University Transportation Research Center - Region 2

Final Report

Air Quality Impact of Traffic Congestion in Midtown Manhattan

Performing Organization: Polytechnic Institute of NYU

January 2014

Sponsor:
University Transportation Research Center - Region 2

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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:

Research

The research program objectives are (1) to develop a theme based transportation research program that is responsive to the needs of regional transportation organizations and stakeholders, and (2) to conduct that program in cooperation with the partners. The program includes both studies that are identified with research partners of projects targeted to the theme, and targeted, short-term projects. The program develops competitive proposals, which are evaluated to insure the mostresponsive UTRC team conducts the work. The research program is responsive to the UTRC theme: "Planning and Managing Regional Transportation Systems in a Changing World." The complex transportation system of transit and infrastructure, and the rapidly changing environment impacts the nation's largest city and metropolitan area. The New York/New Jersey Metropolitan has over 19 million people, 600,000 businesses and 9 million workers. The Region's intermodal and multimodal systems must serve all customers and stakeholders within the region and globally.Under the current grant, the new research projects and the ongoing research projects concentrate the program efforts on the categories of Transportation Systems Performance and Information Infrastructure to provide needed services to the New Jersey Department of Transportation, New York City Department of Transportation, New York Metropolitan Transportation Council , New York State Department of Transportation, and the New York State Energy and Research Development Authorityand others, all while enhancing the center's theme.

Education and Workforce Development

The modern professional must combine the technical skills of engineering and planning with knowledge of economics, environmental science, management, finance, and law as well as negotiation skills, psychology and sociology. And, she/he must be computer literate, wired to the web, and knowledgeable about advances in information technology. UTRC's education and training efforts provide a multidisciplinary program of course work and experiential learning to train students and provide advanced training or retraining of practitioners to plan and manage regional transportation systems. UTRC must meet the need to educate the undergraduate and graduate student with a foundation of transportation fundamentals that allows for solving complex problems in a world much more dynamic than even a decade ago. Simultaneously, the demand for continuing education is growing – either because of professional license requirements or because the workplace demands it – and provides the opportunity to combine State of Practice education with tailored ways of delivering content.

Technology Transfer

UTRC's Technology Transfer Program goes beyond what might be considered "traditional" technology transfer activities. Its main objectives are (1) to increase the awareness and level of information concerning transportation issues facing Region 2; (2) to improve the knowledge base and approach to problem solving of the region's transportation workforce, from those operating the systems to those at the most senior level of managing the system; and by doing so, to improve the overall professional capability of the transportation workforce; (3) to stimulate discussion and debate concerning the integration of new technologies into our culture, our work and our transportation systems; (4) to provide the more traditional but extremely important job of disseminating research and project reports, studies, analysis and use of tools to the education, research and practicing community both nationally and internationally; and (5) to provide unbiased information and testimony to decision-makers concerning regional transportation issues consistent with the UTRC theme.

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Project Date: January 2014

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16. Abstract

Exposure to fine particle pollution can cause premature death and harmful cardiovascular effects such as heart attacks and strokes, and is linked to a variety of other significant health problem. A pilot project was commissioned by the University Transportation Research Center (URTC) to develop a methodology for studying the air quality impact of traffic congestion. The concept is that both the performance criteria of traffic flow and related health issues need be considered in the design of traffic management systems. The above study uses the NYC Midtown Manhattan as the study site incorporating the NYCDOT traffic flow instruments as well as street level air quality monitors, measuring traffic volume and speed and fine particulate matter.

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Disclaimer

Air Quality impact of Traffic Congestion in Midtown Manhattan

Report January 2014

Masoud Ghandehari, NYU Polytechnic School of Engineering, Center for Urban Science and Progress

Executive Summary

"Exposure to fine particle pollution can cause premature death and harmful cardiovascular effects such as heart attacks and strokes, and is linked to a variety of other significant health problems" (USEPA, 4). Studies by the Harvard School of Public Health and subsequent reanalysis covering 83 largest urban areas in the US found evidence of premature death caused by traffic congestion (1,2). NYC, one of the most populous urban areas in the US has been mentioned frequently both as problematic in terms of concentrations of particulate matter and asthma rates, and as a success story in terms of air quality management. Faced with the challenge of urban population growth and the corresponding traffic congestion, many cities around the world have adopted intelligent transportation technologies, carbon taxes on vehicles, congestion pricing and other approaches for dealing with the impact of mobility in cities. It is now agreed that both the performance criteria of traffic flow and related health issues need be considered in the design of traffic management systems. Detailed and quantifiable measures for the correlation of air quality and traffic is key to establishing performance criteria.

