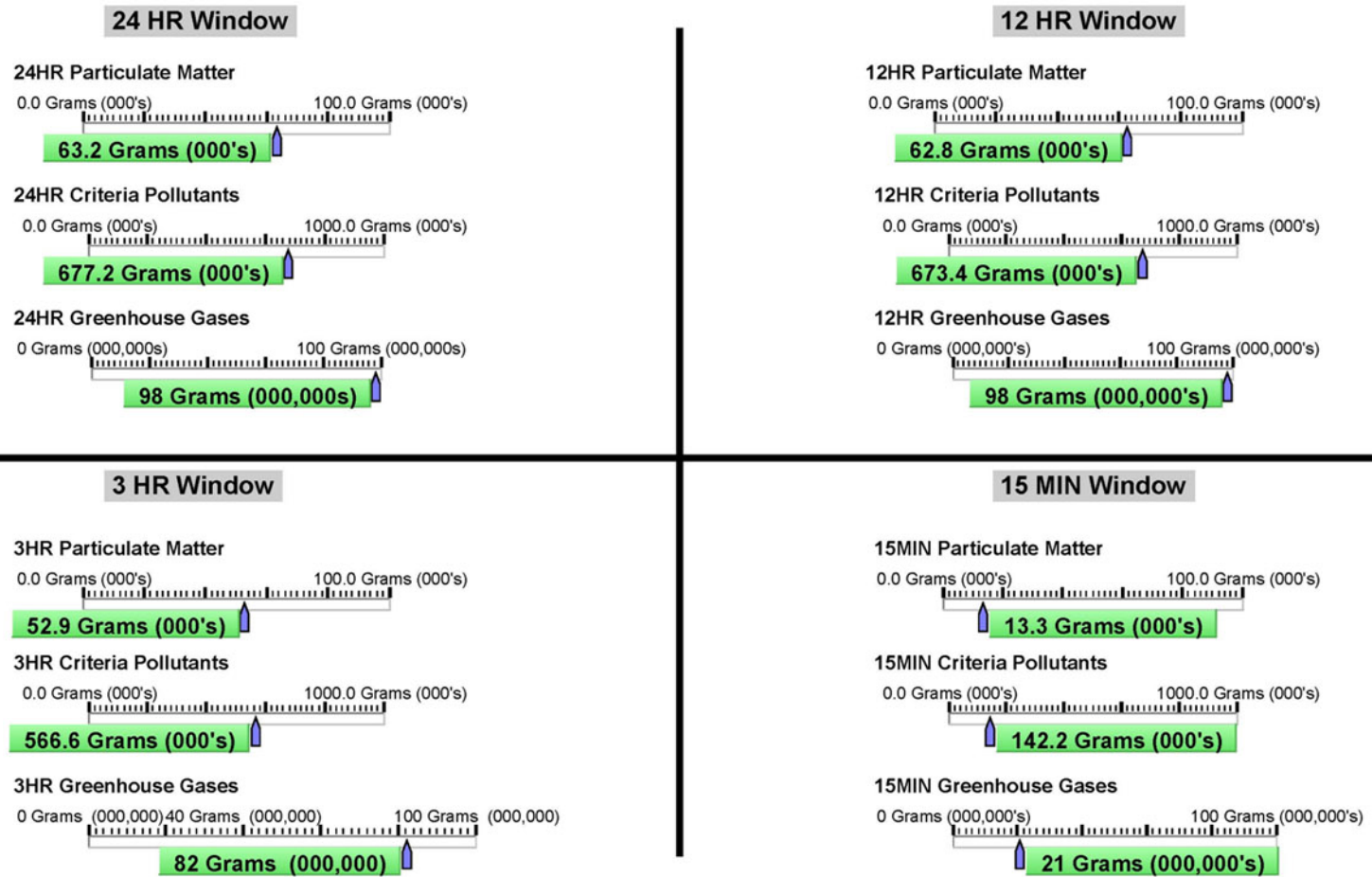
As in Kansas City, these fuel savings also would generate significant reductions in key pollutants and greenhouse gases. For the analysis of emissions savings, CS used the following emissions factors:

- CO: 3 grams per mile;
- CO₂eq: 2,000 grams per mile;
- NO_x: 11 grams per mile;
- PM₁₀: 8 grams per mile;
- PM_{2.5}: 0.75 grams per mile; and
- VOC: 0.6 grams per mile.

These factors were adapted from the Kansas City emissions factors and represent values in between the 30 mph and 35 mph speed bins. As shown in Figure 2.19, the potential emissions reduction is substantial due to the volume of cross-town traffic in Chicago. Assuming the originating railroad had 24 hours to cross-town a container, IMEX could potentially reduce particulate matter emissions by over 63,000 grams; other criteria pollutants (NO_x, VOC, and CO) by nearly 700,000 grams; and greenhouse gas equivalents by almost 100,000 grams. Savings under the 12-hour window are similar in size. Assuming that the 3-hour window is the most realistic, the reductions are still substantial, totaling 53,000 grams of particulate matter, 567,000 grams of other criteria pollutants, and 82,000 grams of CO₂ equivalents. Combining all criteria pollutants (PM plus other criteria pollutants), IMEX could potentially have eliminated more than six-tenths of a ton of harmful diesel emissions in Chicago during the four-month test period. If all six Class I railroads that operate in Chicago participated fully in IMEX, the savings would likely be much greater.

Figure 2.19 C-TIP Potential Emissions Reduction
Chicago Terminal

Estimated Emissions Reduction - Chicago Terminal



2.4 C-TIP USER INTERVIEWS

Interviews with C-TIP system users were conducted to better assess non-quantitative aspects of the application. CS contacted drivers who were using the RTTM/DRG application on iPhones in their cabs as well as dispatchers/terminal managers who were involved in the test. Separate questionnaires were developed for truck drivers and terminal managers/dispatchers. The interview instruments are provided in Appendix B. Responses were collected from two drivers, one dispatcher, and one terminal manager. Feedback is somewhat limited due to the small number of users and difficulties with engaging truck drivers who are not often in an office where they may be reached by telephone. However, the responses that were gathered offer some useful insights about the initial C-TIP deployment, which are summarized below.

- In general, users liked the idea of having a smart phone application that provided routing information, but they did note some practical obstacles to the RTTM/DRG app. Two users from ITS noted that the phone never recommended alternate routes, even during construction on the primary route which caused significant delays. There also were concerns about the truck-friendliness of alternate routes. Even so, most felt the application was convenient to have and could be beneficial.
- Some interviewees felt the user interface could be improved, mainly by reducing the number of steps required to obtain a route. One driver had unspecified problems with the touch screen interface. Older drivers who may not have been highly 'tech-savvy', as well as those for whom English was a second language, required additional training to use the app. However, once they got used to it things seemed to run fairly smoothly.
- One driver did report an example of a significant time savings achieved with DRG. This driver reported that a wreck on I-35 caused the phone to reroute him around the incident, which saved him about five minutes in travel time on that particular trip. The same driver also noted that the application was effective at increasing the number of turns he could make in a day.
- In terms of improvements to the information provided, in general the interviewees didn't see much value in providing estimates of the amount of fuel they could save by taking an alternate route. The terminal manager and one of the drivers indicated that drivers tend to monitor their fuel use closely already. The other driver - who actually did receive alternate routings - stated that his fuel use was about the same and the main benefit was really productivity. Some interviewees felt that an automatic load notification system would be useful (i.e., if the system alerted drivers when a container was released for pickup), but it would still have to keep the dispatcher in the loop to avoid multiple drivers converging on one spot to get a load.

3.0 Drayage Optimization Tests

Given the lack of railroad participation in the operational test, FHWA-OFM sponsored separate drayage optimization tests in Kansas City and Chicago to develop better metrics of bobtail reduction using C-TIP technologies. These tests focused on providing cross-town drayage companies with real-time information on driver location and trip events (e.g., load pick up and drop off) to help rationalize the dispatch process, minimize the potential for human error, and reduce unproductive moves. The following sections describe the Kansas City and Chicago tests and the efficiency improvements associated with them.

3.1 KANSAS CITY IXT TEST

The IXT drayage optimization test was conducted in Kansas City from April 1 to August 31, 2011. The control period was defined as April 1 to June 27, with an operational test period from June 28 to August 31. IXT is a drayage services provider in Kansas City, specializing in moving freight between intermodal terminals and customer locations in the metropolitan area. IXT utilized the C-TIP Open Source Architecture Package (C-TIP OSAP) deployed on in-cab smart phones to help optimize its cross-town drayage moves by minimizing unproductive bobtail moves. C-TIP OSAP provides IXT dispatchers with real-time driver location data along with wireless notification when a container is released for pickup. Dispatchers are therefore able to assign work orders to drivers who are nearby and not carrying a load, thus eliminating a bobtail trip.

CS' evaluation relies on the use of dray movement event data provided by IXT through Profit Tools, a major provider of IT solutions for the trucking industry. The data cover the entire period of the test from April 1 to August 31, 2011. The data describe multiple events, including freight deliveries, 'hooks' (when a driver picks up equipment), 'drops' (the driver drops off equipment), the type of equipment involved, whether the driver bobtailed to the location in question, and miles in bobtail and load status. It also provides the rail terminal, IXT yard, or customer location of each event. Data are provided on an 'itinerary' basis, allowing truck movements to be tracked by driver, date, and sequence of events.

Examination of the detailed data revealed that there were some records in the data set that were not relevant to the present analysis. For example, some records revealed trip lengths of hundreds of miles (clearly outside the realm of cross-town drayage), or trips that occurred outside of Kansas City entirely. Others had no reported mileage. In order to better capture true cross-town freight and improve the accuracy of mileage statistics, all trips greater than 40 miles in length were eliminated, as were all records with no mileage value and all records of movements that occurred outside of the Kansas City metropolitan area. For the purposes of the evaluation, the metropolitan area was defined as all

cities within the 15-county metropolitan statistical area (MSA) with populations of at least 10,000 as of the 2010 Census. These cities are shown in Table 3.1.

Table 3.1 Kansas City Metro Area Cities Included in the IXT Drayage Analysis
By 2010 Population

City	2010 Population
Kansas City, Missouri	459,787
Overland Park, Kansas	173,372
Kansas City, Kansas	145,786
Olathe, Kansas	125,872
Independence, Missouri	116,830
Lee's Summit, Missouri	91,364
Shawnee, Kansas	62,209
Blue Springs, Missouri	52,575
Lenexa, Kansas	48,190
Leavenworth, Kansas	35,251
Leawood, Kansas	31,867
Raytown, Missouri	29,526
Liberty, Missouri	29,149
Gladstone, Missouri	25,410
Grandview, Missouri	24,475
Belton, Missouri	23,116
Prairie Village, Kansas	21,447
Raymore, Missouri	19,206
Gardner, Kansas	19,123
Grain Valley, Missouri	12,854
Ottawa, Kansas	12,649
Lansing, Kansas	11,265
Excelsior Springs, Missouri	11,084
Merriam, Kansas	11,003
Harrisonville, Missouri	10,019

Source: U.S. Census Bureau.

After making these adjustments, revenue loads were identified using a shipment ID field; the number of unique shipment IDs per month equals the number of revenue loads in that month. Records in bobtail status were then identified by month by selecting records where the 'bobtailed' field was equal to 1 (a 0

indicates a truck was pulling equipment, i.e., not bobtailing). Bobtail trips by month were calculated by summing the number of bobtail records in each month of the baseline (April to June) and test (July and August) periods.

The results are shown in Table 3.2 along with monthly percent changes in bobtail trips and revenue loads, as well as the number of phones deployed during the July and August test period. As the table indicates, bobtail activity rose from April to May by 3 percent, then again from May to June by 23 percent. After that, bobtails fell by 6 percent in July and eight percent in August. Revenue loads also rose in May and June, fell slightly in July (though not by as much as bobtails), then rose by 2 percent in August. These data show that there was a reduction in bobtails which coincided with the introduction of the C-TIP OSAP-enabled smart phones. Moreover, bobtail activity continued to fall even as revenue loads grew in August.

The owner of IXT concurred that these reductions in bobtail trips are reasonably the result of the C-TIP OSAP deployment.

Table 3.2 IXT Drayage Optimization Test Results by Month
Kansas City Locations Only

Month	Bobtail Records	Percent Change	Revenue Loads	Percent Change	Telephones Deployed
April	837	–	1,099	–	0
May	865	3%	1,141	4%	0
June	1,061	23%	1,388	22%	0
July	999	-6%	1,326	-4%	4
August	924	-8%	1,346	2%	12

Source: CS analysis of Profit Tools/IXT truck movement data.

Note: All trips greater than 40 miles, outside of the Kansas City metropolitan area, or with no reported miles have been eliminated.

3.2 CHICAGO TEST

Another C-TIP OSAP test was conducted in the Chicago region involving Pride Logistics, LLC, which is a provider of intermodal transportation services located in Palos Heights, Illinois. Flatirons Two, Inc., a technology company specializing in network/database administration, system integration, and smart phone applications, developed an Android smart phone app with the following functionality:

- Upload drivers' daily schedules to smart phone;
- Provide drivers the ability to enter status updates;

- Provide schedule updates to drivers; and
- Periodically capture truck location information.

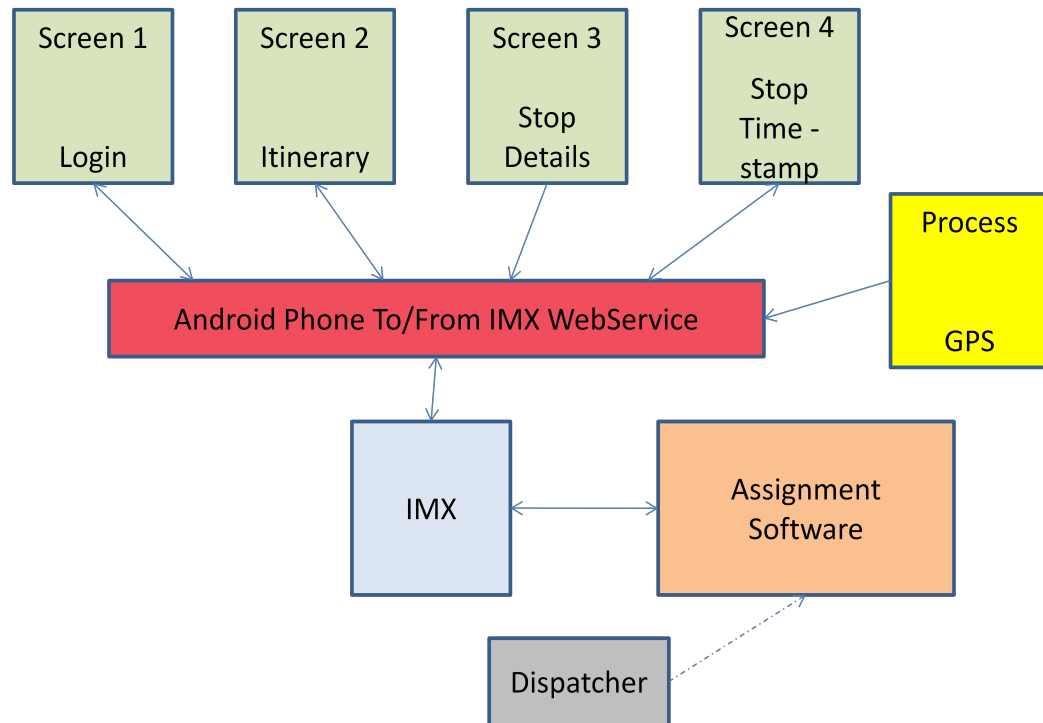
Two truck drivers were provided with Android smart phones during the test. The baseline test period was June through August of 2011, with the operational test period occurring in September.

