University Transportation Research Center - Region 2

Final Report

Evaluating the Impacts of Real-Time Information on Subway Ridership in New York City

Performing Organization: City University of New York (CUNY)

May 2018

Sponsor:
University Transportation Research Center - Region 2

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

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16. Abstract

It is now common for transit operators to provide real-time information (RTI) to passengers about the location or predicted arrival times of transit vehicles. The Metropolitan Transportation Authority (MTA) in New York City has recently made RTI available for most of the subway, which is the largest urban heavy rail system in the United States. In light of this, the objective of this research is to investigate how RTI is likely to impact subway passengers in New York City. The method is a two-part literature review of prior studies that assess the passenger benefits of providing RTI. The first part compiles literature for all transit modes to identify which passenger impacts of RTI are found in multiple studies. In total, twenty-eight studies were reviewed, and five key passenger benefits were identified. The second part includes a more detailed review of prior studies conducted in urban heavy rail systems (six in total), which are most likely to be applicable to the New York City Subway. The results of the first part of the literature review suggest that the five most common impacts associated with providing RTI to passengers pertain to (1) decreased wait times, (2) reductions in overall travel time due to changes in route choice, and (3) increased use of transit. RTI may also be associated with (4) increased satisfaction with transit service and (5) increases in the perception of personal security when riding transit. The prior studies of urban heavy rail systems reveal that the most likely passenger impacts are decreased wait times (three of six studies), decreases in overall travel times (one study), and increased transit use (three studies). Therefore, it is recommended that future research focus on these three areas to evaluate the impacts of RTI on New York City Subway passengers.

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Brakewood and Watkins (2018). A Literature Review of the Passenger Impacts of Real-Time Transit Information. Transport Reviews. DOI: 10.1080/01441647.2018.1472147.

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Executive Summary

It is now common for transit operators to provide real-time information (RTI) to passengers about the location or predicted arrival times of transit vehicles. The Metropolitan Transportation Authority (MTA) in New York City has recently made RTI available for most of the subway, which is thee largest urban heavy rail system in the United States. In light of this, the objective of this research is to investigate how RTI is likely to impact subway passengers in New York City. The method is a two-part literature review of prior studies that assess the passenger benefits of providing RTI. The first part compiles literature for all transit modes to identify which passenger impacts are found in multiple studies. In total, twenty-eight studies were reviewed, and five key passenger benefits were identified. The second part includes a more detailed review of prior studies conducted specifically in urban heavy rail systems (six in total), which are most likely to be applicable to the New York City Subway.

The results of the first part of the literature review suggest that the five most common impacts associated with providing RTI to passengers pertain to (1) decreased wait times, (2) reductions in overall travel time due to changes in route choice, and (3) increased use of transit. RTI may also be associated with (4) increased satisfaction with transit service and (5) increases in the perception of personal security when riding transit. The prior studies of urban heavy rail systems reveal that the most likely passenger impacts are decreased wait times (three of six studies), decreases in overall travel times (one study), and increased transit use (three studies). Therefore, it is recommended that future research focus on these three areas to evaluate the impacts of RTI on New York City Subway passengers.

Introduction

It has become increasingly common for transit operators to provide real-time information (RTI) to passengers about the location or predicted arrival times of transit vehicles. One example is the Metropolitan Transportation Authority (MTA) in New York; over the past decade, the MTA has made RTI available for most of the New York City Subway (MTA, 2010; MTA, 2017). As this industry practice has increased, the body of literature evaluating the passenger impacts of this new information source has also grown, which presents an opportunity to synthesize findings. Synthesizing initial trends is particularly important for transit providers who want to understand how RTI may be impacting their passengers, such as the MTA in New York City. Subsequently, this study aims to conduct a literature review of prior studies evaluating the passenger impacts of RTI, and the findings are discussed in the context of the New York City Subway to identify important areas for future research.