A pilot project was commissioned by the University Transportation Research Center (URTC) to develop a methodology for studying the air quality impact of traffic congestion. The study which is being carried out by the Polytechnic School of Engineering of NYU and the Center for Urban Science and Progress is using the NYC Midtown Manhattan (Fig 1) as the study site incorporating the NYCDOT traffic flow instruments as well as street level air quality monitors. The traffic data includes volume and speed (Fig 3). The air quality data includes fine particulate matter ($PM_{2.5}$) and Black Carbon (BC) (Fig 4), pollutants which are formed by the atmospheric reaction of fossil fuel combustion gases and by insufficient combustion of fuels, respectively. Both pollutants are very fine and are considered highly hazardous due to ease of penetration into human lungs (2). Prescribed by US EPA (3,4,5), the critical limit for the 24 hour levels of $PM_{2.5}$ is 35 $\mu g/m^3$, and the annual average limit is 12 $\mu g/m^3$. There is currently no EPA standards for BC.

The pilot study was carried out on Lexington Avenue near 55th street from 6am to midnight. Results indicated a close correlation of speed with PM2.5 levels. It was also shown that peak levels of the particulate pollutants exceeded the EPA 35 $\mu g/m^3$ daily limits for extended periods, reaching as high as 90 $\mu g/m^3$ (Fig 5). It should be noted that the combination of spatial and temporal variation of the pollutants pose certain limits on drawing concise conclusions on the traffic vs pollution correlation and hence on the exposure levels to pedestrians. For this reason we commissioned the development of *miniature particulate meters*, which can be deployed with high spatial distribution. The mini-monitor is designed to cost less than 10% of cost of available devices while having same quality of detection (Fig 7). Testing of the mini monitors is nearing completion. The deployment of highly distributed network of such air quality sensors at existing DOT traffic measurement sites will be possible by Spring 2014.

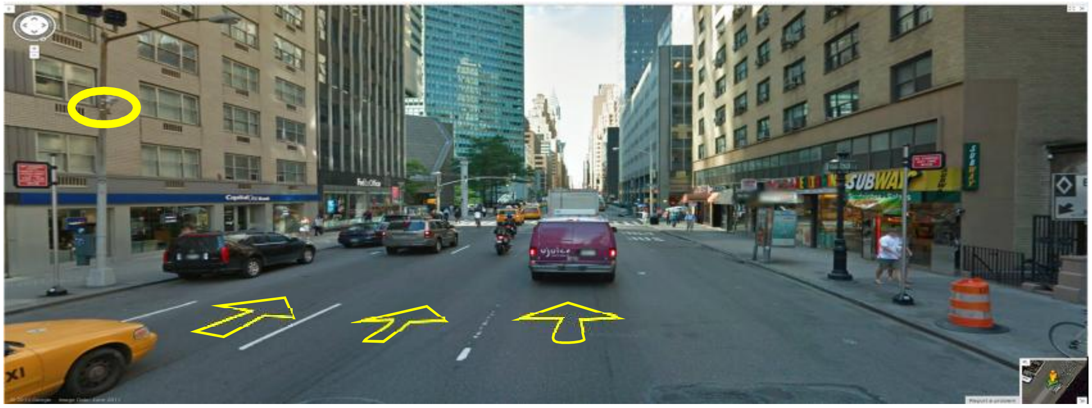


Figure 1 - Test site, Lexington and 55th St.

Study Program

There are four south bound lanes on the Lexington Ave site, not including the parking lane. Traffic sensors are located on the East sidewalk closest to the three lanes being monitored. The lane farthest from the sensors is a bus lane and not included in the study. Traffic data collected include volume, occupancy and speed. The volume is defined as “flow rate measured in vehicles/hour”, and occupancy is the “measure of density” in “percent of time occupied”.

24-hour traffic data was collected at 30 second intervals while measuring air pollutants at 60 second intervals. The air quality data was collected at the site near the traffic sensor for 18 hours from 6:30AM to 12:25AM. Results of volume, occupancy and speed are shown in Figure 3 as well as measured concentration for Particulate matter PM2.4 and elemental carbon (EC) in Figure 5.