Flatirons Two also reviewed Pride's business model and dispatch process to identify opportunities to automate the process and reduce unproductive moves. Under Pride's current business process, customers request container pickup via fax, phone call, or other manual methods. Those requests are then manually entered into a data base called IMX. From the IMX database the Pride dispatcher produces T-Cards with the pertinent information associated with the move. A wall display containing card slots is used to manage the progression from future workload to current workload to assignment to a driver, to the final step of notifying the driver of the work to be completed. This final step is done via e-mails and/or phone calls. Dispatchers must sort T-Cards manually throughout the day and attempt to find the most efficient allocation of equipment and labor resources based on changing customer needs, traffic conditions, and regulatory constraints. With an average of about 60 work orders per day, there is substantial opportunity for human error when planning workload.

Once the work order is completed the completion time is entered into the IMX database for tracking and billing purposes. However, this often occurs several hours later or the next day, thus slowing down the billing process, reducing shipment visibility for customers, and hampering efficiency.

Flatirons Two automated this process by developing a web application to handle the dispatch function. This application enables the dispatcher to sort work orders by origin, destination, and driver itinerary, with results presented clearly and concisely on the computer screen. This allows dispatchers to better match up drivers and loads throughout the day, eliminating the manual resorting of T-Cards. Dispatchers are able to quickly identify potential bobtails and make a more informed assignment. A schematic of the information and data flow for the dispatcher web application is provided in Figure 3.1.

Figure 3.1 Dispatch Web Application Information Flow



Source: Flatirons Two/Pride Logistics.

Determination of Benefits

The benefits associated with this test deployment revolve around three areas:

- **Reduced Bobtail Miles/Trips** - The process of the system being able to sort by origin and destination gives the dispatcher the ability to search for the best, most efficient loads available. This will reduce bobtail miles by eliminating human error in the selection of a load. The process for calculating bobtail miles was as follows:
 - Pride used Google map mileage from actual start point to all stop points to determine actual mileage from each start/stop location. Pride then calculated all bobtail mileage using its internal move records. Total miles were then matched against the odometer reading turned in on each driver's daily log. If there was a discrepancy between the Google map miles and odometer miles Pride checked the route taken and manually adjusted the route on Google maps.
 - Once the miles were verified, bobtail miles were divided into total miles to produce the percentage of total miles that are bobtail miles. This measure adjusts for fluctuation in workload.
- **Driver Productivity** - Driver productivity during the baseline and test periods was measured using the average number of loads per driver. This

was calculated by taking the average number of drivers per day for each month and dividing it into the average number of loads per day. So, for example, if there are an average of 16 drivers per day and an average of 85 loads, this would equate to 5.3 moves per driver (85 moves divided by 16 drivers).

- **Dispatcher Productivity** – Much of the dispatcher’s time is involved in the communication with the drivers and the planning of workload. This system can reduce the amount of phone communication by dispatching through the system. Communication has a minimum of four contacts – when the dispatcher dispatches the load, when the driver arrives at the customer, when the driver departs from the customer and when the move is finished. Drivers equipped with the Android smart phones were able to receive their work orders on the telephone and update their arrival and departure status in real time using a button included in the app.

Test Results

The test results for the bobtail miles/trips and driver productivity metrics as reported by Pride are shown in Table 3.3. These results have not been independently verified but CS believes them to be accurate based on the methodology described by Pride and Flatirons as well as subsequent conversations with them.

Table 3.3 Pride Logistics Test Bobtail and Driver Productivity Metrics

	June	July	August	September
Bobtail Miles	1,967	2,136	2,196	1,061
Total Miles	20,280	23,479	24,677	22,593
Percent of Miles in Bobtail	9.7%	9.1%	8.9%	4.7%
Bobtail Trips	51	53	58	28
Total Trips	522	586	635	690
Percent of Trips in Bobtail	9.8%	9.0%	9.1%	4.1%
Total Loads	522	586	635	690
Drivers	13	15	15	15
Average Loads per Driver	40	39	42	46

Source: Pride Logistics, LLC.

Note: June through August is the baseline; September is the test period.

There was substantial improvement in the bobtail metrics during the September operational test period. The percent of total miles in bobtail status fell from 8.9 percent in August to 4.7 percent in September. Although total miles fell by 8.4 percent in September, bobtail miles fell even faster (more than 50 percent), leading to substantial improvement in this metric. Meanwhile the percent of

total trips as bobtails fell from 9.1 percent to 4.1 percent on a consistently growing number of total trips. Driver productivity also improved, from an average of 40 loads per driver in June to 46 loads per driver in September.

There are no similar quantitative metrics to evaluate dispatcher productivity because this would require detailed time keeping records that were not available for this study. However, under the T-Card system the dispatcher often required help from other employees to accomplish his or her task – thus diverting other staff from their assigned work. Inasmuch as the web application allows the dispatcher to handle more of the dispatch function by himself, Pride can accommodate additional business growth without having to hire another dispatcher or divert labor from other business activities to accomplish the necessary function of allocating drivers and equipment.

While most of the bobtail and driver productivity benefits in this test flow from the dispatch web application, Pride reported substantial business process benefits associated with the real-time arrival/departure information enabled by the Android app. The billing procedure was improved since billers could initiate the process once they knew a container had been delivered to the customer. It also eliminated the manual dispatcher effort required to update IMX for billing purposes and improved shipment visibility for customers. Moreover, the drivers using the app liked the ability to see their work orders on the phone and read them at their convenience. Previously, they would copy down work orders from the dispatcher over the telephone, which required them to pull over if they were driving at the time and also introduced substantial opportunity for transcription or other errors.

An interview was conducted with a driver who was equipped with a smart phone during the test. The interview instrument is provided in Appendix B. This driver confirmed that the primary use of the phone was to obtain dispatch instructions (through the automated T-Card system), and to provide status updates such as pickup/drop off times to the central office. The driver liked the application and stated multiple times that it was much easier than calling back and forth to get work orders from the dispatcher. Previously, the driver obtained work orders via e-mail or instant message, usually the night before; any updates or changes had to be handled on a case-by-case basis through phone calls to the dispatcher. The automated T-Card eliminated the need for him to do this.

4.0 Delphi Study Results

In order to further gauge C-TIP benefits, including more subjective criteria such as the importance of C-TIP software features to users, a targeted Delphi assessment was conducted. Delphi is an analytical method that attempts to quantify expert opinion on a given topic through an iterative polling process. The Delphi approach relies on a survey panel of subject matter experts, who are polled to obtain their opinions about a given topic. Through iterative survey rounds, the panelists' responses are collected and shared anonymously until no further movement towards consensus is evident. The result is the Delphi panel's collective opinion on a value or range of values. Although it does not represent a statistically valid sample, the Delphi process does provide a snapshot summary of expert opinion on the topic, with reasoning to support differing and similar viewpoints. This is particularly useful for capturing information which can't be easily quantified.

The Delphi assessment focused on evaluating the importance of key C-TIP features, and on estimating the potential travel time, bobtail reduction, and other benefits that might be associated with a theoretical Chicago deployment of C-TIP technologies. This was done due to the low participation rate found in Kansas City; since Chicago is the largest intermodal hub in North America, it stands to reason that C-TIP would have greater benefits there and may attract more interest.

The Delphi process was conducted in two rounds via telephone interviews, e-mail, and fax. Questions revolved around the importance of C-TIP features/functions to users; estimated time savings from RTTM and DRG in a theoretical Chicago deployment; estimated bobtail and idle reduction from a Chicago deployment; potential railroad benefits from C-TIP; and the ability of C-TIP to reduce manual processes such as track and trace and dispatching. The first and second round survey instruments are provided in Appendix C.

Fifteen interviews were conducted in the first round, representing the viewpoints of 17 individuals who are experts in the field of intermodal transportation. A list of Delphi panelists is provided in Table 4.1. Respondents included representatives from four Class I railroads, three drayage companies, one terminal operator, one steamship line, and one independent consultant. Some respondents had been involved previously with C-TIP in a conceptual or operational capacity and were, therefore, already very familiar with it; others were new to the project. CS developed a PowerPoint presentation to familiarize participants with C-TIP and the Delphi process; this presentation was sent out to each respondent prior to first round interviews.

Table 4.1 C-TIP Delphi Panel

Name	Title	Company
Karen Duff	President	International Express Trucking
Ron Teague	Regional Manager	In-Terminal Services, Inc.
Dustin Melton	Terminal Manager	In-Terminal Services, Inc.
Carrie Vanderwerf	Dispatcher	In-Terminal Services, Inc.
Gerry Bisailon		Union Pacific Railroad
Dave Collins	Terminal Manager	Union Pacific Railroad
Bob Huffman	Vice President	Norfolk Southern Railroad
Ben Shelton		Union Pacific Railroad (Retired)
Ted Prince	Principal Consultant	T. Prince & Associates, LLP
Vernon Prevatt	Director of Logistics and Safety	CSX Transportation
Tony Clark	Sr. Director, Carrier Services	Union Pacific Railroad
Brad Carper	Hub Manager – Landers Term	Norfolk Southern Railroad
Steve Serio	Director – U.S. Intermodal Ops	Canadian National Railroad
George Baima		Pacella Trucking
Dick Pocius	Manager, Hub Operations Chicago	Norfolk Southern Railroad
Ben Chang	AVP – Intermodal Operations	Yang Ming Lines
Tony Cavalea	CEO	Cavalea Trucking

Note: Delphi panelists were selected based on recommendations from SAIC and RMI.

Upon completion of the first round of interviews, all responses were entered into a spreadsheet for analysis. Questions involving Likert scale responses or ranges of values (e.g., percentage of travel time saved) were coded according to the values defined in the Delphi instrument. Qualitative responses were typed manually into the spreadsheet for comparison across panelists.

A second round questionnaire was then developed for those questions where there was considerable variation of opinion. The second round questions were targeted at those respondents whose answers were in the minority for that question. The new questions presented the majority viewpoint, with reasoning, and respondents were offered the chance to amend their answers or provide further defense for their original opinion. Overall, the second Delphi round did show considerable movement towards consensus on questions where there had been a wide range of responses.

Importance of Features

The first group of Delphi questions attempted to gauge the relative importance of different C-TIP functionalities to potential users. Respondents were asked to rate various features of C-TIP on a scale of 1 to 5, with 1 being not at all

important and 5 being extremely important. The results are presented in Table 4.2. The shaded cells represent the group consensus values. Most of the panelists felt that C-TIP's congestion/traffic avoidance, minimizing terminal delay, and load notification features were either 'very important' or 'extremely important.' Overall, this result lends credence to the idea that there is an opportunity to improve the flow of intermodal freight with a technology like C-TIP that seeks to address these issues.

There appears to be agreement that C-TIP routing features (RTTM/DRG) are slightly more important to users than minimizing terminal delay or automatic notification of load availability. Eighty percent of the panelists rated 'avoiding recurring congestion' and 'avoiding traffic incidents' as either 'very important' or 'extremely important.' Many respondents felt that delays in intermodal terminals already were minimal (the railroads in particular stated that they monitor this metric very closely and have worked hard to reduce turn times over the last few years). Meanwhile some panelists expressed skepticism about the feasibility of a common dispatch platform that would enable an automatic load notification function; although many acknowledged the benefit this could bring, they also noted practical obstacles to making it work, including reluctance to turn over the dispatch function to an outside entity.

Table 4.2 Importance of C-TIP Features to Users

Importance of Features	Number of Panelists Responding			
	Avoiding Recurring Congestion	Avoiding Traffic Incidents	Minimizing Terminal Delay	Automatic Notification of Load Availability
Not at all important	0	0	3	0
Only a little important	2	0	0	2
Moderately important	1	3	1	1
Very important	4	4	4	3
Extremely important	8	8	7	7
No answer	0	0	0	2
	15	15	15	15
Percent rating Very important or Extremely important	80%	80%	73%	67%

Source: CS analysis of C-TIP Delphi responses.

Travel Time Savings

The next set of Delphi questions sought to estimate the per-trip travel time savings that might be achieved in a theoretical Chicago deployment of C-TIP. This question was asked separately for both RTTM (initial route guidance) and DRG (en-route redirection). As shown in Table 4.3, the group consensus fell into the five percent to 10 percent range for both RTTM and DRG, though there also

were several respondents who felt RTTM could achieve time savings of 10-15 percent per trip. There was broad agreement that the potential is greater for initial route guidance (assuming alternate routes are viable for trucks), because accidents or other events that cause non-recurring congestion are random by nature and therefore aren't likely to affect as many trips. Overall, respondents felt that there is likely to be some sort of delay (accident, traffic, or other) on a proportion of trips regardless, and a route recommendation (either before starting the trip or en-route) would help mitigate this. The savings would therefore be a function of the level of the opportunity, which in a city like Chicago could be substantial.

Table 4.3 Potential Chicago Travel Time Savings
Average, per Trip

Potential Time Savings	Number of Panelists Responding	
	Initial Route Recommendations	En-Route Redirection
None	1	1
Less than 5 percent per trip	1	2
Five to 10 percent per trip	6	9
11 to 15 percent per trip	5	1
More than 15 percent per trip	0	0
No opinion/don't know	2	2
Total	15	15

Source: CS analysis of C-TIP Delphi responses.

Bobtails

Another set of questions asked the panelists to provide order-of-magnitude estimates of daily bobtail volumes in Chicago, and the potential for C-TIP to reduce the number of bobtail trips. As shown in Table 4.4, six panelists felt there are between 301 and 500 daily bobtail trips in the region, while another four thought there were more than 500. There was considerable uncertainty regarding this question, with four panelists responding 'no opinion/don't know.' This implies that the estimation of bobtails is difficult, although anecdotal evidence suggests estimates on the higher side are appropriate; one railroad representative stated that his firm probably generates a few hundred bobtail trips per day.

Table 4.4 Estimated Daily Bobtail Volumes in Chicago

Daily Bobtail Volume	Number of Panelists Responding
0 to 150 bobtails per day	0
151-300 bobtails per day	1
301-500 bobtails per day	6
More than 500 bobtails per day	4
No opinion/don't know	4

Source: CS analysis of C-TIP Delphi responses.

There was slightly more certitude about the share of bobtails that could be eliminated with C-TIP. Table 4.5 shows that most of the panelists (9 out of 15) felt there was scope for at least a 16 percent reduction in total daily bobtail trips in Chicago through a C-TIP deployment. Respondents noted that lack of visibility on the other end of cross-town drays creates missed opportunities for matching loads, and that C-TIP's visibility, notification, and prediction capabilities could mitigate this.