This report proceeds as follows. First, background information on important terminology is presented. Then, the methodology used to conduct the literature review is described. After this, the key findings from the literature review are presented, and finally, the results are discussed in the context of New York City.

Terminology

This section provides background information on key terminology used in this report. Real-time information (RTI), real-time passenger information (RTPI), real-time transit information (RTTI), and advanced passenger information systems (APIS) are all commonly used acronyms in the prior literature; for this report, the term real-time information (RTI) is used.

Real-time information is the tracking of transit vehicles by automatic vehicle location systems or track circuit systems. Vehicle location information is typically sent to a central server, which can be located at the transit provider. Then, it is disseminated to riders, either directly or through application programming interfaces (API) used by third party software developers (Brakewood and Watkins, 2018).

RTI can be disseminated to riders via different types of media. RTI is frequently provided via stationary *signage* located at bus stops or in train stations. Variable message signs, such as the one shown in Figure 1, display the location of the transit vehicle or a predicted arrival time, and these are referred to as *countdown clocks* in New York City. Some transit providers, including the MTA's New York City Transit, also display this information on touchscreen kiosks (Kamga, et al., 2013).

Figure 1: Real-time information signage in a New York City Transit station

Over the last few years, RTI is increasingly provided to passengers' *personal devices*, including websites accessed on computers or mobile phones, text messages to cell phones, and smartphone applications, such as the MTA's "Subway Time" app shown in Figure 2.

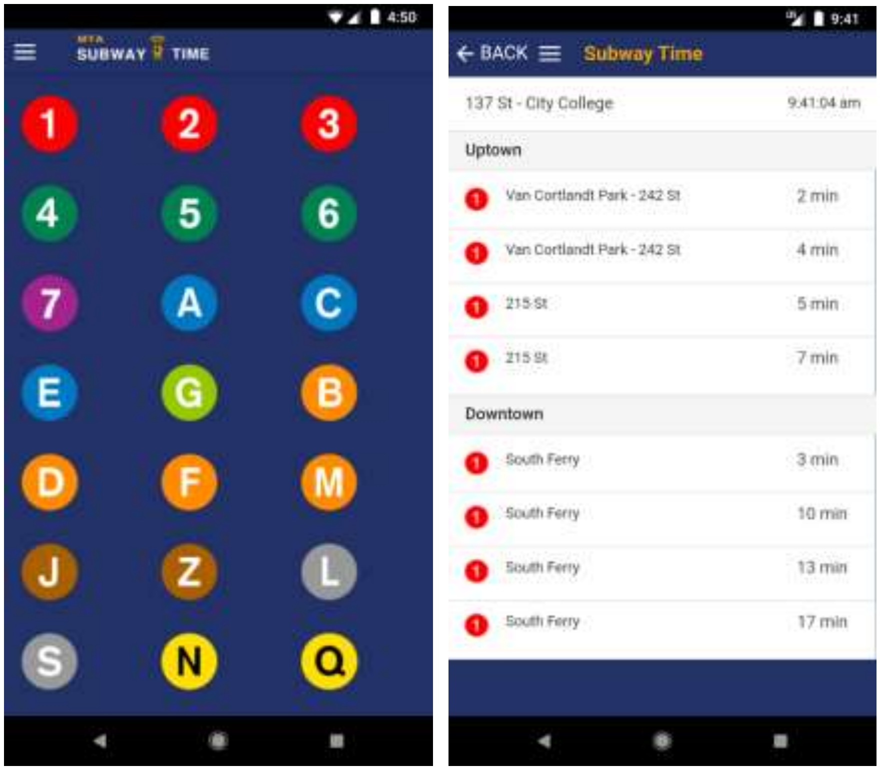

Figure 2: MTA's "Subway Time" app home screen (left) & real-time information screen (right)

Image source: Metropolitan Transportation Authority, 2018

There are a few noteworthy differences between RTI and other forms of transit information. *Schedules* refer to the predefined time and location of vehicles published by the transit operator. When vehicles are running on-time, RTI and schedule information are the same; when transit vehicles are not, RTI is a more accurate method of tracking the location of transit vehicles. Another form of transit information is *service alerts*, which provide notifications about major delays. Although service alerts are often provided to passengers in real-time as incidents occur, they can include varying levels of information (Brakewood and Watkins, 2018). This report focuses specifically on real-time information; prior studies about schedules or service alerts are not considered in the following literature review.

