University Transportation Research Center - Region 2

Final Report

A Simulation-based Assessment Approach to Increase Safety among Senior Drivers

Performing Organization: University at Buffalo, SUNY

April 2013

Sponsor:
Research and Innovative Technology Administration / USDOT (RITA)

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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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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REGION II
UNIVERSITY TRANSPORTATION RESEARCH CENTER

Final Report

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16. Abstract

Statistics show that in the U.S., there are about 38 million licensed drivers over age 65; about 1/8 of our population. By 2024, this figure will DOUBLE to 25%. The current research is intended to address the driving capabilities of our older population, as accident and injury risk has been statistically shown to increase – normalized per mile driven – with advanced age. Our primary objective is to perform a preliminary Pilot Study (N=10) that allows our team to analyze the impact of supplementing traditional driver evaluation for senior persons with cognitive impairment using state-of-the-art driving simulation technologies. Within a simulator, a variety of driving scenarios can be implemented that sufficiently challenge drivers in a way that, due to safety and logistical concerns, cannot be accomplished within the confines of a real vehicle. Longer-term, a driving simulator can be used to define driving tasks that are most likely to be affected by stages of dementia, and to measure, capture, and analyze vital driver performance metrics. Each driver is evaluated at Erie County Medical Center (ECMC) using a conventional driver evaluation mechanism: in-clinic (to measure cognitive, motor and visual skills) and in-vehicle (to measure mechanical ability to operate a vehicle). Prior to these examinations, each driver is evaluated in a motion-based driving simulator located at the University at Buffalo (UB). A subsequent data analysis is performed in an effort to identify any trends or patterns between the three evaluation mechanisms.

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Abstract

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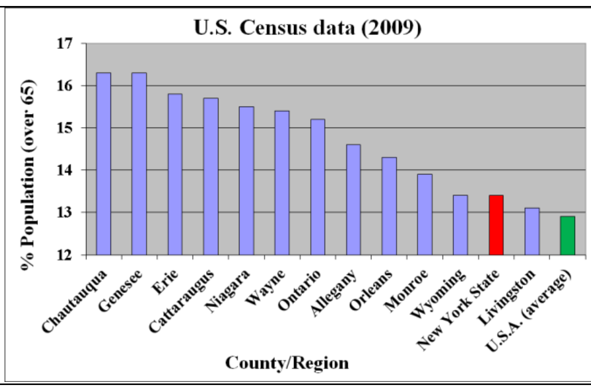

Figure 1. Western New York 65+ population (by County)

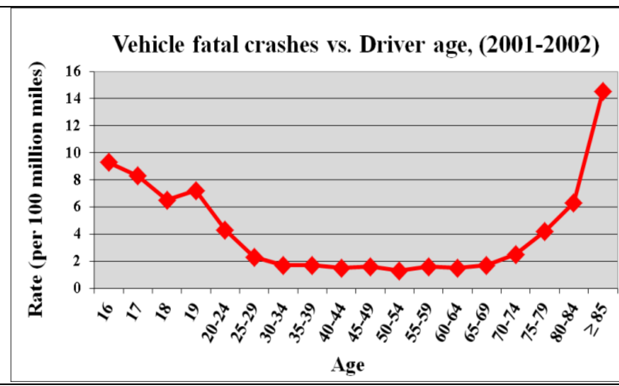

Figure 2. Accidents by age, normalized per mile driven

Introduction and Motivation

Roadway safety is a major public health concern. In the U.S., there are about 38 million licensed drivers over age 65; about 1/8 of our population. By 2024, this figure will DOUBLE to 25%! A related trend of regional interest in Western New York (Figure 1) is that all 12 counties have 65+ populations that are greater than the National average (12.9%), with the top 5 counties being 20% or greater than the national average. As our population ages, 2/3 of which own driver's licenses (FHWA, 2010), there are many age-related conditions that can have a negative impact on a person's driving capabilities. Dementia-related diseases, including Alzheimer's Disease (AD) create functional decline that negatively impacts driving performance. Dementia and AD afflict more than 7 million people in the U.S., and 35 million people worldwide (Osterman, 2009). This number is expected to double every 20 years, such that by 2050, there could be 13 million cases of AD in the U.S. alone (Prince and Jackson, 2009). Figure 2 shows vehicle fatal crash involvements by driver age (IIHS, 2007). Above age 65 (right side of curve), fatal crashes (normalized per miles driven) are seen to exhibit a marked increase accentuating towards age 85. Clearly, this is a continued and growing cause for concern.

