OHIO TRANSPORTATION CONSORTIUM

Annual Report
2010-2011

www.otc.uakron.edu

Director's Message

While research remains to be an important area of focus for the Ohio Transportation Consortium (OTC), we continued to strive for balance between research and education and workforce development. OTC is participated by eight institutions of higher education and the influence of its activities in the above focus areas can reach out to a broad base of approximately 200,000 students. Education at grassroots level and developing and training qualified next generation of work force in transportation is critical to the sustainability of the nation's transportation system; it is so timely needed to support the economic growth and job creation in the country. Our research activities continued to target on practical problems in the planning, operation, and maintenance process of transportation infrastructure for improved safety, efficiency, and economic and environmental sustainability. Our collaborations with state and local transportation agencies as well as the private industry have generated enriching synergy effect from different engineering and science fields, with an emerging focus to enhance education and promote research and development in alternative and green transportation energy for the region's economic competitiveness. We look forward to future challenges and opportunities in today's political and financial uncertainties.

Ping Yi
Director, OTC

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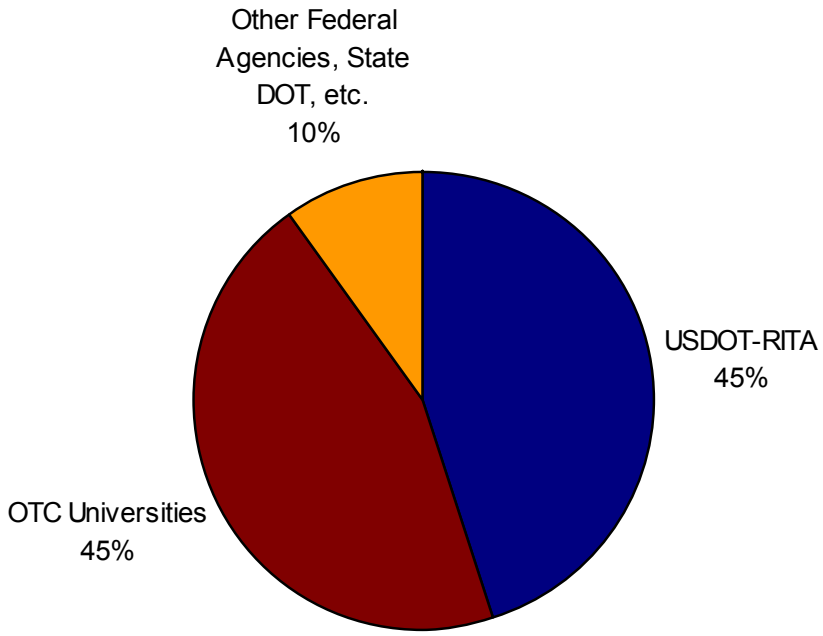
Central State University

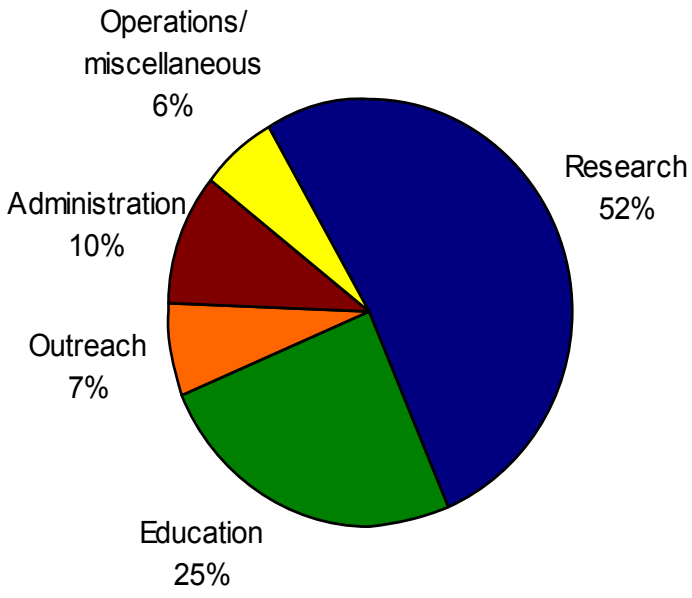
Dr. Heng Wei
Assistant Professor, Transportation Systems and Engineering, Department of Civil & Environmental Engineering
University of Cincinnati

Dr. David Zeng
Frank H. Neff Chair, Professor & Chairman, Civil Engineering
Case Western Reserve University