Methodology

This section describes the methodology for conducting the literature review, including the databases that were searched and the inclusion criteria. Then, a framework for categorizing the passenger impacts of RTI is presented.

Databases Searched

Two scholarly databases were used in the search process. The first database was the Transport Research International Documentation, known as *TRID*. TRID is maintained by the Transportation Research Board (TRB) of the US National Academies and covers all transportation disciplines. This database was selected because it contains nearly 1.2 million records of published research and is considered to be "*the world's largest and most comprehensive bibliographic resource on transportation research information"* (National Academics of Science, Engineering, and Medicine, 2018). The second database that was searched is *Google Scholar*, which "provides a simple way to broadly search for scholarly literature" (Google, 2018). Google Scholar was used to broaden the scope beyond transportation-specific databases. More details on the search process can be found in Brakewood and Watkins (2018).

Inclusion Criteria

To be included in this literature review, RTI studies needed to meet four criteria. First, only studies published in English were included. Second, only studies published since 1995 were included because RTI has only become widely available in the transit industry in the last two decades. Third, the research results must be published in peer-reviewed journals or conference proceedings; technical reports for which peer review status was unknown were excluded from this review. Last, only studies specifically evaluating the passenger benefits of RTI were considered (Brakewood and Watkins, 2018).

Primary Impacts of RTI on Passengers

This report categorizes RTI impacts into five major categories for which multiple studies have been undertaken. Three of the five fall under behavioral outcomes associated with RTI: increased transit use, decreased travel time, and decreased wait time. RTI could impact levels of *transit use* by impacting a passenger's decision to make a trip or by impacting a passenger's choice to take transit versus another mode. RTI could also influence which route a passenger chooses, and this would impact their overall *travel time*, as different paths typically have different travel times. Similarly, RTI could play a role in the decision of which stop a passenger boards a transit vehicle or what time they choose to leave their point of origin, and both could impact the traveler's total travel time or their wait time. Because the prior literature often divides transit travel time into wait time and in-vehicle travel time components, the *wait time* component is presented separately in this review. This report also includes two factors related to passenger feelings and perceptions for which multiple studies have been conducted: increased *satisfaction with transit* and increases in the *perception of security*. Finally, it should be noted that a small number of studies have also identified other potential passenger impacts of RTI (such as increased transfers between modes). However, due to the limited number of studies on other impacts, they are not reviewed in here; interested readers are referred to Brakewood and Watkins (2018) for a brief summary of other impacts.

Findings from the Literature Review

This section presents the key findings from the literature review. First, all studies pertaining to the passenger impacts of real-time information are summarized. Then, more detailed summaries of studies specifically pertaining to urban heavy rail systems (i.e., subway or metro systems) are presented since these findings are most likely to be applicable to the New York City Subway.

Summary of All Studies

In total, twenty-eight studies were identified that pertain to the five primary passenger impacts of RTI, and these studies are summarized in Table 1. The first column of Table 1 shows the authors' names and the year of publication; the second column displays the location where the study was conducted; and the third column identifies the transit modes evaluated. The five rightmost columns in Table 1 summarize the results of the five primary passenger impacts of RTI. A filled circle represents a positive finding; a half-filled circle signifies a finding that is sometimes positive; an empty circle implies that the study investigated the passenger impact but the results were null, negative, or not statistically significant; and a dash means that the study did not investigate that impact (Brakewood and Watkins, 2018).