Literature Review and Objectives

For the current pilot study, our primary goal is to develop and implement driving simulation strategies to supplement existing protocols for the assessment of senior-aged drivers over age 65. Various other research groups have attempted simulation-based approaches for driving studies with the aging/elderly population. The AgeLab at MIT promotes safe driving research with older drivers, and examines the associated risks of health and medicine to driving (e.g., Reimer et al., 2006). Wayne State University makes use of their "Advanced Mobile Operations Simulator" to evaluate cognitive driving skills of senior citizens and persons with disabilities (King, 2009). The Driving Safety and Rehabilitation Research Laboratory (DSRRL) at Purdue is used to perform assessments to identify weaknesses in driving-related performance (Justiss et al., 2006). The National Older Driver Training and Research Center (NODRTC, 2010) at the University of Florida has implemented the "Early Availability Driving Simulator", to assess the capabilities and limitations of older drivers (Classen et al., 2009). The National Advanced Driving Simulator (NADS) has been used to identify requirements for advanced driver assistance systems that specifically address safety needs of older drivers (e.g., McGehee et al., 2004). Finally, (Adler et al., 2005) noted comparisons of driving assessment protocols, and concluded that "while road tests, simulators, and neuropsychological tests are important, each has…limitations". The unique direction employed here -- a hybrid approach of merging physical and virtual road testing for risk assessment of older drivers -- addresses this concern, satisfies an apparent research void in the field of (cognitively-impaired) senior driver assessment, and serves as a novel assessment technique that will strive to substantially impact clinical research.

A driving simulator can be used to define driving tasks that are likely to be affected by stages of dementia (e.g., left turn management, traffic signs and signals, lane maintenance), and to capture driver performance metrics (e.g. speed, lane position, stopping behavior at intersections) that would require expensive equipment if implemented within a "real" vehicle. Such a controlled and measurable environment can be used to implement scenarios that sufficiently challenge "suspect" drivers (i.e., drivers with known or suspected cognitive impairment) in a way that, due to safety and other logistical concerns, could not be accomplished within the confines of an actual vehicle. The anticipated outcome of the proposed study is to serve as a small but vital first step towards the validation of using simulators for senior driver evaluation. Ultimately, this would allow the proposed simulation-based evaluation protocols (in varying levels of fidelity) to be broadly disseminated, deployed, and implemented by external organizations (local, regional, and national) resulting in fewer accidents and fatalities, and safer roadways for all drivers.

Methods

Our study population was recruited largely from flyer postings at regional senior community centers. Flyers were postal mailed to every community center within a 30 mile radius, so more than 60 centers were contacted during our outreach phase. Candidate participants were informed that their participation would require two separate visits, encompassing approximately 3 hours of their time: one to UB (for the driving simulator session and cognitive evaluation), and one to ECMC (for a clinical and in-vehicle driving evaluation). Eligibility criteria for the study (established during a telephone screen) included the following: over 65 years of age, with an active New York State driver's license, and of good general health (i.e., free of seizures, not afraid of closed/dark spaces, does not suffer from motion sickness). Incentive for participation was a $100 gift card, upon completion of both major portions of the study. For this pilot study, we had a total of 10 recruits (7 males and 3 females); these "Senior Driver Simulator Study" (SDSS) participants are summarized in Table 1.

Table 1. Basic Details of Pilot Study Population

Part. code	**Age**	**Gender**	**Part. code**	**Age**	**Gender**
SDSS-01	66	M	SDSS-06	77	M
SDSS-02	72	M	SDSS-07	67	M
SDSS-03	66	F	SDSS-08	65	F
SDSS-04	71	F	SDSS-09	70	M
SDSS-05	66	M	SDSS-10	65	M
Age statistics: Mean: 68.5, Std. Dev.: 3.92					