Funding Sources



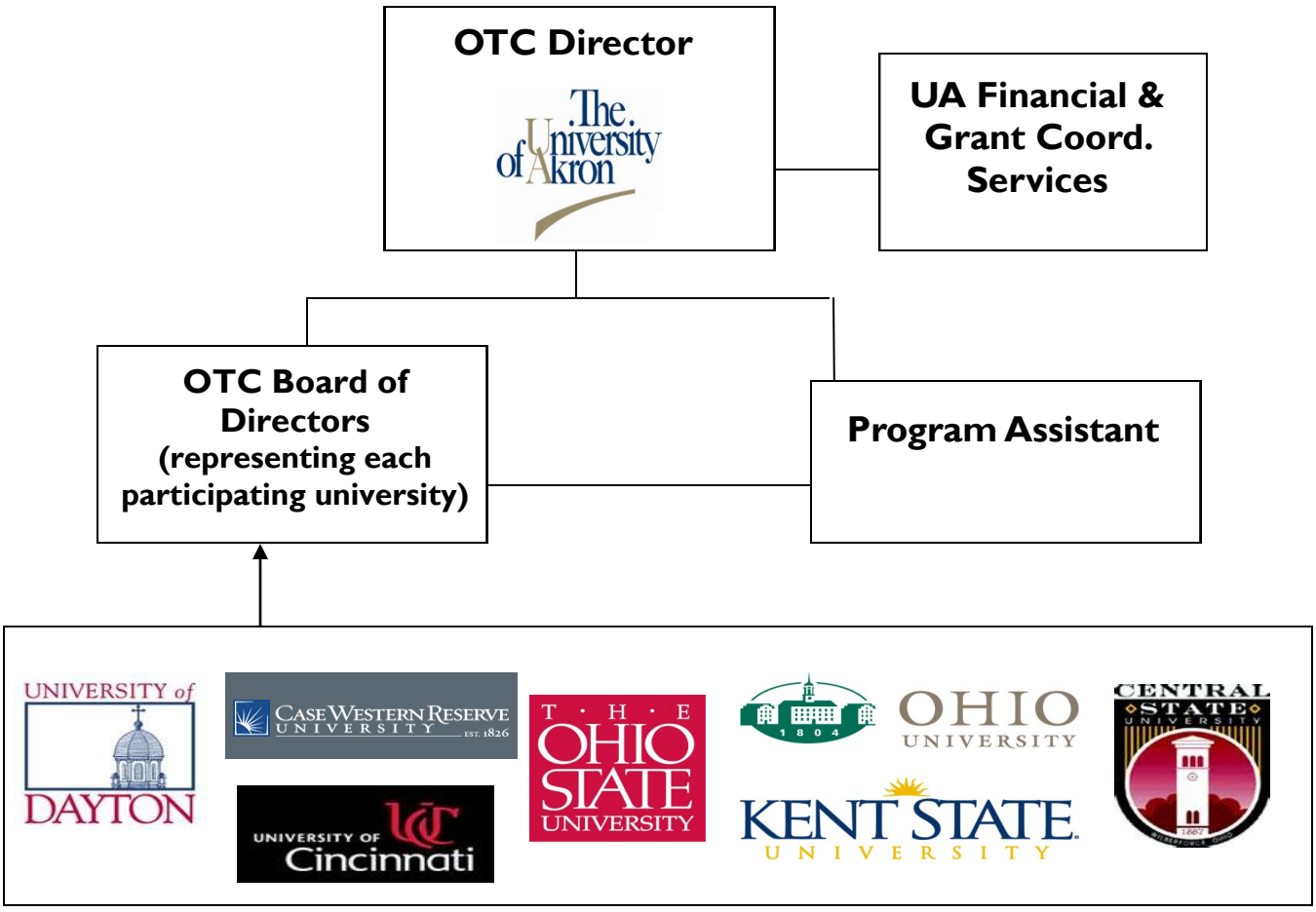
Expenditures



About the OTC

The OTC is a Tier II University Transportation Center operating under the theme of *Transportation Mobility and Infrastructure Management*. Recently, the OTC has focused its research on "Sustainable and Green" transportation and infrastructure. In doing so, we have been able to utilize the knowledge and expertise of our OTC partner universities while aligning our goals with the needs of our surrounding communities and the state of Ohio as a whole.