Of the twenty-eight studies, thirteen examined the wait time implications of RTI, and twelve of these studies found positive results. This implies that wait times have the most supporting evidence of the five impacts. Six of the twenty-eight studies examined travel time implications from path choice. Thirteen studies evaluated the impacts of RTI on transit use, and nine of them found positive results. Six studies examined satisfaction, and of those, only three found fully positive results. Similarly, five of the twenty-eight studies examined perceived personal security, and of those, only two found fully positive results. Satisfaction and perception of security are areas where future research could address impacts more thoroughly.

Table 1: Summary of all studies on the impacts of real-time information

#	Authors (Year)	Study Location	Modes	Wait Time	Total Travel Time	Transit Use	Satisfaction	Perceived Security
1	Brakewood, Barbeau & Watkins (2014)	Tampa, USA	Bus	●	-	○	◖	◖
2	Brakewood, Macfarlane & Watkins (2015)	New York City, USA	Bus	-	-	●	-	-
3	Brakewood, Rojas, Zegras, Watkins & Robin (2015)	Boston, USA	Commuter Rail	◖	-	-	-	-
4	Cats, Koutsopoulos, Burghout & Toledo (2011)	Stockholm, Sweden	Subway	-	●	-	-	-
5	Cats & Gkioulou (2014)	Stockholm, Sweden	Subway, Bus, Light Rail	●	-	-	-	-
6	Chow, Block-Schachter & Hickey (2014)	Boston, USA	Heavy Rail	●	-	●	○	-
7	Dziekan & Vermeulen (2006)	The Hague, Holland	Tram	●	-	-	-	○
8	Estrada, Giesen, Mauttone, Nacelle & Segura (2015)	Rivera, Uruguay	Bus	-	●	-	-	-
9	Fan, Guthrie & Levinson (2016)	Minneapolis & St. Paul, USA	Light Rail, Commuter Rail, BRT	○	-	-	-	-
10	Ferris, Watkins & Borning (2010)	Seattle, USA	Bus	●	-	●	●	●
11	Fonzone & Schmöcker (2014)	Fictitious Network	Not Specified	-	●	-	-	-
12	Fries, Dunning & Chowdhury (2011)	Clemson University, USA	Bus	●	-	○	-	-
13	Ge, Jabbari & MacKenzie (2017)	Seattle, USA	Transit (bus, streetcar), Shared Modes (car-, bike- & ride-share)	-	-	○	○	-
14	Gooze Watkins & Borning (2013)	Seattle, USA	Bus	-	-	●	●	●

● = positive finding; ◖ = sometimes positive finding; ○ = negative / not significant finding; - = did not consider

Adapted from Brakewood and Watkins (2018)

Table 1 (continued): Summary of all studies on the impacts of real-time information

#	Authors (Year)	Study Location	Modes	Wait Time	Total Travel Time	Transit Use	Satisfaction	Perceived Security
15	Hickman & Wilson (1995)	Boston, USA	Bus	-	●	-	-	-
16	Ji, Zhang, Gao & Fan (2017)	Nanjing, China	Metro, BRT, Bus	●	-	-	-	-
17	Kaplan, Monteiro, Anderson, Nielsen & Santos (2016)	Recife/Natal, Brazil & Copenhagen, Denmark	Bus, BRT, LRT (Brazil) & Metro, Local/ Suburban/ Regional Trains, Buses (Denmark)	-	-	●	-	-
18	Liu, Shi & Jian (2017)	Chengde, China	Bus	●	-	-	-	-
19	Papangelis, Nelson, Sripada & Beecroft (2016)	Rural Scotland	Bus	●	-	-	-	-
20	Politis, Papaioannou, Basbas & Dimitriadis (2010)	Thessaloniki, Greece	Bus	-	-	●	-	-
21	Reed (1995)	University of Michigan, USA	Bus	●	-	-	-	-
22	Tang & Thakuriah (2007)	Chicago, USA	Bus & Train	-	-	●	-	-
23	Tang & Thakuriah (2011)	Chicago, USA	Transit	-	-	●	-	-
24	Tang & Thakuriah (2012)	Chicago, USA	Bus	-	-	●	-	-
25	Trozzi, Gentile, Kaparias & Bell (2013)	Fictitious Network	Bus	-	◖	-	-	-
26	Watkins, Ferris, Borning, Rutherford & Layton (2011)	Seattle, USA	Bus	●	-	-	-	-
27	Zargayouna, Othman, Scemama & Zeddini (2015)	Toulouse, France	Bus	-	◖	-	-	-
28	Zhang, Shen & Clifton (2008)	University of Maryland, USA	Shuttle Bus	-	-	○	●	◖