Visit #1 - University at Buffalo (UB)
Prior to boarding the simulator, participants were issued two standardized and well-respected cognitive examinations: the Mini-Mental State Examination (MMSE) (Folstein et al., 1975) and the Montreal Cognitive Examination (MoCA) (Nasreddine et al., 2005). In addition, participants were issued the Motion Sickness Assessment Questionnaire (MSAQ) (Gianaros et al., 2001) both pre- and post- simulator. Both the MMSE and the MoCA are scored on a 0-30 scale, where 30 is a perfect score, scores in the low 20's represents mild cognitive impairment, and scores in the teens (or below) represents severe impairment. Once on-board the simulator, located at UB (Figure 3), the driver was asked to perform 3 drives of increasing duration. The first drive was an acclimation drive (3 minutes), followed by a left-hand turn drive-around the block (6 minutes), followed by a drive that examined hazard management, multi-tasking, and road signs (9 minutes). A variety of performance data was collected, both quantitative (i.e., as measured by the simulation software) and qualitative (i.e., as observed by the session evaluator) in nature. This data includes a score sheet that contains ten major categories, each scored from 0 (normal) to 3 (severely impaired). Thus, upon completion of the simulator drive(s), each participant scored between 0 (a perfect score) and 30 (severely impaired driving in all categories). The ten categories are: right turns, left turns, lane maintenance, proper following distance, proper lateral distance from cars, control of speed, brake reaction time, visual scanning at stop signs/signals, visual scanning during driving, and orientation/attention. Lastly, upon exiting the simulator session, participants were asked to complete a brief survey requesting self-feedback (based on one's own driving performance), technical feedback on the simulator itself, and an overall simulator satisfaction metric.

Visit #2 - Erie County Medical Center (ECMC)
Prior to driving within the test vehicle, participants were issued a number of in-clinic tests. Specifically, during the in-clinic evaluation, the participant's motor, sensory, visual, cognitive and functional skills were assessed. Routine history taking was omitted so that the evaluator did not have any knowledge of the status of the subject (i.e., "mild dementia" or "well elderly"). Immediately following the in-clinic evaluation the participant was escorted to a 2008 Ford Taurus (Figure 4), dual equipped vehicle, to complete the in-vehicle portion of this evaluation.

The participant was oriented to the vehicle, and all necessary adjustment to seat position and mirrors was made prior to the start of driving. During the 20-30 minute excursion, the participant is exposed to the following general driving environments: closed course, residential, commercial and expressway. As a portion of the examination, the participant is oriented to the location of the hospital, and is asked to drive two traffic lights North (on Grider Street). Here, the participant then makes all navigation decisions to return to ECMC. Note that the in-vehicle evaluator used the very same score sheet that was used for the simulator trials (i.e., a score of 0 to 3 in each of 10 different categories).

Figure 3. UB driving simulator

Figure 4. ECMC test vehicle

Results

Subsequent to participant trials at UB and ECMC, all collected data was analyzed and tabulated. A selection of results attained during our Pilot study is offered in Table 2. The first two columns are the cognitive exams (MMSE and MoCA) offered prior to the simulator (0 to 30). The third column is the simulator performance score (30 to 0), and the fourth column represents the total pre/post MSAQ scores (0 to 1). The fifth column is the AAA-brake reaction time (e.g., Parnell et al., 2007) in seconds (i.e., lower is better), the sixth column is scores from the Trail Making B exam -- a neuropsychological test of visual attention and task switching (Bowie and Harvey, 2006), measured in seconds (i.e., lower is better) and the seventh column is the in-vehicle performance score (30 to 0). The eighth and final column is the participant rating score (0 to 10) for overall impressions of the simulator experience.

The analysis of Table 2, column by column, proceeds as follows. (Note that the first four columns represent results attained at UB). The first two columns represent the cognition segment of our analysis of each participant. On the whole, scores were in the “normal” range for both the MMSE and MoCA exams, with two “lower normal” scores observed for the MoCA exam (SDSS-06, 23, and SDSS-10, 22). Overall simulator performance rating is seen in the third column. Scores ranged from a 5 to a 9, where again, a lower score of 0 represents a perfect score. It is surmised that most instances of poor performance observed here is less attributable to poor driving skills, and more attributable to poor driving skills on a simulator, where all participants were novices to the environment. The fourth column is the MSAQ (post simulator), which is a measure of simulation sickness. After 15-20 minutes of total exposure, two participants showed no signs of simulator sickness (SDSS-05 and SDSS-07); five participants showed mild symptoms (SDSS-01, SDSS-02, SDSS-03, SDSS-04, and SDSS-09); two participants showed mild-moderate symptoms (SDSS-08 and SDSS-10), and one participant (SDSS-06) was very adverse to the simulator, and even vomited as a result of his exposure.