Table 4.5 Estimated C-TIP Bobtail Reduction in Chicago

C-TIP Potential Bobtail Reduction	Number of Panelists Responding
None	1
< 5% bobtail reduction per day	0
6%-10% bobtail reduction per day	2
11%-15% bobtail reduction per day	1
16%-20% bobtail reduction per day	4
More than 20% bobtail reduction per day	5
No opinion/don't know	2

Source: CS analysis of C-TIP Delphi responses.

Idle Time

There was general agreement in the first Delphi round about the average time trucks spend idling in the terminal per trip; in fact, follow up was not required for these questions because consensus was achieved in the first round. As shown in Table 4.6, all 15 panelists felt average idle times in Chicago were 60 minutes or less, and a plurality (8 out of 15) thought they were 30 minutes or under.

Table 4.6 Estimated Terminal Idle Time in Chicago
Per Trip

Terminal Idle Time (per Trip)	Number of Panelists Responding
0-30 minutes per trip	8
31-60 minutes per trip	7
61-90 minutes per trip	0
More than 90 minutes per trip	0
No opinion/don't know	0

Source: CS analysis of C-TIP Delphi responses.

Given the general agreement that idle time in the terminal already is minimal, panelists only estimated mild idle reduction from a theoretical Chicago C-TIP deployment (Table 4.7). Eight respondents thought C-TIP would not achieve any reduction in terminal idle times if it was deployed in Chicago; five felt it would achieve minimal savings of up to 15 minutes per trip on average, while one panelist estimated idle reduction of 16-30 minutes per trip.

The general consensus appears to be that railroads already manage dwell time quite well. Waiting time outside the terminal gates is another matter, but panelists did not perceive C-TIP to offer much benefit in that regard. However, reductions in unproductive bobtail trips may reduce queues outside the gates, and Delphi participants may not have fully considered this.

Table 4.7 Potential Terminal Idle Reduction in Chicago
Per Trip

Potential Idle Reduction	Number of Panelists Responding
None	8
0-15 minutes per trip	5
16-30 minutes per trip	1
31-60 minutes per trip	0
More than 60 minutes per trip	0
No opinion/don't know	1

Source: CS analysis of C-TIP Delphi responses.

Other Questions

The final set of questions dealt with other topics such as key intermodal routes/lanes in the Chicago region; C-TIP benefits that might accrue to the railroads; and C-TIP's potential to help rationalize business processes and reduce manual effort in intermodal transportation. Responses to these questions are summarized below.

- Key Chicago cross-town lanes. There are a few high-volume intermodal lanes that were mentioned frequently. Examples include from the BNSF Cicero and Corwith yards to the Norfolk Southern 47th Street and 63rd Street facilities and CSX Bedford Park. Another was from UP Global 2 to the same NS and CSX yards. Overall the prevailing pattern is from western railroads to eastern railroads, which is not unexpected and is similar to Kansas City but greater in scope. These lanes would probably be the most promising if C-TIP technologies were to be deployed in Chicago.
- C-TIP financial benefits for railroads. Panelists generally felt that there may be a benefit to the railroads but it would probably be modest, perhaps in the form of slightly lower rates for cross-town service, or reduced fuel surcharges resulting from fuel savings and the reduction in unproductive trips. This suggests that future deployments of C-TIP technologies should focus on the drayage community, allowing them to find the best operational efficiencies within the markets they serve.
- C-TIP potential to replace manual processes. Most respondents felt that C-TIP could reduce manual processes substantially, though the amount of manual work that might be reduced varied. Savings mostly revolved around track and trace, routing, visibility of bobtailing drivers to dispatchers, and dispatch (having a central dispatch system used by multiple trucking firms). The best opportunities for business efficiencies therefore probably arise from improving the dispatching system for draymen, e.g., by allowing dispatchers to see where drivers are in real-time and dispatch bobtailing truckers who are close to available loads. This is what happened in the drayage optimization tests in Kansas City and Chicago.

5.0 Summary of Findings

Table 5.1 summarizes the key findings of this report by evaluation area.

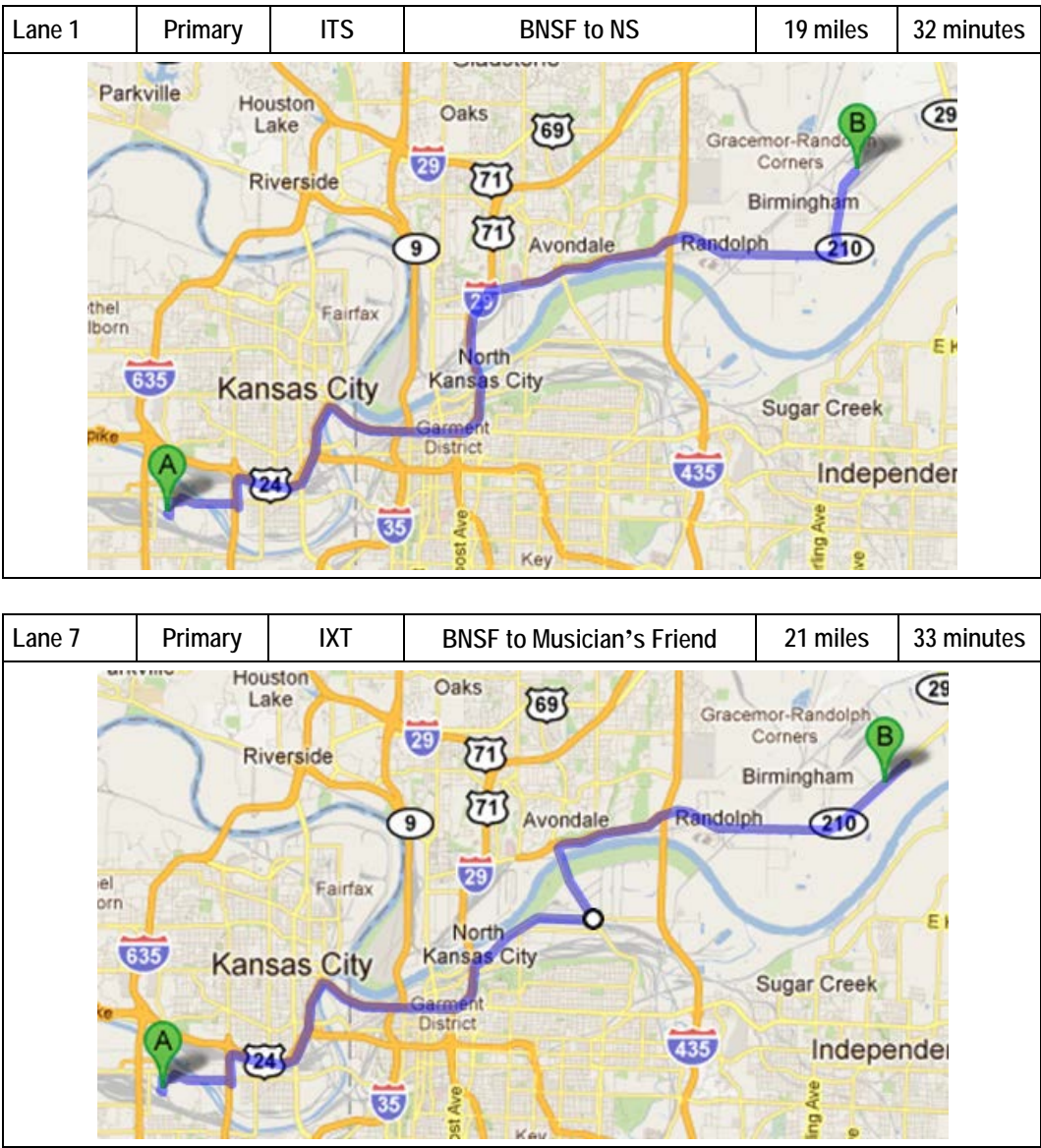
Table 5.1 Summary of Key C-TIP Evaluation Findings

Evaluation Component	Key Findings
Real-Time Traffic Monitoring	<ul style="list-style-type: none"> • Although alternate routes were not offered on all lanes, drivers generally followed them when they were, providing measurable time savings. • RTTM route recommendations also reduced emissions on two lanes by nearly 54,000 grams of CO₂ equivalents and almost 500 grams of other pollutants.
Dynamic Route Guidance	<ul style="list-style-type: none"> • Of 95 total trips with DRG route guidance during the test period, 30 were redirected to avoid congestion, saving an average of six minutes of travel time, or 21 percent with deployment of DRG. • DRG redirects reduced greenhouse gas emissions by about 109,000 grams and other diesel emissions by nearly 800 grams over the four-month test period.
Intermodal Move Exchange	<ul style="list-style-type: none"> • If all stakeholders had followed the C-TIP work plans during the Kansas City test, it would have eliminated 135 bobtail trips and 1,080 empty truck miles, saving 180 gallons of diesel fuel. This would have achieved emissions reductions of over 2.5 million grams of greenhouse gases and almost 19,000 grams of other pollutants. • In a theoretical Chicago deployment involving two railroads, IMEX could potentially reduce bobtails by up to 1,977 trips, saving nearly 50,000 empty miles and over 8,000 gallons of fuel. This would reduce greenhouse gases by about 98 million grams and other pollutants by approximately 740,000 grams.
User Interviews	<ul style="list-style-type: none"> • Although they reported some minor issues with the C-TIP iPhone user interface, in general truck drivers like the idea of having a smart phone application that provides real-time traffic and routing information.
Drayage Optimization Tests	<ul style="list-style-type: none"> • The IXT drayage optimization test in Kansas City revealed a 13 percent decline in bobtail trips over a two-month period after introduction of C-TIP OSAP-enabled smart phones. This reduction coincided with slight growth in revenue loads, indicating that C-TIP OSAP may have contributed to this efficiency gain. • The automated T-Card dispatch system developed for Pride Logistics using C-TIP OSAP provided Pride dispatchers with real-time driver location intelligence, which enabled them to make better resource allocation decisions and reduce bobtail trips and bobtail miles by more than 50 percent.
Delphi	<ul style="list-style-type: none"> • Intermodal industry experts polled for this evaluation collectively thought that a theoretical Chicago deployment of C-TIP could achieve per trip travel time savings of 5 to 10 percent on average, and bobtail reductions of at least 15 percent per day.

A. RTTM/DRG Intermodal Lanes and Route Maps

A.1 RTTM MAPS

Figure A.1 Primary and Alternate Routes by Lane



Lane 7	Alternate	IXT	BNSF to Musician's Friend	20 miles	30 minutes

Lane 7	Alternate	IXT	BNSF to Musician's Friend	22 miles	32 minutes

Lane 9	Primary	Comtrak	Toyota to Grainger	25 miles	30 minutes

Lane 9	Alternate	Comtrak	Toyota to Grainger	23 miles	28 minutes

Lane 9	Alternate	Comtrak	Toyota to Grainger	22 miles	29 minutes

Lane 10	Primary	Comtrak	UP to Toyota	25 miles	31 minutes

Lane 10	Alternate	Comtrak	UP to Toyota	23 miles	27 minutes

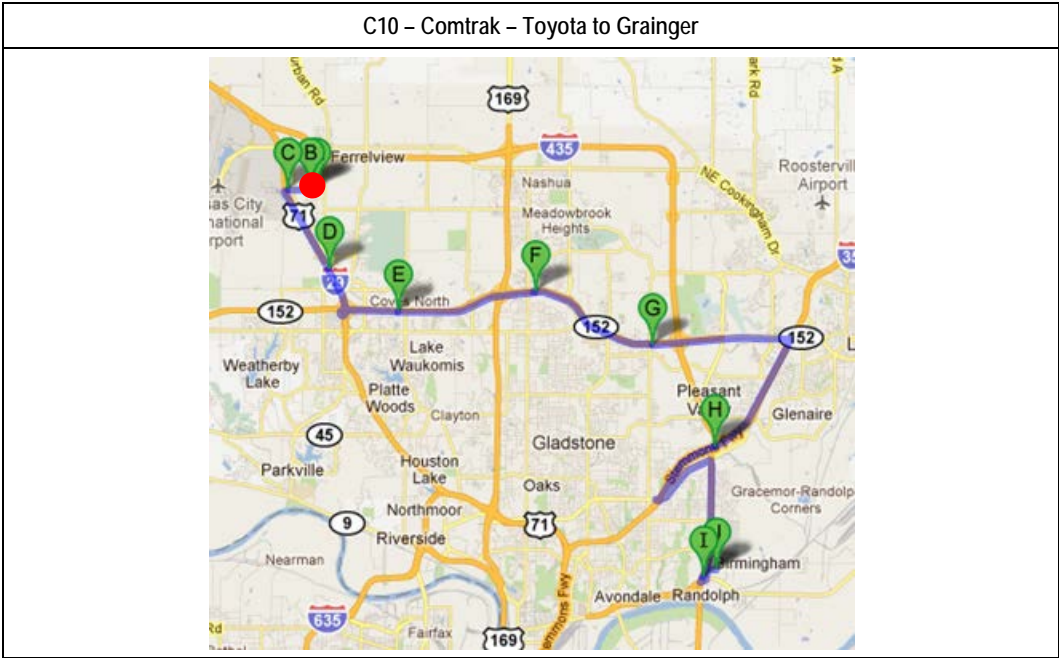
Lane 10	Alternate	Comtrak	UP to Toyota	19 miles	25 minutes

Lane 11	Primary	Comtrak	BNSF to Topeka	59 miles	60 minutes
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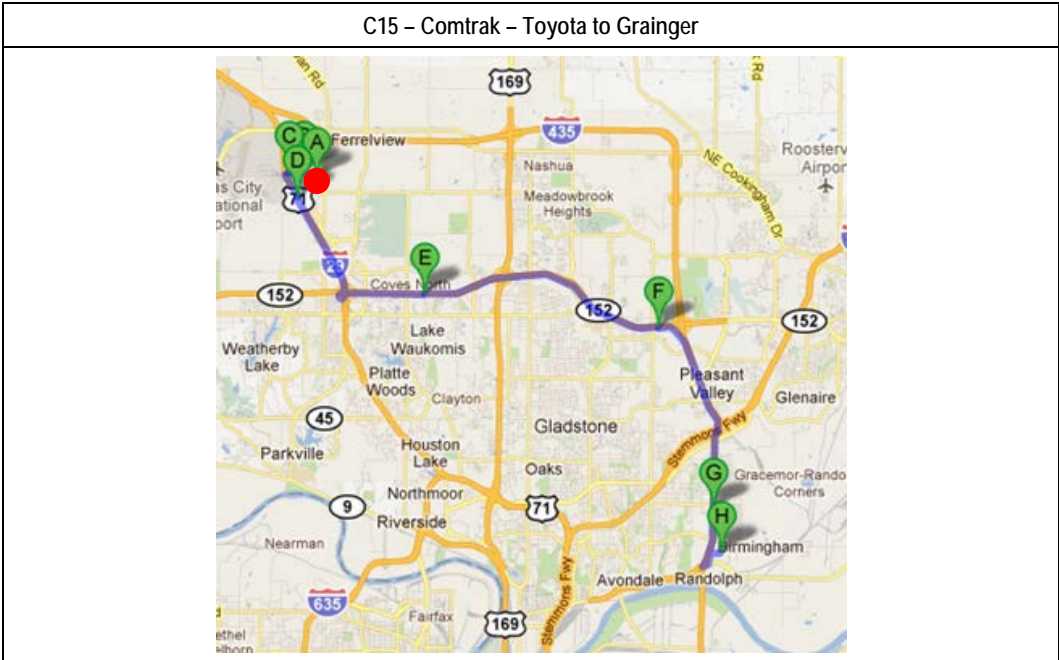
A.2 DRG MAPS

In the following maps, the red dots indicate the point of DRG redirect for each trip. The upper left corner of each map contains a unique identification number for each trip.