● = positive finding; ◖ = sometimes positive finding; ○ = negative / not significant finding; - = did not consider

Adapted from Brakewood and Watkins (2018)

Summary of Urban Heavy Rail Studies

Of the twenty-eight studies reviewed in the previous section, only six studies evaluated the impacts of real-time information on passengers in urban heavy rail systems (i.e., subway or metro systems). These six studies were reviewed in detail, and the results are shown in Table 2, which focuses on four key dimensions.

The first dimension shown in Table 2 is the *media* through which RTI is provided to the transit rider, and this was divided into signage or personal devices, such as smartphone applications. Most of these studies (five of six) considered RTI provided via stationary signage.

The second dimension is the *method* used in the study. The methodologies were classified into a general approach, which were either surveys of individual travelers or simulation models, and then additional details about the analysis are provided. Four of the six prior studies utilized survey-based methods, and for these, the sample size of individuals participating in the survey and the statistical method utilized were noted.

The third and fourth dimensions shown in Table 2 are the passenger *impacts* that were evaluated and the key *findings*. These six studies considered a total of four passenger impacts: wait times (three studies), total travel times (one study), transit use (three studies), and satisfaction (one study). As can be seen in Table 1 and Table 2, the only study that had a negative findings (findings that were not significant) pertained to passenger satisfaction levels, which was Chow et al., 2014. The studies of wait time, total travel time, and transit use impacts all had positive results, which suggest that these are most likely to be found in other urban heavy rail systems with RTI. However, there were a limited number of studies on each impact, particularly path choice, and therefore, future research is deemed necessary.

Table 2: Studies on the impacts of real-time information in urban heavy rail systems

Year	Authors	Media	Method		Impacts	Findings
			Approach	Analysis		
2007	Tang & Thakuriah	Signage	Survey-based method (n=1,020)	Survey of both transit riders and non-riders; Asked if availability of RTI would increase their transit use; Bivariate probit model estimated to explore simultaneous choice of transit use and RTI use relate to demographics, automobile availability, etc.	Transit use	67% of all respondents stated that they would increase their transit use if RTI became available at stops/station; This was higher among current transit riders (70%) compared to non-riders (60%); Bivariate probit models showed some differences based on demographics, etc.
2011	Cats, Koutsopoulos, Burghout & Toledo	Signage & Personal Devices	Simulation model	Dynamic transit model (BusMezzo) with three components: traffic dynamics, transit operations and passenger demand; Scenarios were evaluated with different levels of RTI provision and transit operations	Total travel time	Comprehensive RTI systems have the potential to lead to shifts in path choice and travel time savings
2014	Cats & Gkioulou	Personal Devices	Simulation model	Dynamic transit model (BusMezzo) considering RTI with varying levels of reliability	Wait time	RTI users adapt their behavior to shorten their wait times
2014	Chow, Block-Schachter & Hickey	Signage	Survey-based method (n=4,118)	Before-after passenger surveys conducted in heavy rail stations; passengers were asked to estimate how long they expected to wait for a train and to rate the overall transit system on a scale from 1 (poor) to 5 (great); Automated fare collection system data used in a fixed effects regression model; dependent variable is the log of boardings; independent variables included fare changes, station effects, line effects and seasonal effects	Wait time, transit use, satisfaction	After RTI, passengers reduced their wait time estimates by 0.85 minutes on average; after further controlling for service disruptions, wait time estimates were reduced by 1.3 minutes on average (17% of total wait times). After RTI, passengers had a higher overall rating of the transit agency (3.46 compared to 3.41), but this was not statistically significant. The fixed effects model suggests that ridership increased by 1.7% ; however, the authors said this is "preliminary".
2016	Kaplan, Monteiro, Anderson, Nielsen & Santos	Signage & Personal Devices	Survey-based methods (n=1123)	Web-based survey of university students in two regions (Brazil and Denmark); structural equation models to explain transit use	Transit use	Results show that searching for real-time information is associated with trips at night and to unfamiliar places (non-routine transit use)
2017	Ji, Zhang, Gao & Fan	Signage	Survey-based method (n=1031)	Survey of passengers at stops/stations asking them to self-report their wait times; video footage of passengers waiting at stops/station to capture actual wait times; structural equation model of wait times	Wait time	Results of the structural equation model suggest that RTI signage decreases the perception of wait times; shorter wait times (5 minutes) decreased 15.6%; longer wait times (10 minutes) decreased 30.6%