Table 2. Summary of Pilot Study results

Part. code	MMSE	MoCA	Simulator	MSAQ	Reaction Time	Trail Making B	Vehicle	Rating
SDSS-01	28	23	5	0.16	0.75	113.0	0	8
SDSS-02	28	24	7	0.14	0.63	88.0	0	8
SDSS-03	29	27	9	0.19	0.65	46.8	0	6
SDSS-04	28	27	5	0.15	0.68	76.0	0	8
SDSS-05	27	24	5	0.11	0.62	123.0	0	10
SDSS-06	26	23	7	0.45	0.80	84.0	0	7
SDSS-07	29	27	5	0.11	0.65	55.30	0	9
SDSS-08	27	27	9	0.22	0.75	130.0	1	5
SDSS-09	29	27	7	0.16	0.69	78.2	0	8
SDSS-10	28	22	7	0.24	0.78	99.31	0	10
Avg.	***27.9***	***25.1***	***6.6***	***0.19***	***0.70***	***89.4***	***0.1***	***7.9***
STDEV	***1.0***	***2.1***	***1.6***	***0.10***	***0.07***	***27.4***	***0.3***	***1.6***

The next two columns represent results attained during the in-clinic portion of the exam at ECMC. The first is brake reaction time, as measured by AAA’s “blue box”. Most participants demonstrated a reaction time of close to the 0.70 second average, plus or minus a small standard deviation. (ECMC’s acceptance standard is < 0.75 seconds). SDSS-06 displayed a 0.80 second reaction time, and the evaluator noted that this participant “required cueing to go faster”. The next column presents results from the Trail Making B exam. Results here had quite a wide scatter, with min/max times of 46 and 130 seconds, respectively. Acceptance criteria for this exam vary greatly in the literature; (Stutts et al., 1996) suggests normal times of between 80 and 110 seconds, varying with age. Accordingly, few of the times observed in this study were worthy of concern; perhaps only SDSS-05 and SDSS-08 exhibited performance that was on the high side of normal. The next column, “Vehicle”, represents performance scores inside the vehicle. Note again that the same score sheet was used for the Simulator (results seen in column 3). In the vehicle, drivers were measured as almost perfect, with only one demerit denoted for any of the drivers (SDSS-08).

The final column is the overall program rating, as scored after the UB portion of the exam, but before the ECMC segment. On the whole, our drivers seemed to like the program (with some variance). All drivers noted the value and potential for using simulators as a driver evaluation tool, but many made note of the weaknesses that need to be overcome for simulators to be used most effectively. All participants complained about the brake pedal not feeling “like their own”, and being too touchy. Most participants would stop long before an intersection, and required some time/practice to get a feel for when to apply braking force, and how much to apply. Numerous participants also struggled with turning in our multi-screen, wide field-of-view environment. The viewpoint transition appeared to confuse and disorient many of our participants. It should be noted that based on evaluator observations, both of these anomalies contributed (with some significance) to the simulator sickness effects that were noted.

The UB evaluator, based primarily upon performance observations in the simulator, "passed" all drivers. As seen when comparing the third and seventh columns of Table 2, performance scores observed were not as good as they were for performance observed inside the actual vehicle. The evaluator finally noted that participants SDSS-03, SDSS-06, and SDSS-08 were passed "with some reservation", as based solely on their respective simulator performances. ECMC evaluators had generally positive things to say about the entire cohort. All drivers "passed" their portion of the exam. The only restriction issued was a "day time only" restriction for SDSS-06, due primarily to poor performance on a number of vision tests (whose results are not summarized here.)

Conclusions

It is normal for our driving abilities to change with age. Both by reducing risk factors and by incorporating safer driving practices, many can continue driving safely long beyond age 65. We must, however, pay attention to any age-related warning signs that interfere with our driving safety, and make appropriate adjustments. To this end, a driving simulator has the potential to be a useful performance evaluation mechanism.