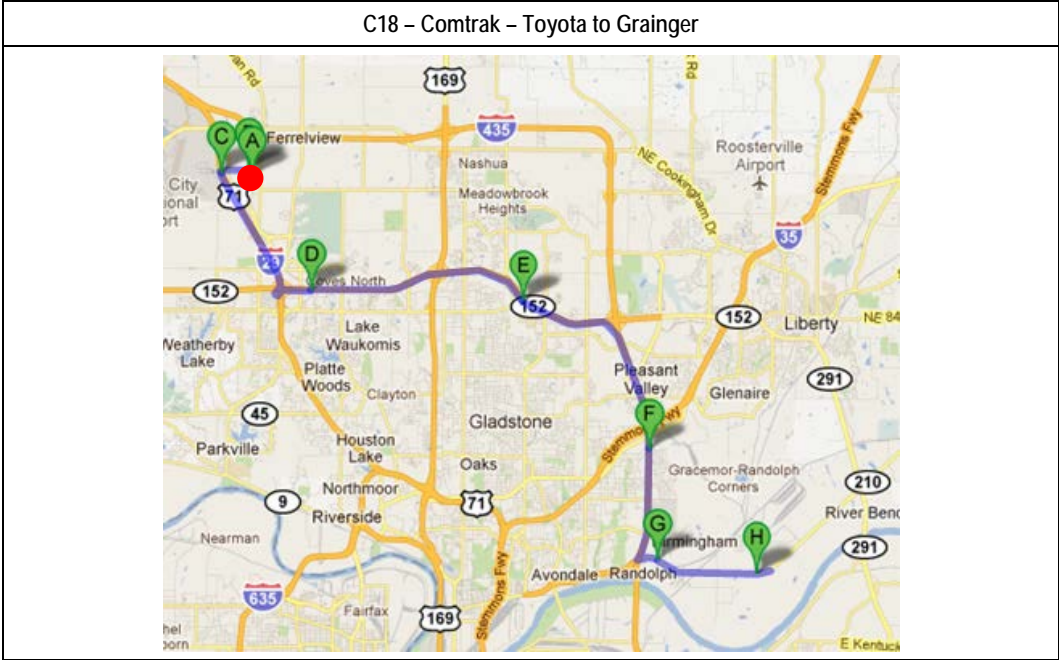
Figure A.2 Toyota to Grainger



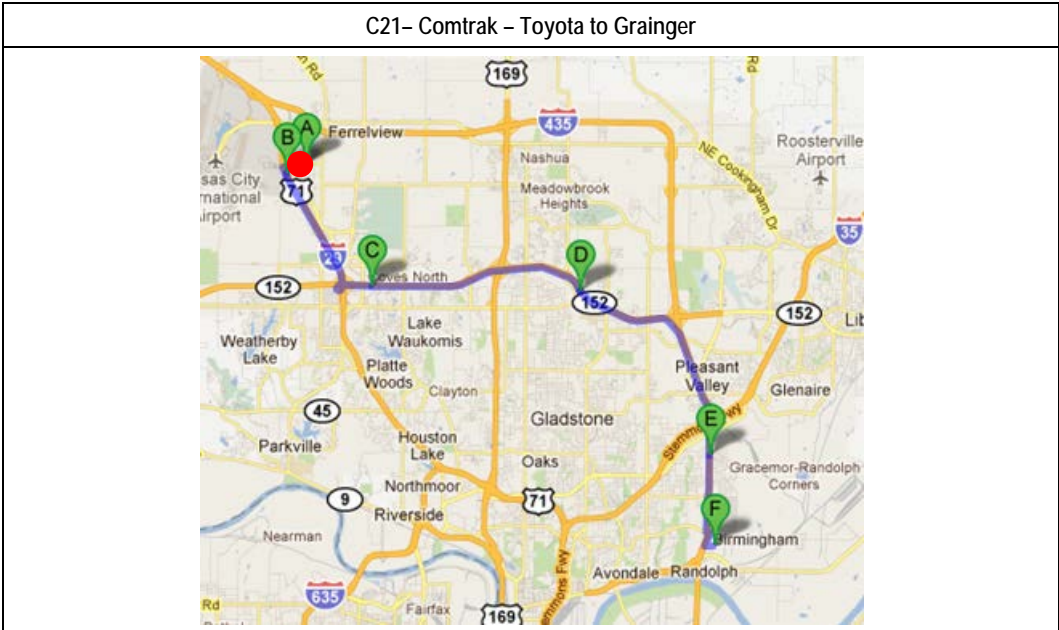
C15 - Comtrak - Toyota to Grainger



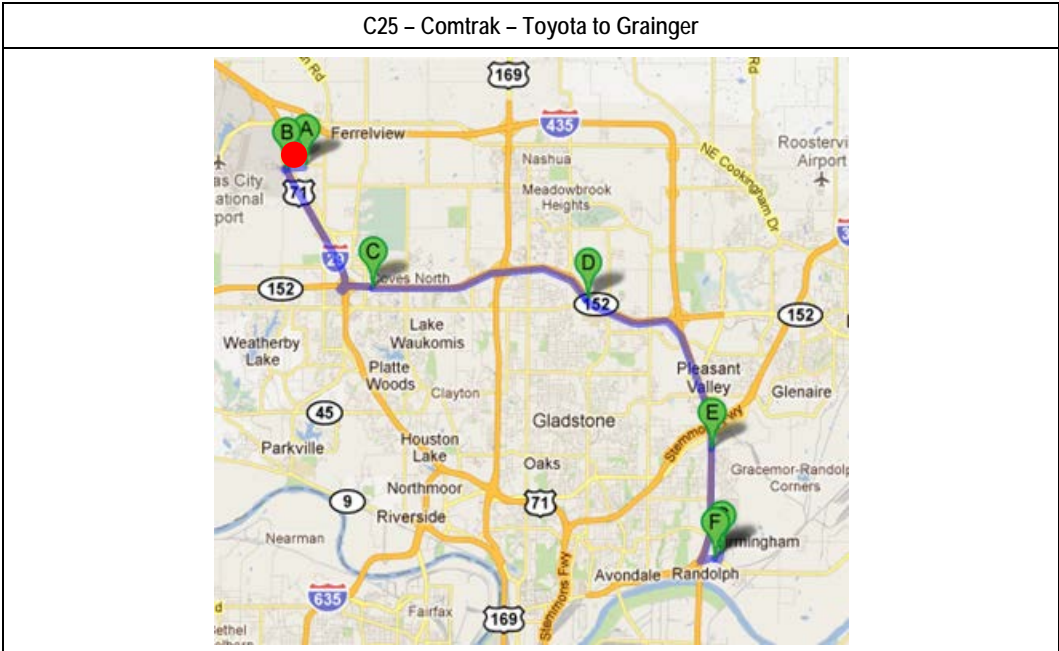
C18 - Comtrak - Toyota to Grainger



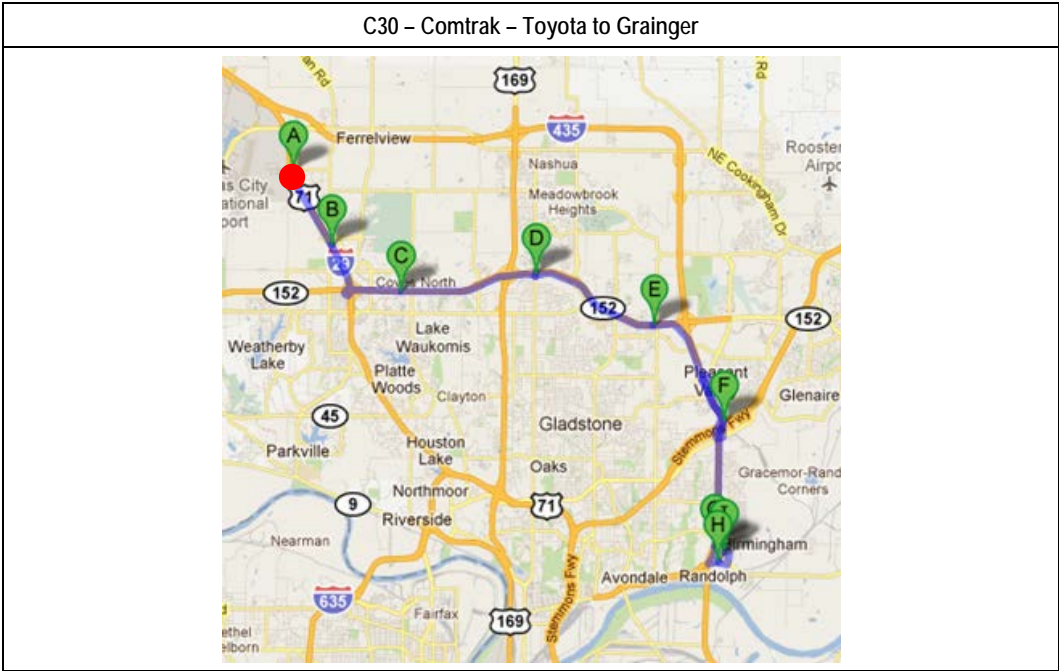
C21- Comtrak - Toyota to Grainger



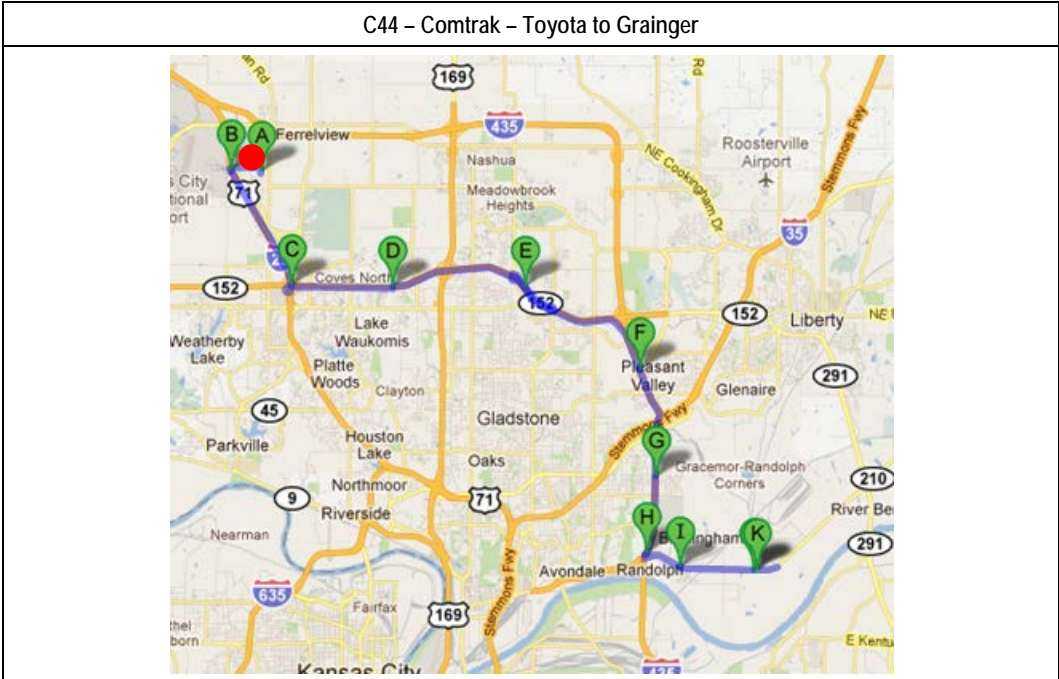
C25 - Comtrak - Toyota to Grainger



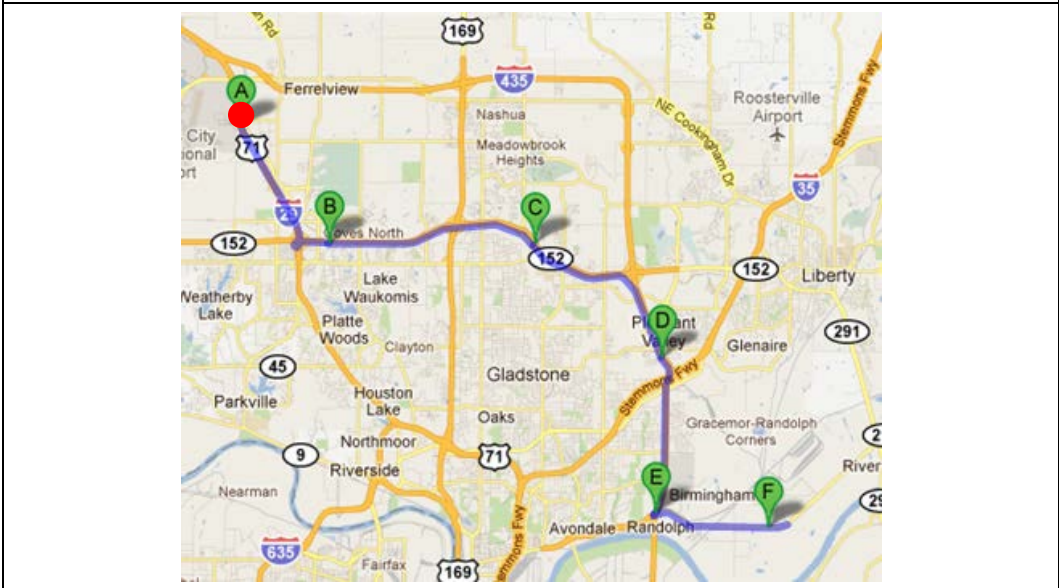
C30 - Comtrak - Toyota to Grainger