Adapted from Brakewood and Watkins (2018)

Discussion of New York City and Areas for Future Research

This section presents a brief discussion of how the findings from the literature review may be applicable to New York City, where real-time information has been made available for most of the subway over the past decade (MTA, 2010; MTA, 2017).

The most promising benefit for subway passengers is reduced *wait times*. In the first part of the literature review, twelve of twenty-eight studies across various transit modes found reductions in passenger wait times associated with RTI, and three of these studies were conducted in urban heavy rail systems. If future research is conducted for the New York City Subway, one important difference to evaluate is *actual wait times* (i.e., how long a passenger waits in a station for the train) versus *perceived wait times* (i.e., how long a passenger *thinks* s/he has been waiting) for RTI users versus non-users. One of the most cited prior studies of RTI impacts on bus riders found significant decreases in both actual and perceived wait times for RTI users compared to non-users (Watkins et al., 2011); however, this difference has not been explored in the context of urban heavy rail systems. RTI provided via smartphone apps may reduce actual wait times because a subway passenger checking an RTI app at home or at work could "time" his or her arrival to the station to meet the train; however, this impact may be limited in urban heavy rail systems due to high frequencies on many subway lines. Additionally, countdown clocks that have been installed in most subway stations are likely to reduce perceived wait times since passengers may have a better understanding of how long they are waiting when RTI signage is nearby.

A second passenger benefit identified in the literature review is reductions in *total travel time* due to changes in path choice. Six of the twenty-eight studies examined in the first part of the literature review revealed travel time impacts; however, only one of these studies was conducted for heavy rail systems. This could be a particularly promising area for future research in a dense transit network like the New York City Subway because there are often multiple paths between origin-destination pairs. For example, a passenger choosing between a "local" train arriving at the station sooner and an "express" train arriving later may ultimately select the later arriving express train to minimize overall travel time to his or her destination station when RTI is available. Future research in urban heavy rail systems could conduct rider surveys of route choice, which would be different from the prior studies that primarily utilized simulation modelling.

Nine of the twenty-eight studies found increases in *transit use* associated with RTI, and three of these were specific to urban heavy rail systems. Therefore, future research in New York City could aim to assess this impact. Finally, there were limited prior studies pertaining to increased *satisfaction* with transit and increased *perceptions of security* when riding transit associated with RTI in urban heavy rail systems. Because these impacts were measurable in other transit modes, future research may also find positive results in heavy rail systems.

In summary, five key benefits of providing real-time information to transit passengers were identified from a comprehensive literature review (Brakewood and Watkins, 2018). Of these five impacts, the two most promising impacts for New York City Subway passengers are reductions in *wait times* – particularly perceived wait times when countdown clocks are installed in stations – and reductions in *overall travel times*, which may be possible in dense transit networks like the subway where passengers often have multiple paths between origin-destination pairs. Future research is recommended to evaluate these two impacts.