The primary purpose of this Pilot Study has been to examine the feasibility of using a driving simulator as a supplemental evaluation mechanism for senior driver evaluation. At present, in-clinic and in-vehicle evaluations are performed customarily, but there are no standardized metrics in place to concretely determine driving performance for those persons aged 65 and over. Anecdotally, this study cohort was useful for the ECMC evaluators to formalize, establish and put to practice a performance evaluation "system", and place some measures on in-clinic items that have been historically quantified by "feel". Our research team was curious to observe if a driver's performance in the simulator (based on both quantified and observed metrics) would confirm (or deny) that of the clinic/vehicle evaluation. Although there were numerous elements of the simulator that demand improvement, this study cohort did inform recommendations for making the simulator more successful in the future. As an example, much can be learned about senior driving behaviors while driving in a straight path at a relatively constant speed. Such would minimize the need for braking behavior and multi-screen turning – two areas that induced numerous participant complaints and seemed to induce simulator sickness symptoms.

Moving forward, we expect that with a larger and more cognitively diverse study population, the data collected will indicate that current driving evaluation protocols, alone, are not sufficient – particularly for older drivers with suspected or known cognitive impairment. Further, such a study could confirm our hypothesis that drivers with dementia will exhibit a marked decrease in simulator performance in defined challenge scenarios when not provided ample and explicit navigation cues. As such, a driving simulator can serve as a meaningful, repeatable, safe, and cost-effective tertiary evaluation mechanism for drivers within this demographic.

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References

Adler, G., Rottunda, S., and Dysken, M., (2005). "The older driver with dementia: An updated literature review". *Journal of Safety Research* 36 (2005) 399 – 407.

Bowie, C., and Harvey, P., (2006). "Administration and interpretation of the Trail Making Test", *Nature Protocols* 1, 2277 – 2281.

Classen, S., Winter, S., & Lopez, E.D.S. (2009). "Meta-synthesis of qualitative studies on older driver safety and mobility". *The Occupational Therapy Journal of Research: Occupation, Participation and Health*, 29(1), 24-31.

Federal Highway Administration (FHWA), (2010). "Highway Statistics 2010", (web link), http://www.fhwa.dot.gov/policyinformation/statistics/2010/dv1c.cfm.

Folstein, M.F., Folstein, S.E., and McHugh, P.R., (1975). "Mini-mental state. A practical method for grading the cognitive state of patients for the clinician", *Journal of Psychiatric Research*, 12 (3): 189–98. doi:10.1016/0022-3956(75)90026-6.

Gianaros, P.J., Muth, E.R., Mordkoff, J.T., Levine, M.E., and Stern, R.M., (2001). "A Questionnaire for the Assessment of the Multiple Dimensions of Motion Sickness", *Aviat Space Environ Med*, February; 72(2): 115–119.

Insurance Institute for Highway Safety (IIHS), (2007). "Fatality Facts – 2007 – Older People", (web link), http://www.iihs.org/research/fatality_facts_2007/olderpeople.html.

Justiss, M.D., et al., (2006). "Development of a behind-the-wheel driving performance assessment for older adults". *Topics in Geriatric Rehabilitation*, 22(2): 121-128.

King, J., (2009). "Driving Simulator Aids Accident Victims", Chicago Tribune (web link), http://www.chicagotribune.com/classified/automotive/chi-rides-simulator-0315mar15,0,6251527.story, March 15, 2009.

McGehee, D.V., Lee, J.D., Rizzo, M., Dawson, J., and Bateman, K., (2004). "Quantitative analysis of steering adaptation on a high performance fixed-base driving simulator", *Transportation Research Part F: Traffic Psychology and Behavior*, Vol. 7, No. 3, 181-196.

Nasreddine, Z. et al., (2005). "The Montreal Cognitive Assessment (MoCA): A Brief Screening Tool for Mild Cognitive Impairment". *J. of the American Geriatrics Society*, 53:695-699.

Osterman, C. (ed.), (2009). "Dementia Toll Shocking – Over 35 Million Plagued Globally". Health News, (web link), http://www.postchronicle.com/cgi-bin/artman/exec/view.cgi?archive=161&num=257188, September 22, 2009.

Parnell, M. et al., (2007). "On the Road to Safety: Standardizing the RT-2S Brake Reaction Time Tester", ROADI, East Carolina University, (slide show web link), http://www.ecu.edu/cs-dhs/ot/upload/AOTA_Brake_Reaction_Poster.pdf

Prince, M., and Jackson, J. (ed.), (2009). "Alzheimer's Disease International - World Alzheimer's Report 2009", (web link), http://www.alz.co.uk/research/worldreport/.