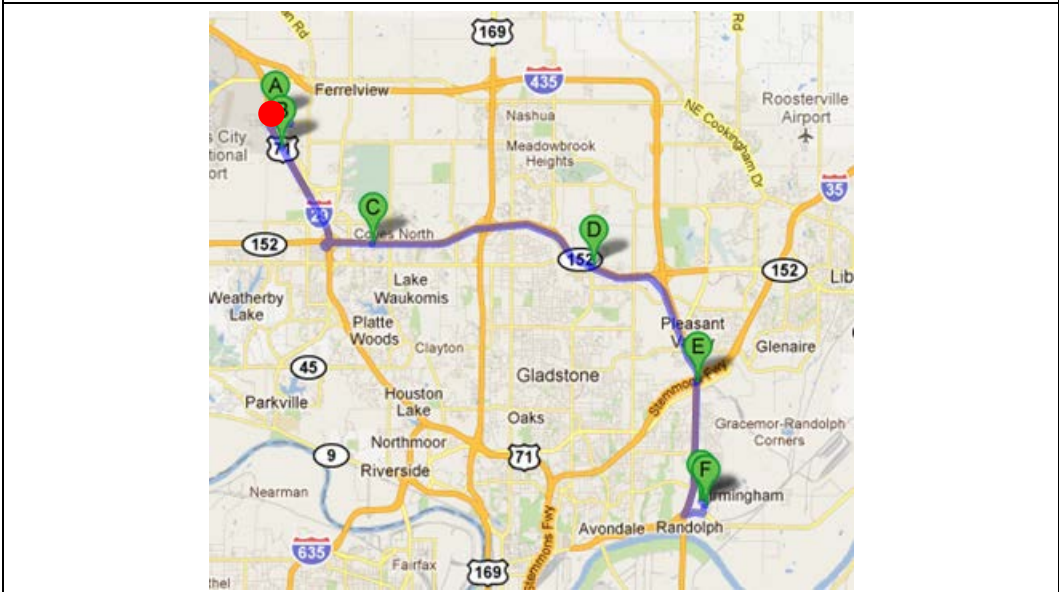
C44 - Comtrak - Toyota to Grainger



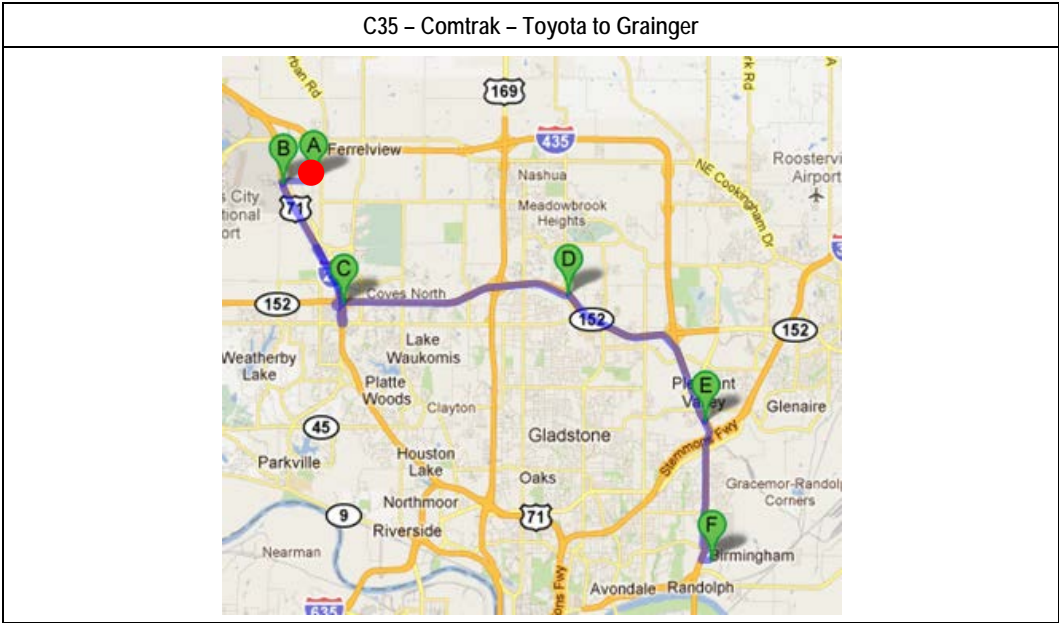
C52 - Comtrak - Toyota to Grainger



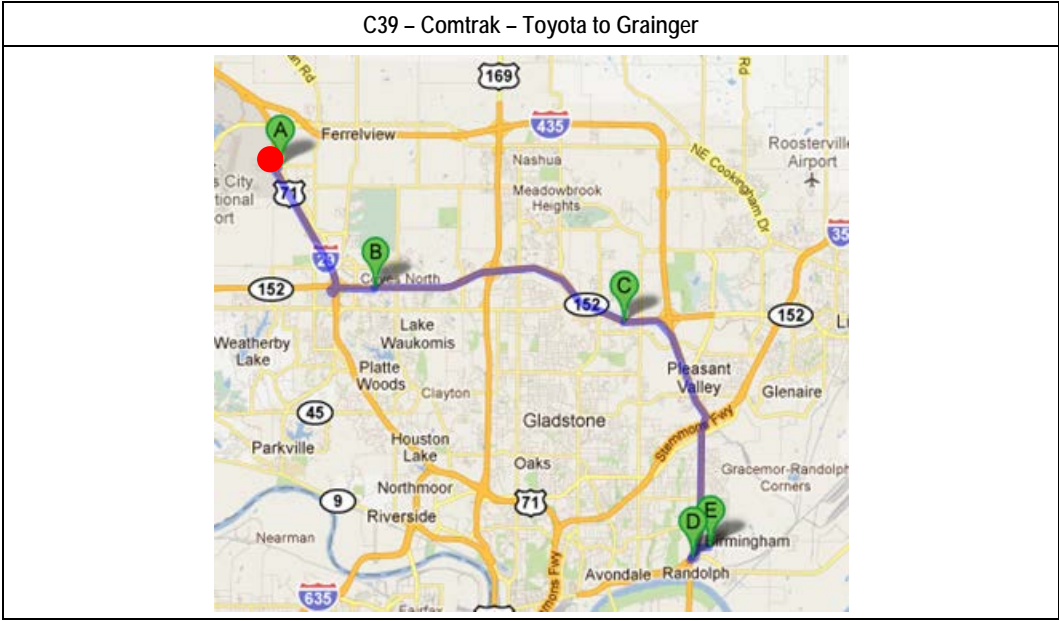
C28 - Comtrak - Toyota to Grainger



C35 - Comtrak - Toyota to Grainger



C39 - Comtrak - Toyota to Grainger



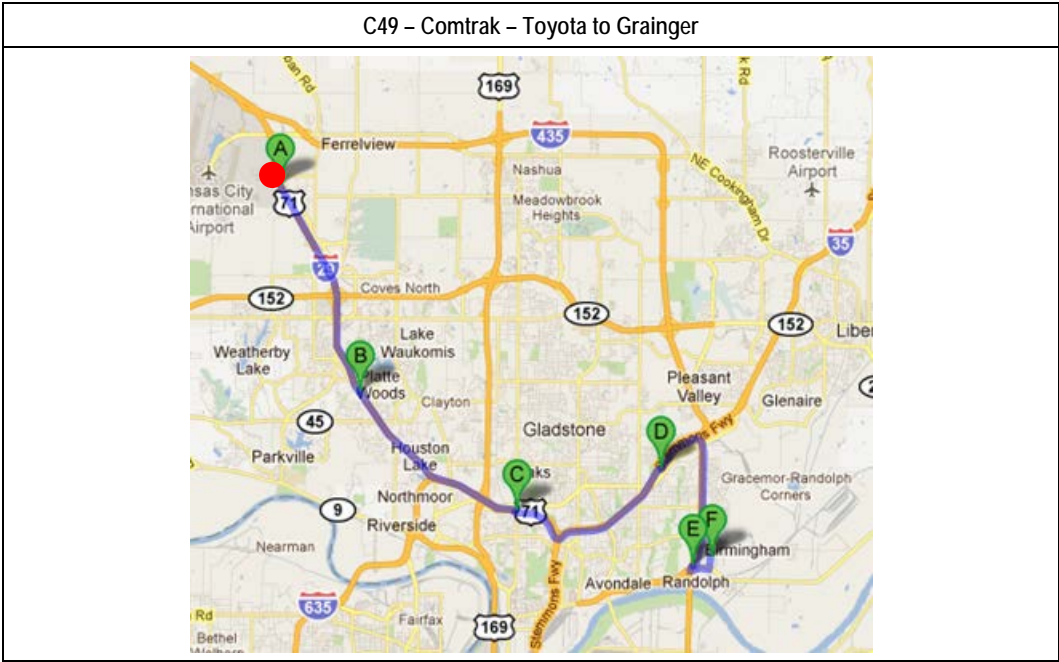
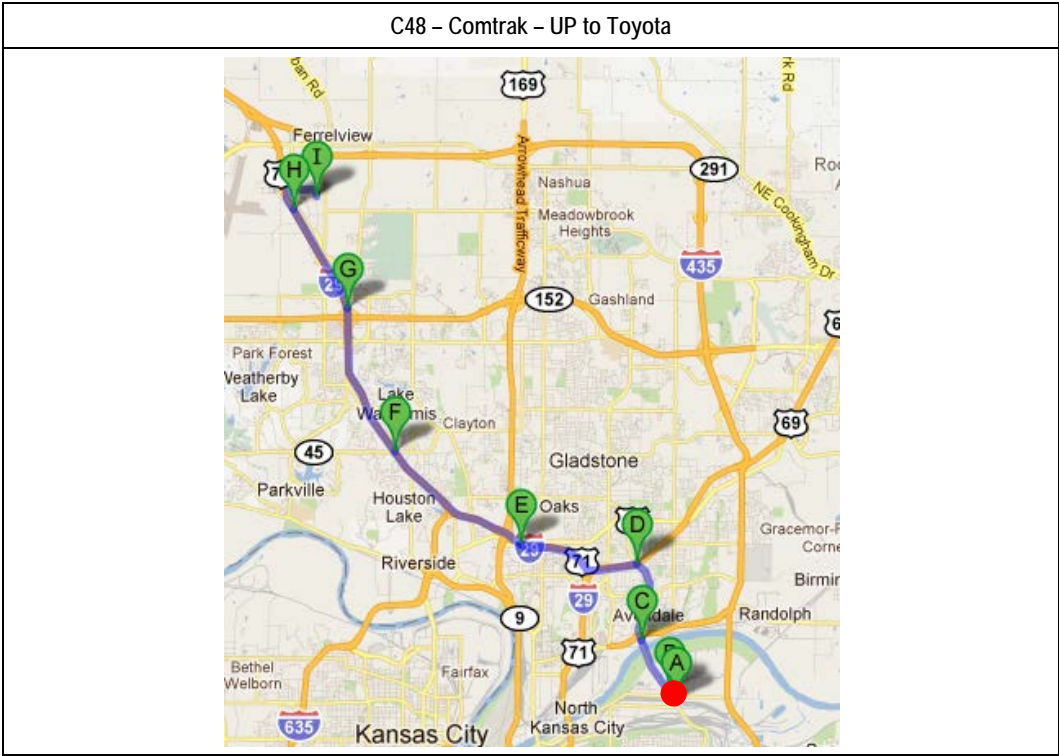
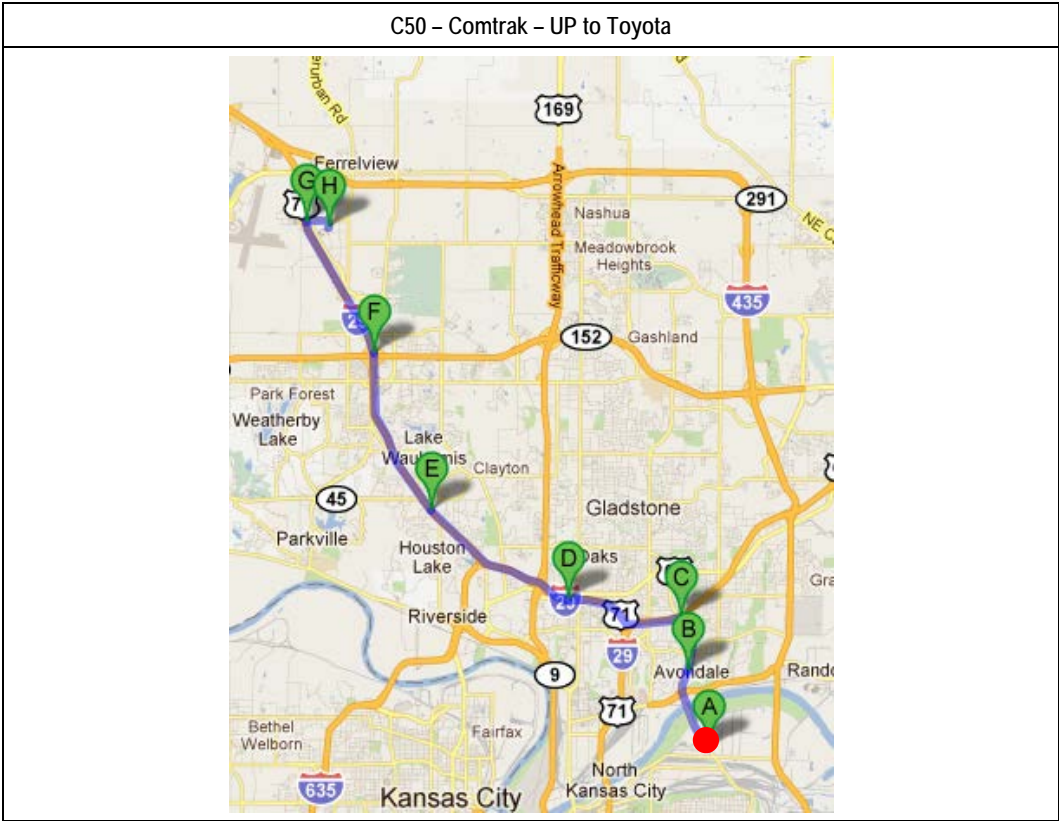