Traffic

The hourly traffic volume of all three lanes on Lexington Avenue is shown in Figure 2. Lane2 (next to bus lane) had low traffic flow compared to Lane3 and Lane4. Traffic was lowest at 3AM, then peaked during the rush hour in the morning and at night. The total volume of three lanes peaked three times once at 7AM, then 6PM and 9PM. Some blockages of the micro wave signal may have resulted in underestimating the traffic volume.

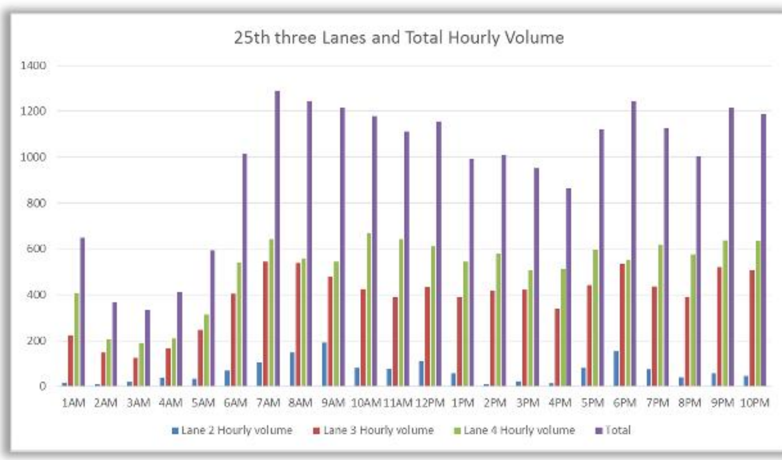


Figure 2 – Traffic Volume per lane.

For this reason future test will include analysis of traffic camera. The camera feed analysis will also provide classification information which will be used for drawing more accurate conclusion regarding concentration and speciation of the pollutants.