Reimer, B., Mehler, B., Pohlmeyer, A., Coughlin, J., and Dusek, J., (2006). "The use of heart rate in a driving simulator as an indicator of age-related differences in driver workload". *Advances in Transportation Studies - an International Journal*, Special issue, pp.9-20.

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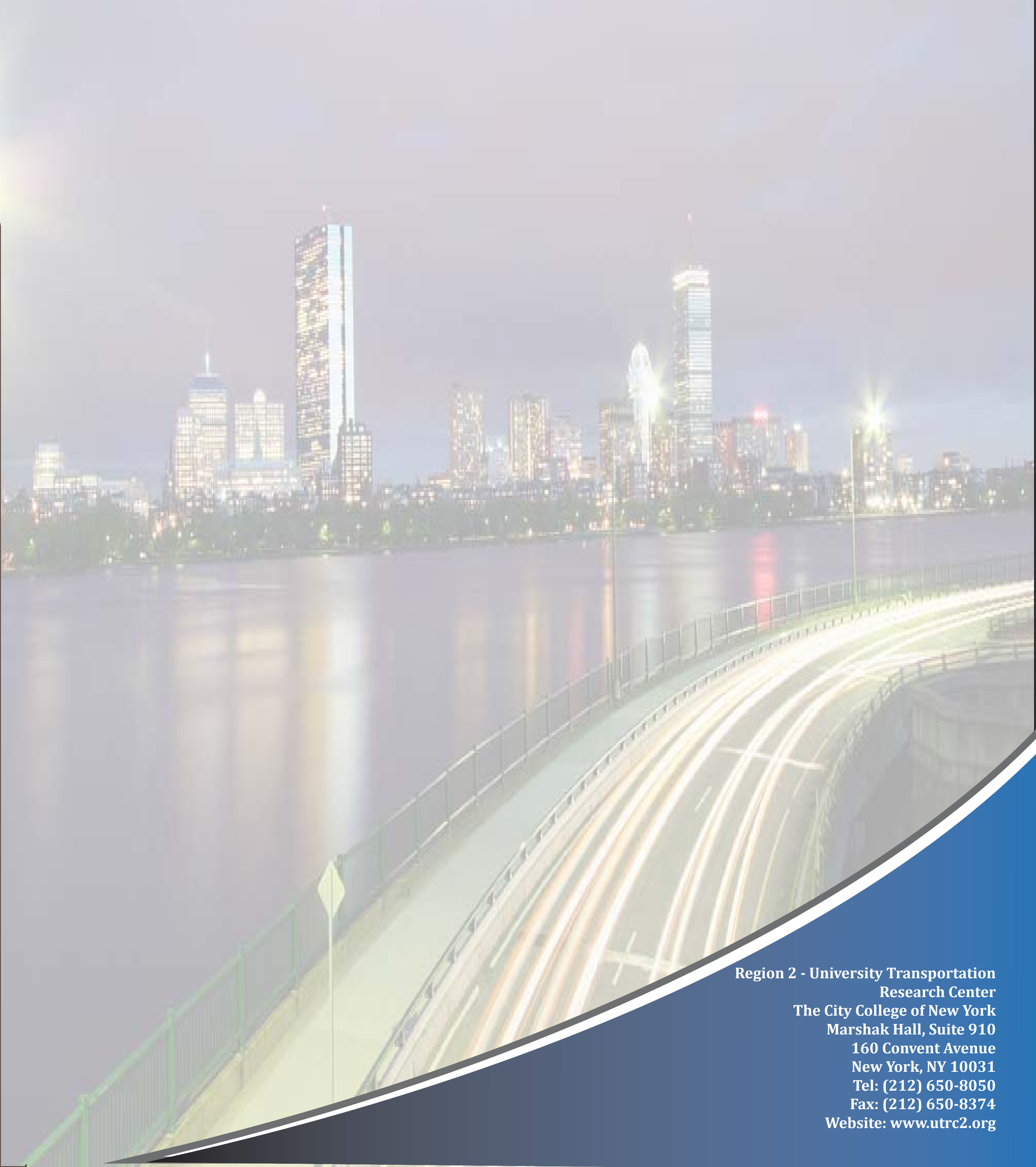

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