Figure A.3 UP to Toyota



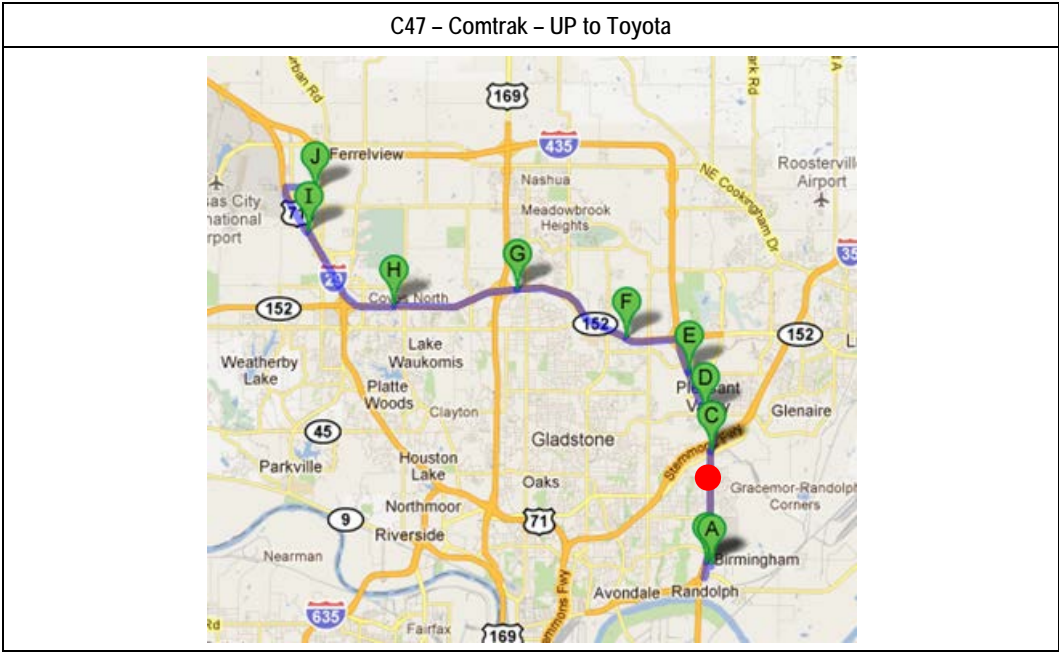
C50 – Comtrak – UP to Toyota



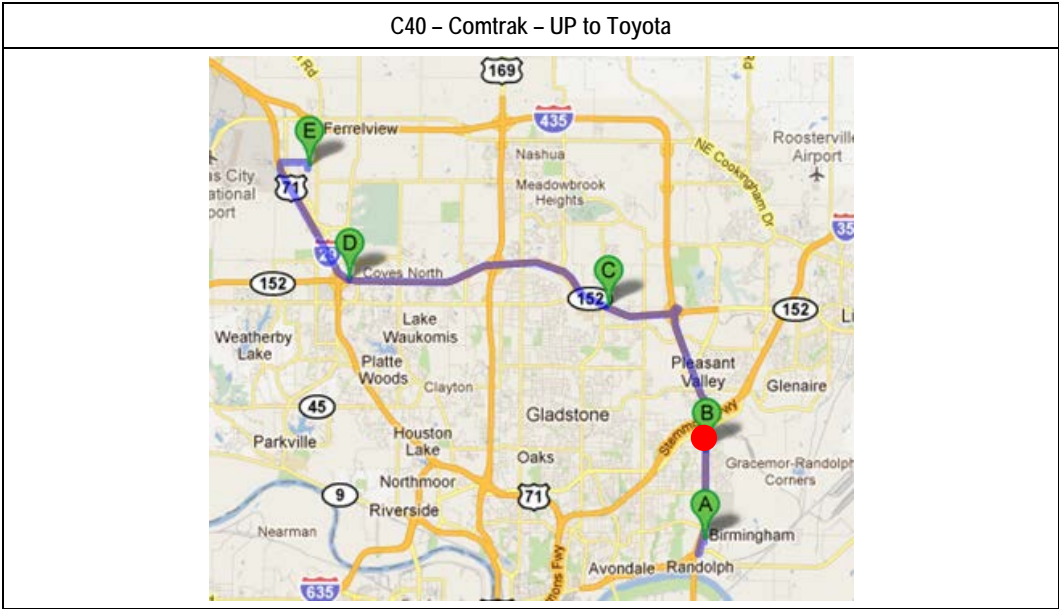
C43 – Comtrak – UP to Toyota



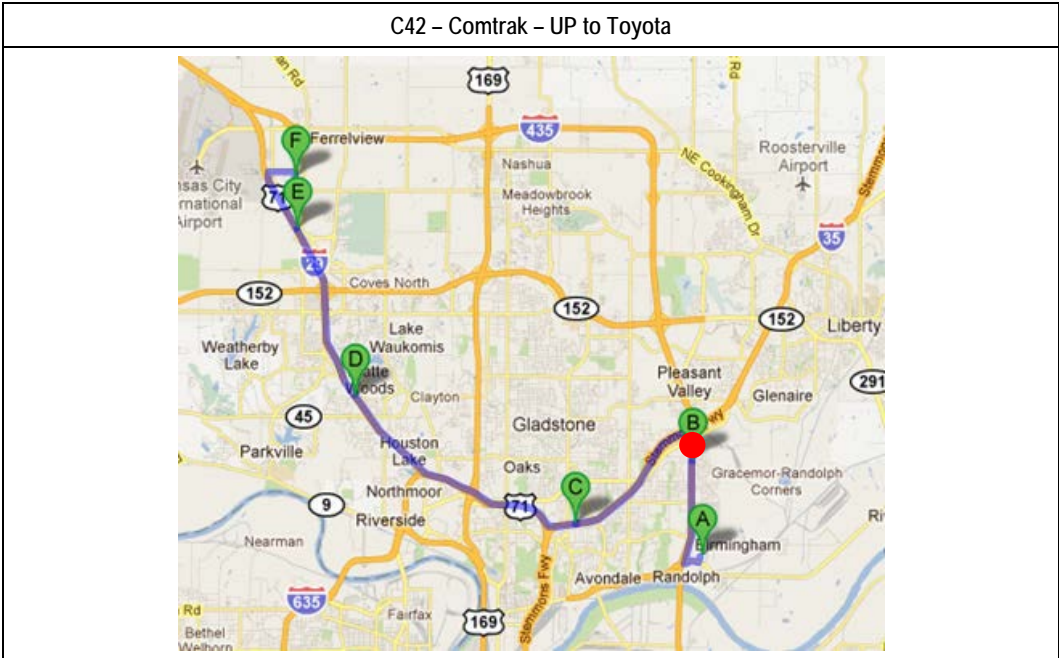
C47 – Comtrak – UP to Toyota



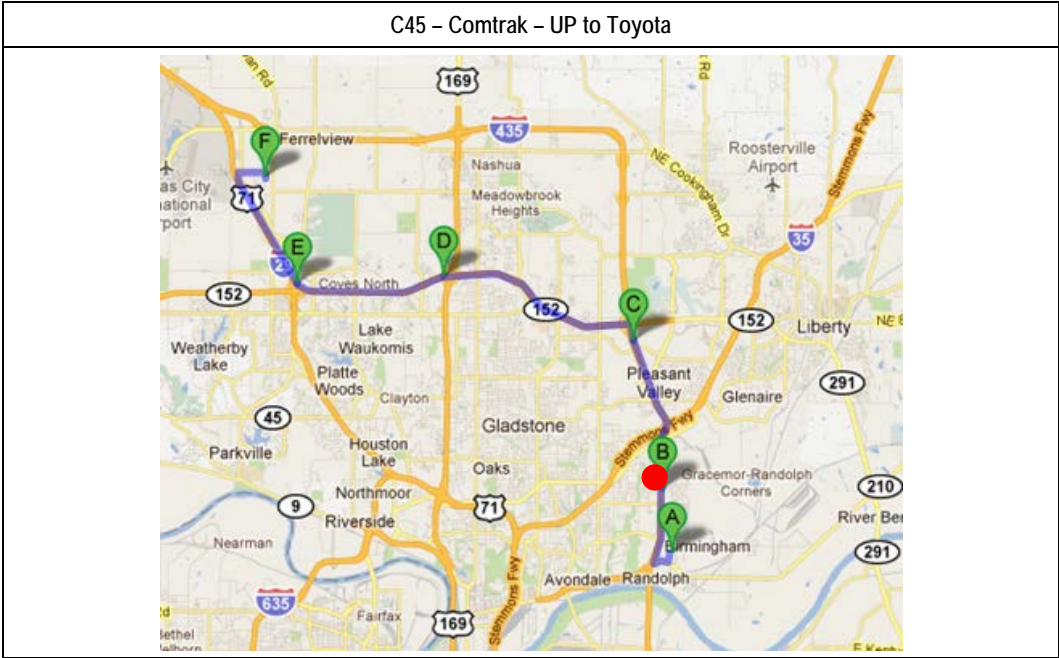
C40 – Comtrak – UP to Toyota



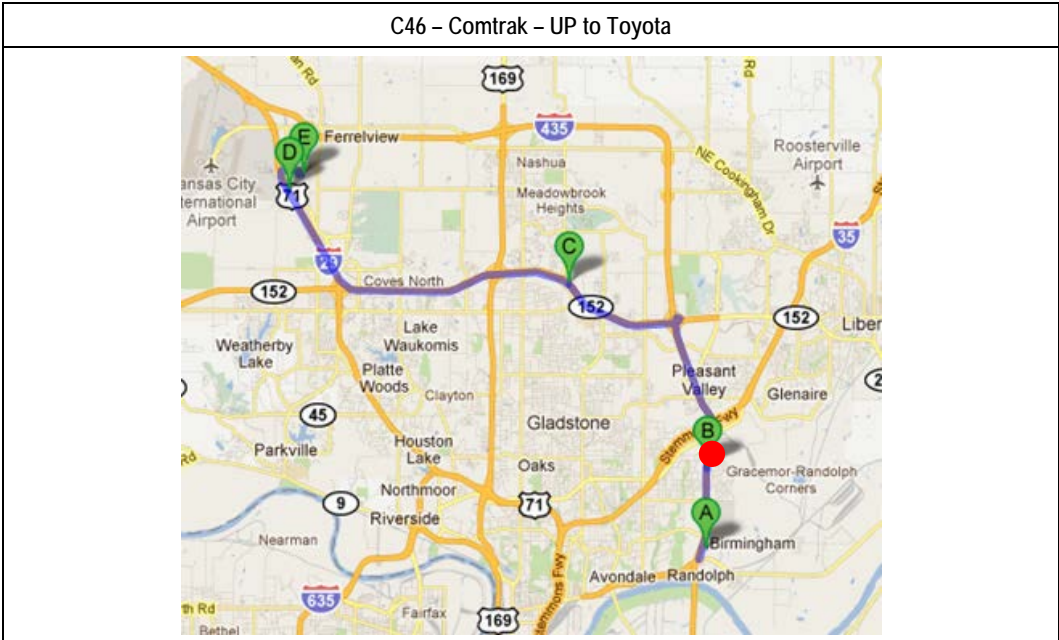
C42 - Comtrak - UP to Toyota



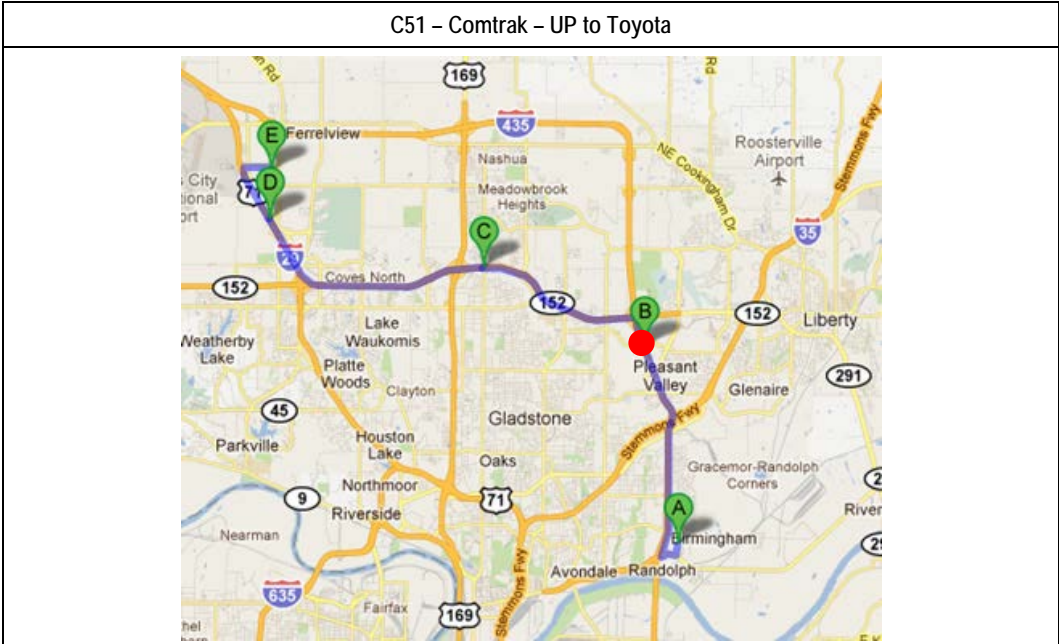
C45 - Comtrak - UP to Toyota

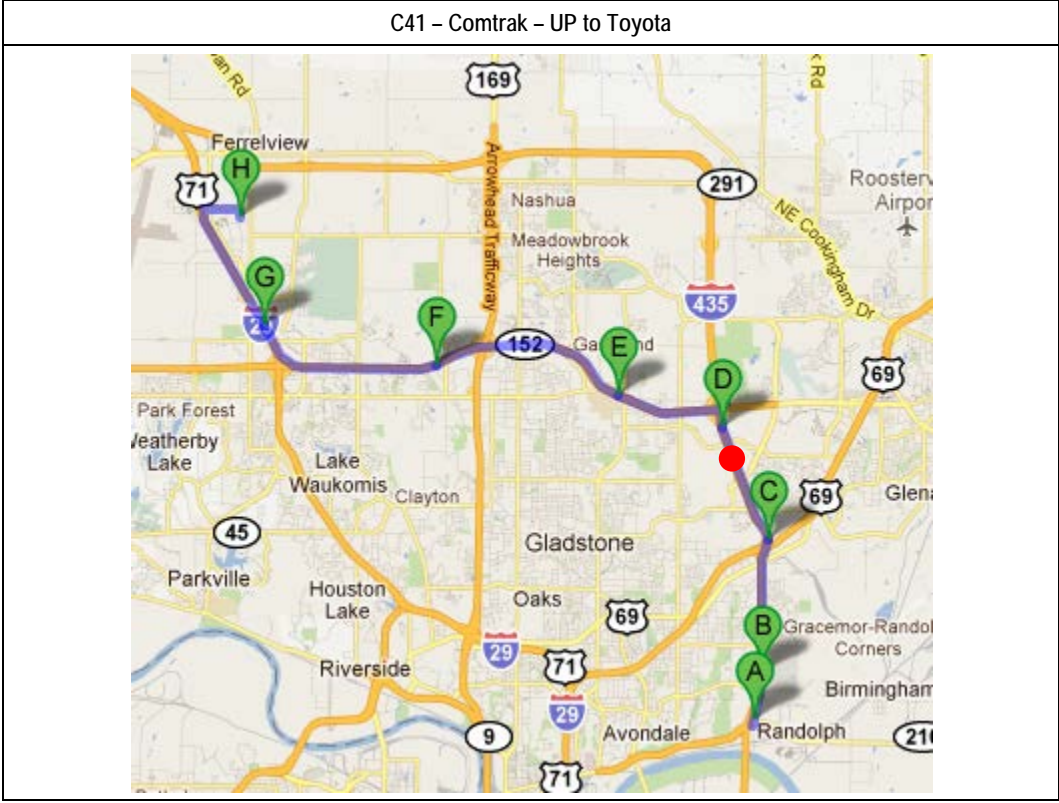
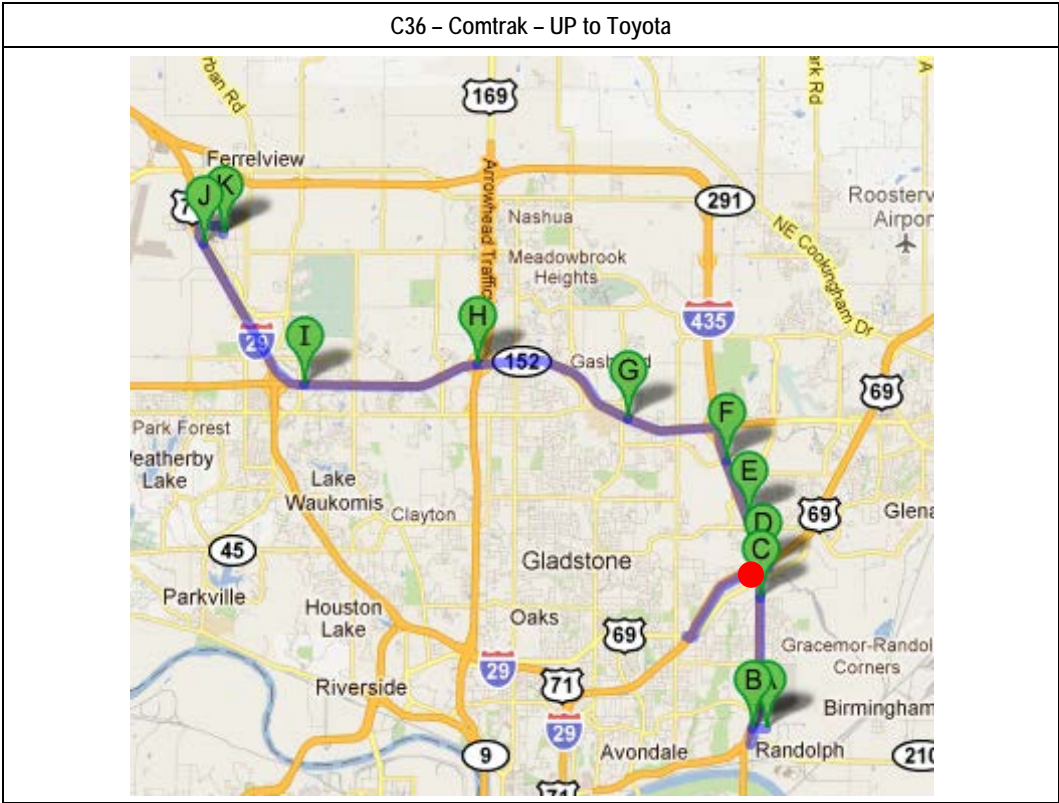