OTC Organizational Flow Chart



New and Updated Transportation Courses at OTC Universities

Pavement Analysis and Design

Case Western Reserve University is offering a new undergraduate course in Pavement Analysis and Design. This course offers instruction in analysis and design of rigid and flexible airfield and highway pavements as well as pavement evaluation and rehabilitations and overlay design.

Traffic Signal Design and *Computer Methods in Transportation*

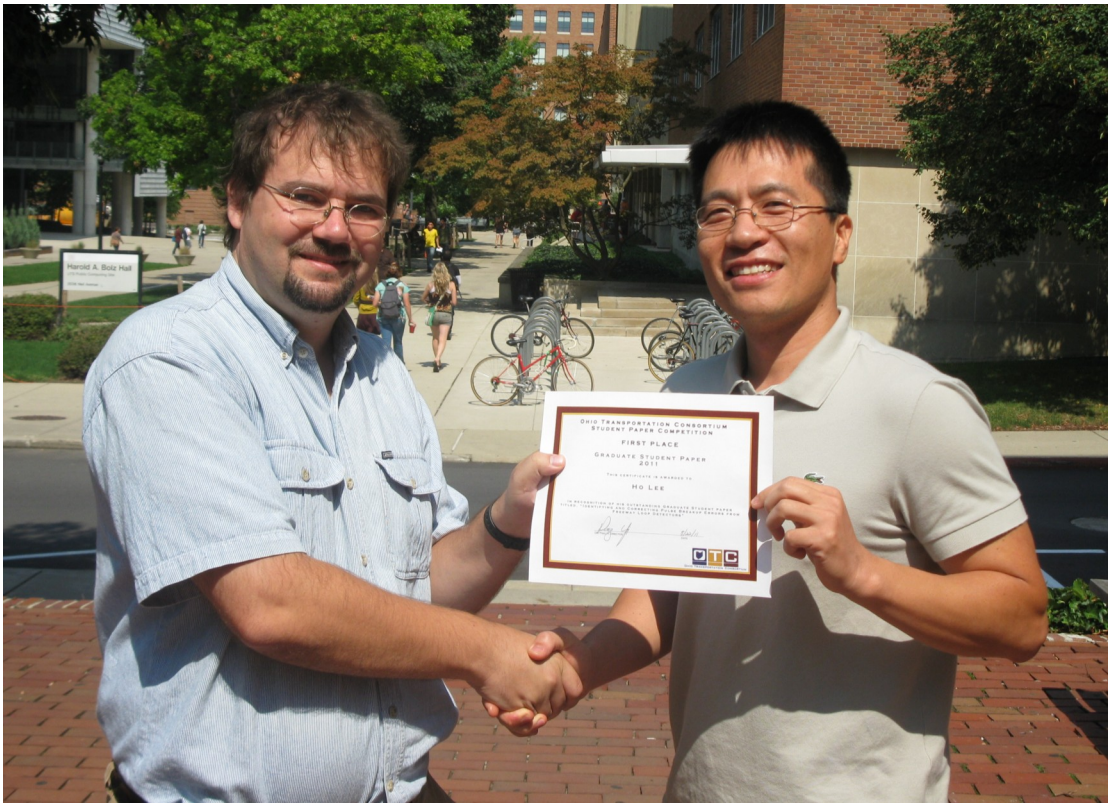
The University of Cincinnati has updated two of their graduate courses in traffic engineering to incorporate OTC research. The issue of yellow light dilemma is always regarded as a major cause of right angle and rear end accidents at high speed signalized intersections. The concept of signal dilemma zone along with its mathematical model, the GHM model, has been applied in the handbooks of the Institute of Transportation Engineers for determining the safe yellow change interval. To date, however, there are no textbooks that cover the dilemma zone problems. Moreover, the issue in features of yellow light dilemma zone has been raised by researchers for many years. As a result of an OTC funded project, the dynamic characteristics of the signal dilemma zone have been well investigated and quantified using the cost-effective software VEVID and real-world data, and relevant models have been successfully improved based on the form of the GHM mod. Upon completion of the project, the concepts and quantitative features as well as models for estimating the locations and ranges of various types of signal dilemma zones have been adopted as one single section into two graduate courses at the University of Cincinnati. Those courses include: CVE 622 Traffic Signal Design for Fall 2010 and CVE610 Computer Methods in Transportation for Winter 2011.