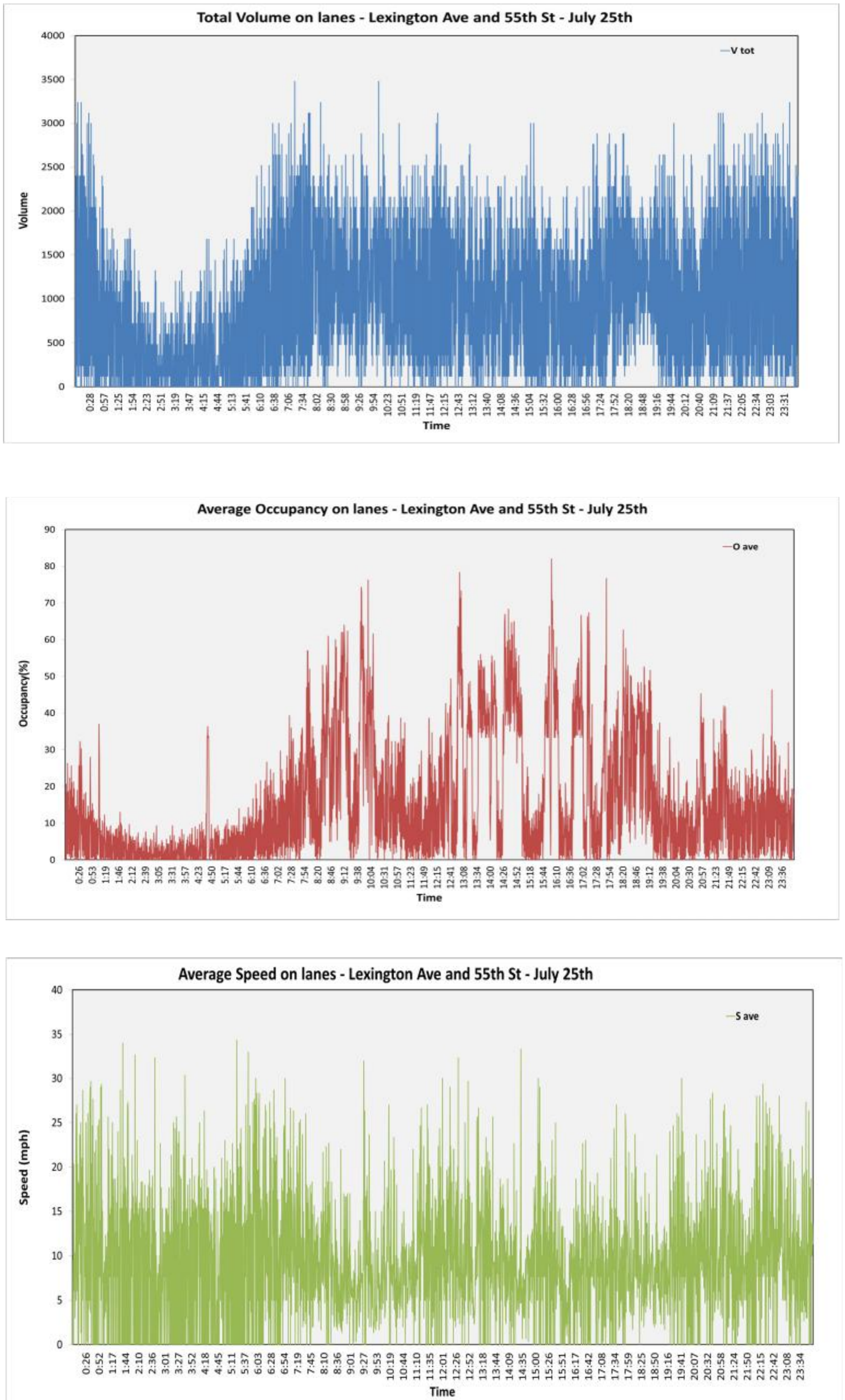


Figure 3 – Lexington Ave and 55th st, (top) volume, (middle) speed, (bottom)

Air quality measurement

Figure 4 –Air Quality Monitors (left) PM2.5 monitor MIE PDR 1000, (center) BC monitors microAeth® Model AE51, (right) William measuring street level air quality

Results of measurements indicate that peak levels of the particulate pollutants exceeded EPA limits of 35μg/m^3 mostly all day reaching as high as 90 μg/m^3. Comparison of street levels pollutants content with the concentration of PM2.5 measured at EPA sites both in NYC highlights the importance of measuring these levels at the site of human exposure.

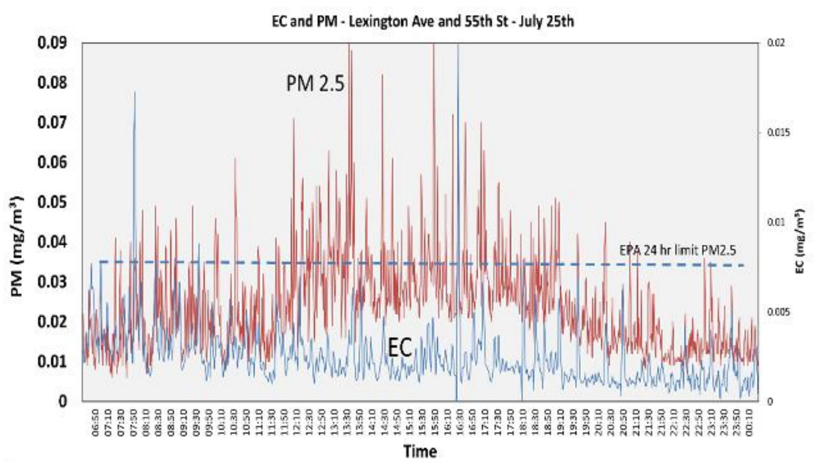


Figure 5 – Lexington Ave PM2.5 and BC level from 6am to midnight

For this reason future tests will include analysis of traffic camera. The camera feed analysis will also provide classification information. This will be of value for drawing more accurate conclusion regarding concentration and speciation of the pollutants. It should be noted that the combination of spatial and temporal variation of the pollutants pose certain limits on drawing concise conclusions regarding the correlation of traffic vs pollution, and hence on the exposure levels to pedestrians. For this reason we commissioned the