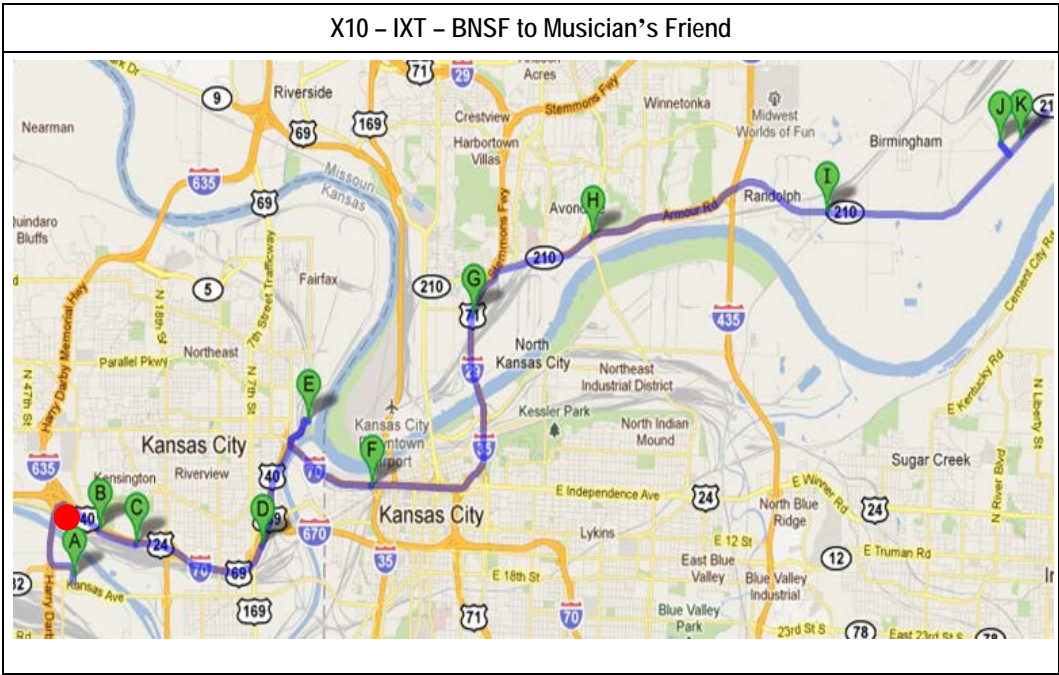
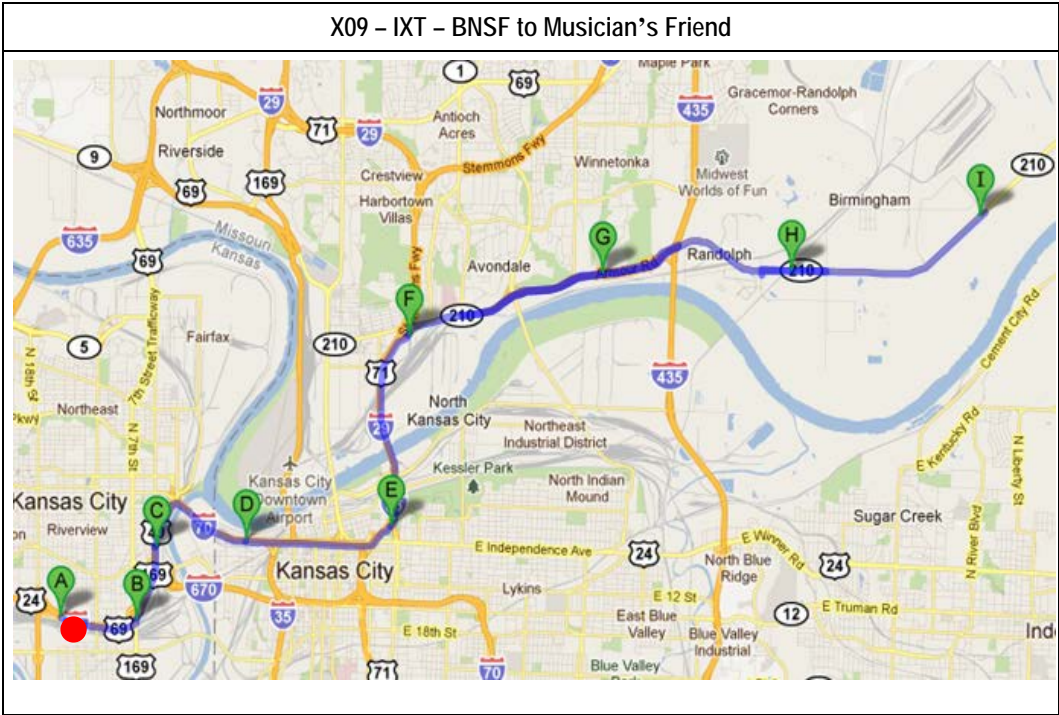
C46 – Comtrak – UP to Toyota



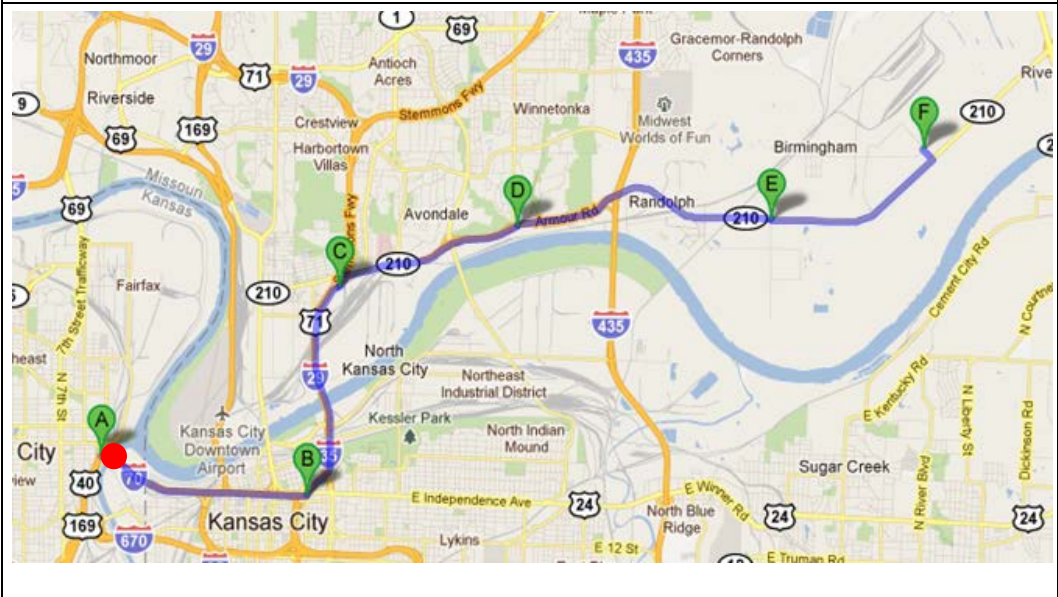
C51 – Comtrak – UP to Toyota



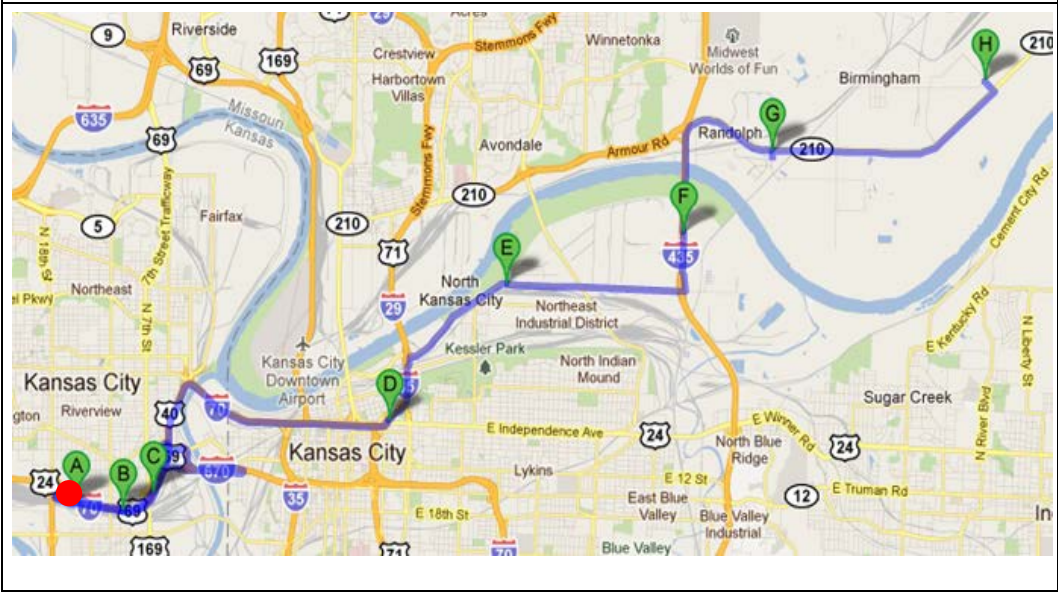




X13 - IXT - BNSF to Musician's Friend



X16 - IXT - BNSF to Musician's Friend



B. C-TIP User Interview Instruments

B.1 C-TIP DRIVER QUESTIONNAIRE

Contact Information (Optional)

Name:

Title/Position:

Company/Organization:

Phone/Fax:

E-mail Address:

1. Please rate the usability of the C-TIP software (e.g., functionality, design, capabilities, etc.) on a scale of 1 to 5, with one being not at all usable and 5 being extremely usable.

1 2 3 4 5

What are the specific strengths of the software?

What are its limitations?

2. Please rate the user-friendliness of the software (e.g., ease of use, training required, etc.) on a scale of 1 to 5, with one being not at all user friendly and 5 being extremely user friendly.

1 2 3 4 5

3. Did the C-TIP software save you time, for example by avoiding traffic congestion, avoiding traffic incidents, or reducing the amount of idle time awaiting processing of information?

If so, how?

Can you provide an estimate of travel time savings per trip?

If not, why not?

4. If you used C-TIP for route guidance, did you primarily use it for initial route recommendations at the beginning of the trip or for en-route redirection?
5. What specific reroutes did you perform (either route recommendations or en-route redirects) based on the smart phone recommendations?

6. Did the software increase your productivity (e.g., number of turns per day)?
If so, how?
If not, why not?
7. Did you notice any other benefits associated with the application (e.g., fuel savings)? What were they?
8. Was the information provided by C-TIP accurate (i.e., did it accurately reflect conditions on the ground)?
9. Were the route recommendations provided by C-TIP timely (i.e., did you receive them in time to act on the information)?
10. Did you ever find the software application distracting (i.e., would you be concerned about safety when using the device while driving)?
11. Overall, how do you rate the viability of the C-TIP application for use in a commercial trucking environment?
1 2 3 4 5
12. Are there any specific changes that you would make to the system to make it better serve your needs? If so, what are they?

B.2 C-TIP TERMINAL MANAGER QUESTIONNAIRE

1. Do you or your drivers like the idea of having routing information available on a smart phone like the iPhone?
2. Did your drivers like the iPhone or would they prefer to use some other type of device?
3. What do you think about the idea of having an application that gives travel times for different routes?
4. What is your impression of the value of the application based on your specific routes, and feedback from your drivers?
5. Would your impression be any different if your drivers drove routes of different types and distances?
6. Do your drivers have the freedom to take whatever route they feel is best, or are they expected to take certain routes?
7. Did any of your drivers specifically say they saved time through:
 - An initial route recommendation (i.e., at the outset of their trip)? If so, how much, and what were the baseline and alternate routes?
 - An en route redirection (i.e., they were diverted during their trip to avoid congestion)? If so, how much and what were the baseline and alternate routes?

8. What prevented your drivers from using the routing application more than they did?
9. What conditions would need to exist for you or your drivers to see value in such an application?
10. Do you think your drivers trusted the travel time data they received? Why or why not?
11. Do you feel that the verbal/spoken recommendations provided by the application are adequate, or would a visual display be more useful?
12. Do you think your drivers would ever want to use a smart phone to receive dispatching and routing information? Why or why not?
13. What did you like about the application?
14. What didn't you like about the application?
15. Are there specific cross-town lanes that would be more conducive to such an application? If so, what are they?
16. Would the application be more useful if:
 - It alerted drivers when a shipper releases a container for pickup?
 - It told you how much fuel you would save by taking a different route?
17. If those changes were made, would you or your drivers want to use it on a regular basis?

B.3 PRIDE LOGISTICS DRIVER QUESTIONNAIRE

Contact Information (Optional)

Name:

Title/Position:

Company/Organization:

Phone/Fax:

E-mail Address:

1. How did you use the phone during the test period? To receive work orders, update status (e.g., pickup/drop off), or both? Other?
2. What are the specific strengths of the application? What are its limitations?
3. How would you characterize the benefits of the application? In other words, how did the Android smart phone improve operations over the previous dispatch method?

Can you provide an estimate of the benefits, for example additional turns per day or travel time savings?

4. Did you notice any other benefits associated with the application (e.g., fuel savings)? What were they?
5. Did you ever find the software application distracting (i.e., would you be concerned about safety when using the device while driving)?
6. Are there any specific changes that you would make to the application to make it better serve your needs? If so, what are they?