Introduction of Transportation Engineering

The University of Cincinnati has incorporated the concepts of signal dilemma zone problems into the undergraduate course CVE351 Introduction of Transportation Engineering for Winter and Spring quarters in 2011. This addition is a result of their OTC-funded research on Dynamic Dilemma Zones.

Our Students

Student Paper Competition



Graduate Paper Winner Ho Lee (right) pictured with his advisor Dr. Benjamin Coifman

Each year the OTC sponsors a student paper competition for all OTC participating universities. The contest winner is awarded a cash prize, a certificate, and his/her bio along with a link to the winning paper on the OTC website. Once again, the OTC received a number of submissions spanning a variety of areas of expertise. This year's contest winner was Ho Lee, graduate student from the Ohio State University, for his paper, *Identifying and Correcting Pulse Breakup Errors from Freeway Loop Detectors.*

Mr. Lee is a Ph.D. candidate in the Transportation Engineering program in the Department of Civil and Environmental Engineering and Geodetic Science at the Ohio State University. He is now under the supervision of Dr. Benjamin Coifman. His research interests include intelligent transportation systems and application of advanced technologies to transportation.

He received his B.S in Transportation Engineering (2000) and M.S in Transportation Planning (2002) from Hanyang University in South Korea. After receiving a master's degree, he worked as a research

associate in the Korea Railroad Research Institute, South Korea. His major responsibility was the economic feasibility analysis of investing in light-rail transit as well as the analysis of the financing needs. In addition, he was involved in developing new travel demand models to evaluate the impacts of alternative transportation investments. In 2007, he graduated from the Ohio State University with a second M.S in Transportation Engineering. He has been involved with research projects using traffic surveillance systems (e.g., loop detectors and RTMS). The research focused on improving the quality of archived data in existing systems and extracting new information from the freeway traffic stream. Presently, he is working on LIDAR (Light Detection and Ranging) based vehicle classification that is a promising alternative to existing classification station. Go to http://www.otc.uakron.edu/docs/PulseBreakup_Paper_OSU_Ho[1].pdf for a complete copy of Ho Lee's winning paper.

Student of the Year

Stephen Busam, graduate student at Ohio University, was selected as the OTC's 2010 Student of the Year. Under the advisement of Dr. Deb McAvoy, Mr. Busam has demonstrated his dedication to transportation engineering both in and out of the classroom. His high academic marks earned him membership into Tau Beta Pi, the National Honor Society for Engineers, and Chi Epsilon, the National Honor Society for Civil Engineers, where he served as treasurer for two academic years. He also served as the Vice President for the Institute of Transportation Engineers student chapter since 2009.

Mr. Busam has led multiple projects in terms of data collection efforts and analysis as a research graduate student. He has co-authored two papers as well as a report for the OTC which he presented at both the 2010 Ohio UTC Student Research Conference and the Ohio University Student Research and Creativity Expo where he earned first place for his presentation. He has assisted in the preparation of various research proposals and is sure to make a positive impact in his career as a Transportation Engineer.

Our Students

OTC Hosts Ohio UTC Student Research Conference

The OTC hosted the Ohio UTC Student Research Conference in collaboration with Youngstown State University's Center for Transportation and Materials Engineering, University of Toledo's Intermodal Transportation Institute & University Transportation Center and Cleveland State University's University Transportation Center. The UTC-related research efforts of students representing the Ohio UTCs were highlighted, allowing them to share their results with the local engineering community, academians, and local leaders. OTC students were involved in twelve of the presentations ranging from (environmentally friendly topics such as a campus-wide bicycle sharing program and a Solar Car Project Team to safety issues involving dynamic dilemma zones and work zone drums to datamining and traffic data collection utilizing advanced mobile technology.

OTC student Zhixia Li, University of Cincinnati, was one of three winners chosen for a "Best in Conference" for his presentation on *Dynamic Dilemma Zone at Signalized Inersections: Safety Issue and Solutions*. Other winners were the Solar Car Team from the University of Toledo and Amar Shukla, Youngstown State University for his presentation on *Causes of Bumps at Pavement-Bridge Interface*. The complete list of OTC

participants and their presentation titles is listed below.