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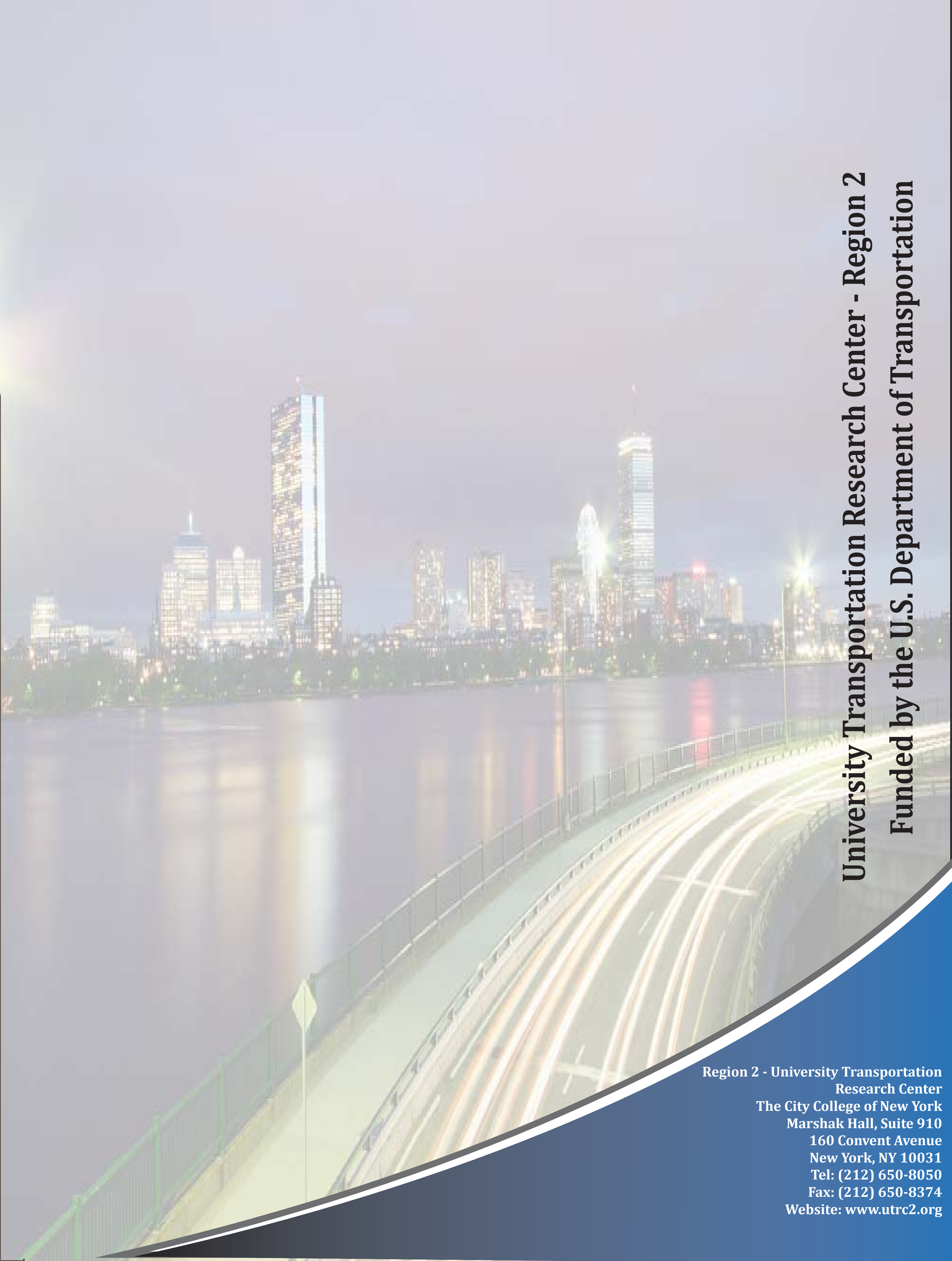

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