C. Delphi Assessment Questionnaires

C.1 FIRST ROUND QUESTIONNAIRE

Contact Information (Optional)

Name:

Title/Position:

Company/Organization:

Phone/Fax:

E-mail Address:

Introduction and Problem Statement

In many large cities where multiple railroads converge (e.g., Chicago or Kansas City), intermodal freight transfers between railroads necessitate truck trips between rail carriers. Intermodal rail movements also generate significant local deliveries which must be made by truck. There are known inefficiencies associated with these cross-town “rubber tire” freight transfers, including freight delays due to congestion, significant unproductive truck moves (bobtails, chassis repositioning), and emissions, noise, and safety impacts. The Cross-Town Improvement Project (C-TIP) is an experimental technology application designed to improve the efficiency of intermodal container transfers via truck between cross-town railroads. C-TIP is comprised of the following key elements:

- **Intermodal Move Exchange (IMEX)** - An open architecture port that allows for a **collaborative** dispatch management model among rail lines, truckers, and terminal operators;
- **Real-Time Traffic Monitoring (RTTM)** - Real-time monitoring and distribution of route- and location-specific travel time and congestion information and control of traffic management systems and devices;
- **Dynamic Route Guidance (DRG)** - Combines RTTM, GIS, and simulation tool inputs to provide real-time visual routing around congested areas;
- **Chassis Utilization Tracking (CUT)** - An application that allows for collaborative use and management of intermodal chassis among railroads and trucking companies;

- **Wireless Drayage Updating (WDU)** - Utilizes low-cost wireless technology as an interface between drivers and dispatchers, and between the core functions within C-TIP and its users; and
- **Wireless Notification System** - Notifies cross-town truck drivers when a load is available for pickup, allowing them to respond in real-time rather than returning to their home base or awaiting direction from a dispatcher.

An initial C-TIP system has been deployed in Kansas City. This study seeks to assess the potential benefits of, and private sector interest in, full deployment of a similar system in Chicago.

Survey Questions

1. What segment of the intermodal freight transportation industry do you represent? Please check one:
- Freight railroad Drayage trucking firm Terminal operator
 Other (please describe)

2. In terms of time savings, please rate the importance of the following C-TIP capabilities on a scale of 1 to 5 (1 being not at all important, 3 being moderately important, and 5 being extremely important):

Avoiding recurring traffic congestion (e.g., rush hour traffic)

1 2 3 4 5

Please explain. _____

Avoiding traffic incidents (e.g., accidents)

1 2 3 4 5

Please explain. _____

Minimizing delays at the terminal (e.g., idle time waiting for information to be processed)

1 2 3 4 5

Please explain. _____

Automatic notification of load availability to truckers (i.e., when a load is grounded at the terminal, or when a shipper such as a retail store releases a box for pickup)

1 2 3 4 5

Please explain. _____

3. If the C-TIP system were fully implemented in Chicago, what percentage of travel time do you think could be saved on a per-trip basis through the following C-TIP route guidance features?

Initial route recommendations - This alerts drivers if a particular route is congested, and suggests alternate routes prior to beginning the trip

- None
- Less than 5% per trip
- 5%-10% per trip
- 10%-15% per trip
- More than 15% per trip
- No opinion/don't know

Please provide your rationale for your estimate of travel time savings from initial route guidance: _____

En-route redirection - This provides drivers with real-time dynamic route guidance, allowing them to avoid congestion arising from an accident or similar event

- None
- Less than 5% per trip
- 5%-10% per trip
- 10%-15% per trip
- More than 15% per trip
- No opinion/don't know

Please provide your rationale for your estimate of travel time savings from en-route redirection: _____

4. In the entire Chicago region, how many bobtail trips (trucks moving without a chassis) do you think are made between cross-town rail terminals each day?

- 0 to 150 bobtail trips per day
- 151 to 300 bobtail trips per day
- 301 to 500 bobtail trips per day
- More than 500 bobtail trips per day
- No opinion/don't know

5. If the C-TIP system were fully implemented in Chicago, what percentage of those bobtail trips do you think could be eliminated each day?

- None
- <5% bobtail reduction per day
- 6%-10% bobtail reduction per day
- 11%-15% bobtail reduction per day
- 15%-20% bobtail reduction per day
- More than 20% bobtail reduction per day
- No opinion/don't know

Please provide your rationale for your estimate of bobtail reductions: _____

How many additional revenue loads do you think this would translate to? _____

6. In the entire Chicago region, on average, how much time do you estimate a typical truck spends idling in intermodal terminals on a per trip basis? This includes time spent waiting in check-in/check-out lines, waiting for lifts, looking for units, inspecting units, problem resolution, etc.

- 0 to 30 minutes per trip
- 31 to 60 minutes per trip
- 61 to 90 minutes per trip
- More than 90 minutes trip
- No opinion/don't know

Please explain your rationale for your estimate of average terminal idle time. _____

7. If the C-TIP system were fully implemented in Chicago, approximately how much of this terminal dwell time (idle time) do you think could be eliminated per trip?

- None
- 0 to 15 minutes idle time per trip
- 16 to 30 minutes idle time per trip
- 31 to 60 minutes idle time per trip
- More than 60 minutes idle time per trip
- No opinion/don't know

Please provide your rationale for your estimate of daily terminal dwell time reduction:

8. Are there specific cross-town routes/lanes (i.e., origins and destinations) in the Chicago region that have particularly high volumes of dray movements? If so, what are they?

Please describe specific cross-town routes: _____

9. In your view, how would improving the efficiency of cross-town drayage movements improve railroad financial performance? Please be specific.

10. Do you think C-TIP has the potential to replace manual processes such as telephone calls and faxes?

- Yes No No opinion/don't know

If so how? What specific processes could be automated? _____

Assuming these processes are not totally automated, what percentage of them do you think might be reduced? _____

How would this benefit your business operations? _____

C.2 SECOND ROUND QUESTIONNAIRE

Contact Information (Optional)

Name:

Title/Position:

Company/Organization:

Phone/Fax:

E-mail Address:

Introduction and Problem Statement

In many large cities where multiple railroads converge (e.g., Chicago or Kansas City), intermodal freight transfers between railroads necessitate truck trips between rail carriers. Intermodal rail movements also generate significant local deliveries which must be made by truck. There are known inefficiencies associated with these cross-town “rubber tire” freight transfers, including freight delays due to congestion, significant unproductive truck moves (bobtails, chassis repositioning), and emissions, noise, and safety impacts. The Cross-Town Improvement Project (C-TIP) is an experimental technology application designed to improve the efficiency of intermodal container transfers via truck between cross-town railroads. C-TIP is comprised of the following key elements:

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An initial C-TIP system has been deployed in Kansas City. This study seeks to assess the potential benefits of, and private sector interest in, full deployment of a similar system in Chicago.

Survey Questions

Importance of Features

In the first round of the Delphi, respondents were asked to rate various features of C-TIP on a scale of 1 to 5, with 1 being not at all important and 5 being extremely important. The following questions seek to achieve a consensus group opinion on these features by summarizing the overall group ‘majority’ response, and providing you an opportunity to either amend answers from the first round, or provide additional justification for them.

1. **Avoiding recurring traffic congestion (e.g., rush hour traffic).** [Provide respondent with their answer from the first round.] The majority of respondents rated the ability to avoid recurring congestion as either ‘very important’ or ‘extremely important.’ Their reasoning included: maximizing efficiency under hours of service limitations, the fact that dray truckers only make money when they’re moving, and the ability to make tight delivery windows. Given this information, would you rate the importance of a C-TIP feature that lets truckers avoid recurring traffic congestion using real-time data differently than you did (1 being not at all important, 3 being moderately important, and 5 being extremely important)?

1 2 3 4 5

If not, why? _____

2. **Avoiding traffic incidents (e.g., accidents).** [Provide respondent with their answer from the first round.] The majority of respondents rated the ability to avoid traffic incidents or other nonrecurring congestion as either ‘very important’ or ‘extremely important’. Their reasoning included: It adds to the situation awareness that drivers have, truckers wouldn’t normally have that information, it would help to keep them moving rather than sitting in traffic, and it allows them to make tight delivery windows more easily.

Given this information, would you rate the importance of real-time dynamic route guidance to avoid traffic incidents differently than you did (1 being not at all important, 3 being moderately important, and 5 being extremely important)?

1 2 3 4 5

If not, why? _____

3. **Minimizing delays at the rail terminal (e.g., idle time waiting for information to be processed).** [Provide respondent with their answer from the first round.] The majority of respondents rated the ability to minimize delays at the rail terminal as either ‘very important’ or ‘extremely important’. Their reasoning included: There are substantial inefficiencies associated with truckers having to wait around at a terminal, so anything that could reduce turn times at a congested terminal would be beneficial. Taking that into account, would you rate the importance of this feature differently (1 being not at all important, 3 being moderately important, and 5 being extremely important)?

1 2 3 4 5

If not, why? _____

4. **Automatic notification of load availability to truckers.** [Provide respondent with their answer from the first round.] The majority of respondents rated automatic notification of load availability as either ‘very important’ or ‘extremely important.’ Their reasoning included: Timeliness of moving boxes out of the yard is paramount, it would save a lot of trucker driving time, truckers wouldn’t have to wait for a train to be unloaded at the terminal (they could just come get their box when they are notified of its availability), and elimination of human error. Given this information, and assuming full availability and use of a common dispatch platform that could notify bobtailing truckers about available loads in a safe manner, would you rate the importance of this feature differently (1 being not at all important, 3 being moderately important, and 5 being extremely important)?

1 2 3 4 5

If not, why? _____

Travel Time Savings

This set of questions seeks to clarify the group response to the estimated travel time savings associated with C-TIP, based on a theoretical Chicago deployment. Again, the ‘majority’ view is presented, with reasoning; respondents are asked whether they would like to amend their previous answer, or provide additional defense for their original opinion.

1. If the C-TIP system were fully implemented in Chicago, what percentage of travel time do you think could be saved on a per-trip basis through the following C-TIP route guidance features?

Initial Route Recommendations - This feature provides estimated travel time on a primary route at trip outset, and suggests alternate routes if they are expected to be faster. [Provide panelist with their answer from the first round.] Most of the respondents felt this feature could save 5 to 15 percent of travel time per trip in Chicago, on average. Their reasoning tended to revolve around the idea that there is going to be an accident/traffic/delay of some type on a proportion of trips regardless, and an initial route recommendation would help mitigate this; the savings would therefore be a function of the level of the opportunity, which in a city like Chicago could be substantial. Given this information, and assuming the routes offered are suitable for trucks, would you estimate the travel time savings associated with initial route recommendations in Chicago differently?

- None
- Less than 5% per trip
- 5%-10% per trip
- 10%-15% per trip
- More than 15% per trip
- No opinion/don't know

If not, why? _____

En-route redirection - This provides drivers with real-time dynamic route guidance, allowing them to avoid congestion arising from an accident or similar event after they have begun their trip. [Provide panelist with their answer from the first round.] Most respondents felt travel time savings of 5 to 10 percent could be achieved in Chicago with this feature. These savings are more modest than those for initial route guidance because accidents are random events, so there is less opportunity for savings; nonetheless, most felt

travel time savings of at least 5 percent per trip on average could be achieved. Taking this into account, would you estimate the potential travel time savings from en-route redirection differently?

- None
- Less than 5% per trip
- 5%-10% per trip
- 10%-15% per trip
- More than 15% per trip
- No opinion/ don't know

If not, why? _____

Bobtail Volume and Potential Reduction

These questions attempt to clarify the group opinion on the approximate volume of daily bobtails in Chicago, and how many could be eliminated if C-TIP were fully deployed there. Again, the group consensus estimate is described for each question; you may either amend your response or provide additional justification for your original estimate.

1. [Provide respondent with their answer to the first round.] Most respondents felt there were more than 300 daily bobtail moves in Chicago, and quite possibly more than 500 each day; one railroad representative stated that his firm alone does a few hundred per day. Taking that into account, would you estimate the number of daily bobtail moves in Chicago differently?
 - 0 to 150 bobtail trips per day
 - 151 to 300 bobtail trips per day
 - 301 to 500 bobtail trips per day
 - More than 500 bobtail trips per day
 - No opinion/ don't know

If not, why? _____

2. [Provide respondent with their answer to the first round.] Most respondents felt that C-TIP could eliminate at least 15 percent of empty bobtail moves each day if it was fully implemented in Chicago. Respondents noted that lack of visibility on the other end of cross-town drays creates missed opportunities for matching loads, and that C-TIP's visibility, notification, and prediction capabilities could mitigate this. Taking this into account, and

assuming full cooperation among all stakeholders was achieved, would you estimate potential bobtail reduction in Chicago differently?

- None
- <5% bobtail reduction per day
- 6%-10% bobtail reduction per day
- 11%-15% bobtail reduction per day
- 15%-20% bobtail reduction per day
- More than 20% bobtail reduction per day
- No opinion/ don't know

If not, why? _____

Other Questions

This set of questions deals with C-TIP's potential to help rationalize business processes and reduce manual effort. Again, the majority view is provided with rationale; you may revise your original answer or provide additional justification for it.

1. Most respondents felt that C-TIP could reduce manual processes substantially, though the amount of manual work that might be reduced varied. Savings mostly revolved around track and trace, routing, visibility of bobtailing drivers to dispatchers, and dispatch (having a central dispatch system used by multiple trucking firms). Given that, would you rate C-TIP's ability to reduce manual processes differently?

Do you think C-TIP has the potential to replace manual processes such as phone calls (e.g., dispatchers tracking down drivers) and faxes? [Provide respondent with their answer from the first round.]

- Yes No No opinion/don't know

What percentage of these processes might be reduced? [Provide respondent with their answer from the first round.] _____

How would such efficiency improvements benefit your business, if at all? [Provide respondent with their answer from the first round.] _____

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16. Abstract This report summarizes the findings of an independent evaluation of the FHWA Cross-town Improvement Project (C-TIP), which was deployed in Kansas City and Chicago in various periods from October 2010 through September 2011. The Dynamic Route Guidance (DRG) and Real-Time Traffic Monitoring (RTTM) components of C-TIP achieved measurable dray truck travel time savings and emissions reductions in operational tests. Separate deployments of in-cab smart phones running the C-TIP Open Source Architecture Package with drayage companies in Kansas City and Chicago achieved measurable reductions in bobtails even as revenue loads grew or remained stable. Simulations of the Intermodal Move Exchange (IMEX) component of C-TIP revealed the potential to reduce bobtails through better information sharing between cross-town railroads and drayage firms. There were some operational constraints to full utilization of C-TIP in Kansas City. Changing railroad business practices, along with a generally low level of economic activity during the test, contributed to a lack of railroad participation in the program. More broadly, the test experience suggests that the intermodal industry probably lacks the collaborative mentality to make a cooperative dispatch platform work. Nonetheless, this initial deployment of C-TIP technologies did prove the concept that such applications can provide public and private sector benefits including congestion mitigation, emissions reductions, and truck travel time savings. The results suggest that future research may be best targeted towards freight information exchange, improving the truck dispatch operation, and in providing real-time information and tools to support truck routing decisions.			
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U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
1200 New Jersey Avenue, SE
Washington, DC 20590

<http://www.ops.fhwa.dot.gov/freight/>
FreightFeedback@dot.gov

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