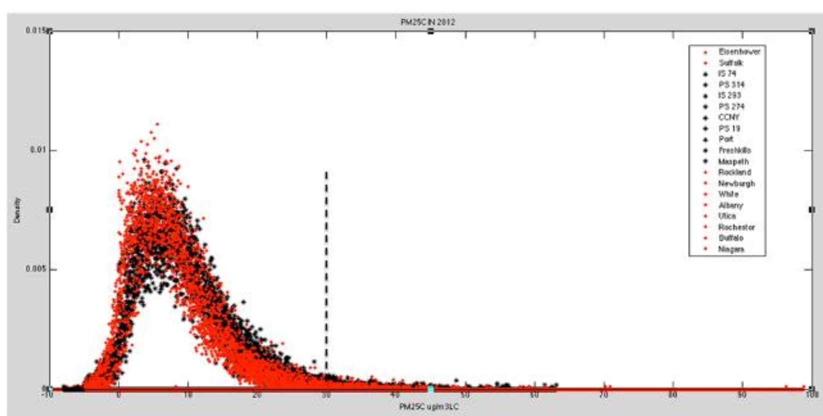
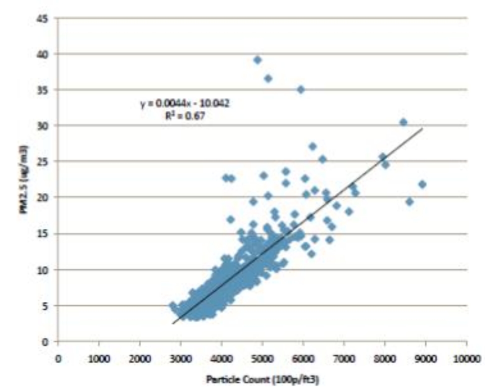


Figure 6 – Hourly PM2.5 data for 12 months starting January 2012. Upstate (red), and NYC (black). Dashed line indicates EPA PM2.5 limits

development of *miniature particulate meters*, which can be deployed with high spatial distribution. The mini monitor is designed to cost less than 10% of cost of available devices while having same quality of detection (Fig 7). Testing of the mini monitors is nearing completion.

<u>Mini Monitor</u>

With the intention of acquiring accurate and reliable information on the pedestrian exposure to traffic induced air pollutants, we took the important step of developing a device that can be deployed in large numbers (~200) at low price (approximately $150) each. The unit was developed by a small Brooklyn based enterprise. The housing was 3D printed and designed for mass production. Results of comparison of measurements by the unit compared to commercially available units exceeding price of $5000 is shown below, suggesting excellent performance.



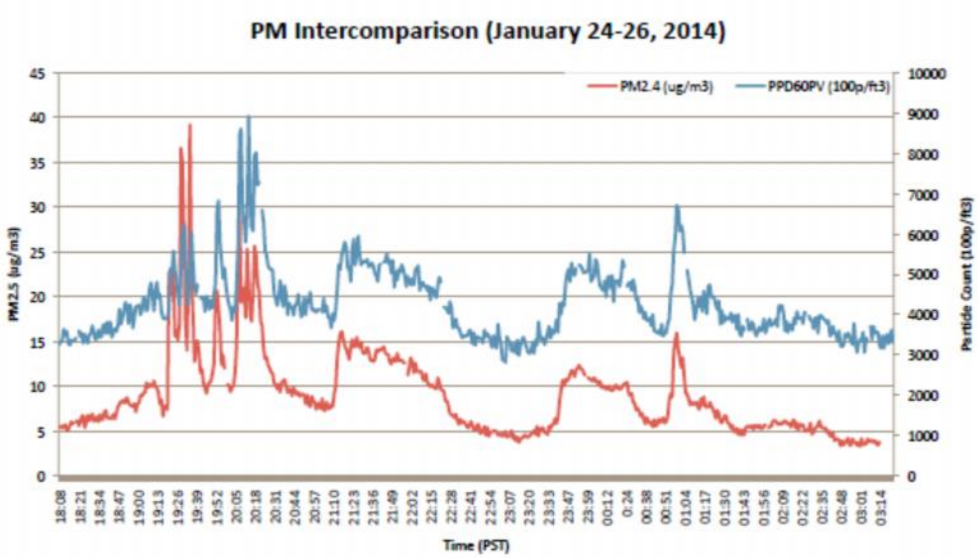


Figure 7– (top left) Air beam device, (upper right and bottom) comparison of mini meter to a Thermo Scientific pDR-1500.

Conclusions and recommendations

Measurement and analysis of traffic volume and speed, as well as particulate air pollutants in midtown Manhattan indicated that speed has closer correlation to air pollution than traffic volume.

PM2.5 levels on days of study exceeded the EPA daily limit of 35 $\mu g/m^3$ for extended periods, reaching as high as 90 $\mu g/m^3$.

There is considerable spatial and temporal variability in the pollutant concentration. This poses certain limits on drawing concise conclusions on the correlation between traffic and pollution and therefore uncertainty in pedestrian exposure levels. For this reason we commissioned the development of a *miniature particulate meter* for distributed deployment. The above meters cost less than 10% of commercially available devices but have comparable accuracy.

Made possible through the support by UTRC, the deployment of highly distributed network of air quality sensors is now feasible. This is largely due to the cost-performance value of the developed PM meter.

We therefore recommend the deployment of the miniature air sampling devices to be collocated at 100 selected NYCDOT traffic measurement sites. We recommend the remote and continuous measurement of street level particulate air pollutants for period of one year. This is expected to result in reliable and accurate measurements leading to a better understanding of the relationship between various features of traffic congestion and air quality. This will be the first such study in the nation.

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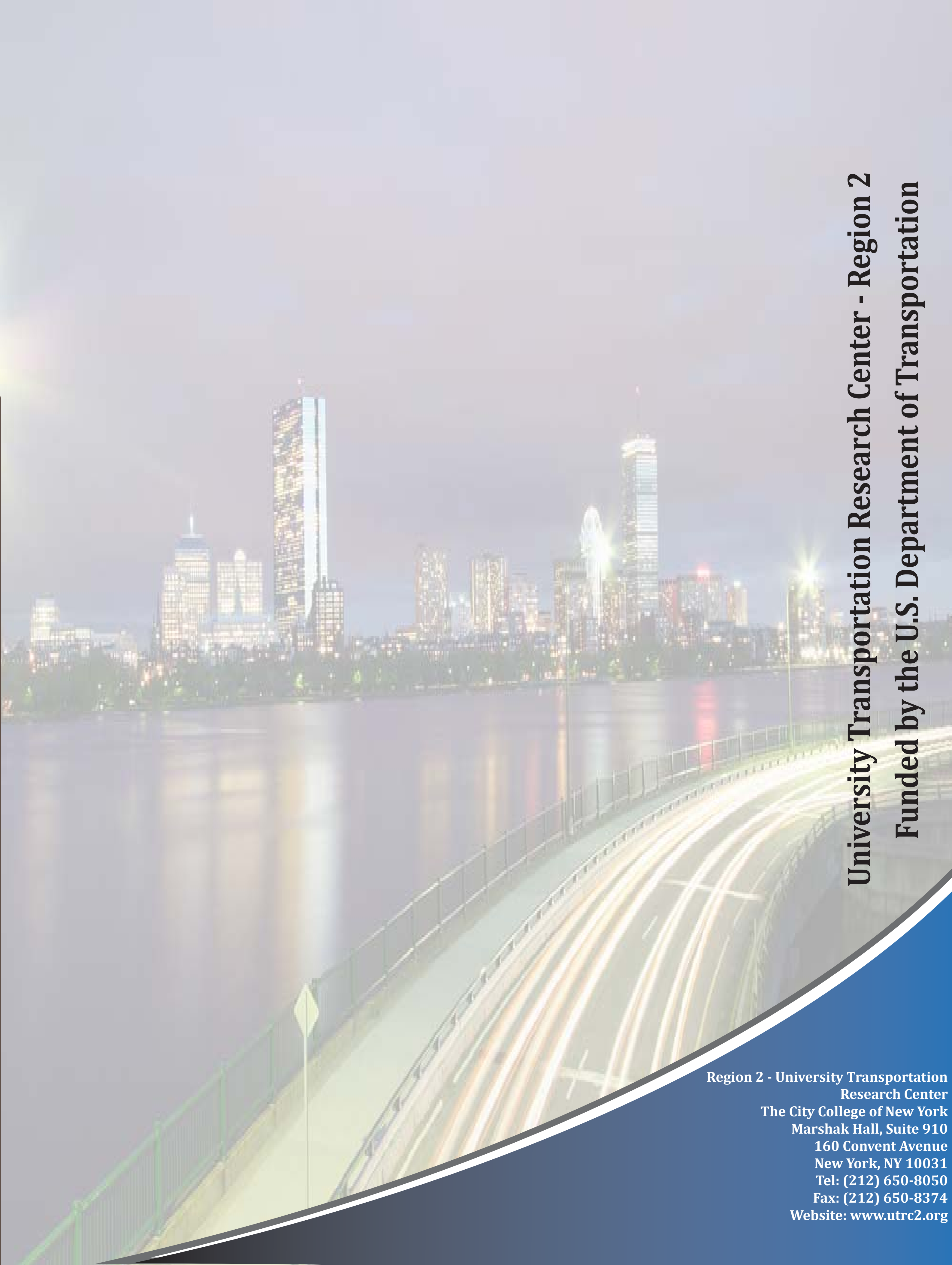

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