For a review of the 2010 Ohio UTC Student Research Conference abstract summaries, please go to http://www.otc.uakron.edu/docs/2010%20OH%20UTC%20Student%20Presentation%20Summaries%20final.pdf

OTC Student Presentations at Ohio UTC Student Conference

An Innovative Method for Soil Water Characteristic Curve Measurement with a Thermo-TDR Sensor, Zhen Liu, Case Western Reserve University

Bicycle-Sharing in a College Environment, Megan Petroski, Kent State University

Comparison of Advance Dilemma Zone Protection Algorithms, Sai Geetha. K, The University of Akron

Coupled Thermo-hydro-mechanical Model for Pavement Under Frost Action, Zhen Liu, Case Western Reserve University

Dynamic Dilemma Zone at Signalized Intersections: Safety Issue and Solutions, Zhixia Li, University of Cincinnati

Effects of Left-Side Ramps on Crash Frequency on Urban Freeway Segments, Aline Aylo and Worku Mergia, University of Dayton

Enabling Dual Loops to Accurately Estimate Vehicle Speed and Length under Congestion, Qingyi Ai, University of Cincinnati

Estimating On-Road Mobile Source Pollution in Ohio, Andre Morton, Central State University

Evaluating Traffic Safety Behaviors of College Students, Sowjanya Ponnada, University of Dayton

Safety Evaluation of Diamond-Grade vs. High-Intensity Sheeting for Work Zone Drums, Stephen Busam, Ohio University

Traffic Data Collection Using Multi-Touch Technology on Mobile Device, Yunke Du and Yikun Wang, The University of Akron

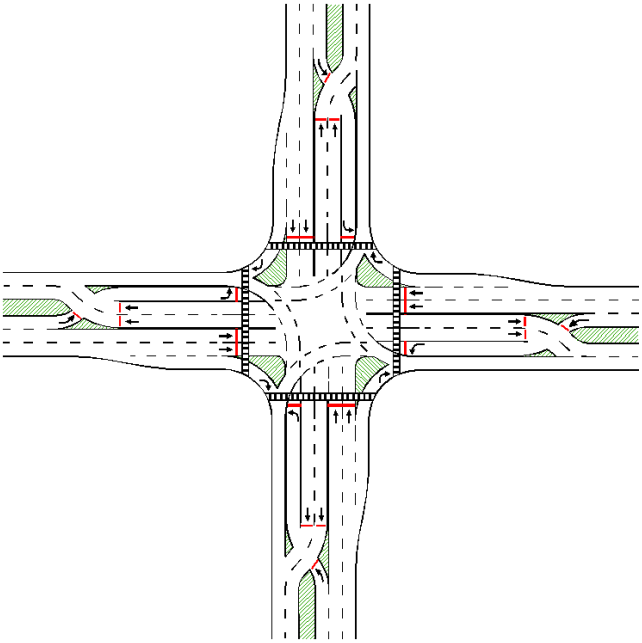
Using Datamining in Classifications of Traffic Counting Locations: A Case Study in Ohio, John Davenport, Central State University

Research

Maximizing Intersection Capacity and Improving Pedestrian Safety Through Unconventional Geometric Design

Angela Coates, Sai Geetha Koganti, Yunke Du and Srivaitaran Mothukuri, Graduate Students, University of Akron, Civil Engineering

Typical four-phase, four-legged intersections often operate inefficiently, severely restricting vehicle throughput and resulting in large delays. These configurations are limited by the traditional geometric design, and by altering the geometry of the entire intersection, the capacity can be significantly increased. Two phase intersections (2-PI) utilize an unconventional lane arrangement in order to maximize the vehicular throughput. This arrangement involves displacing left turn lanes across opposing through traffic before the main intersection is reached. Such an alteration allows left and through vehicles to proceed simultaneously, and consequently, only two signal phases are required. Numerous studies have validated the operational improvements associated with such a geometric design, but our efforts have focused on further enhancement both in terms of safety as well as efficiency. We have proposed a split 2-PI operation, increasing pedestrian safety by designating time intervals for pedestrians crossing. In addition, we have conducted an in-depth system analysis of the split 2-PI configuration (pictured below) in order to maximize the benefits of this unconventional geometry. Previous studies have given very limited effort to the system optimization for capacity enhancement and reducing delay. By formulating a system of equations to represent this configuration during optimization, we used the objective function of maximizing throughput for congested flows and minimizing delay for less congested flows. After defining the main objective functions and a list of constraints, preliminary tests were performed to show the effectiveness of the method adapting to changes in traffic demand. Then, the results found from the optimization were used to run simulation tests comparing the capacity and delay at a split 2-PI to those from a conventional four-legged geometric design. The results of our trials thus far have strongly showed the optimum



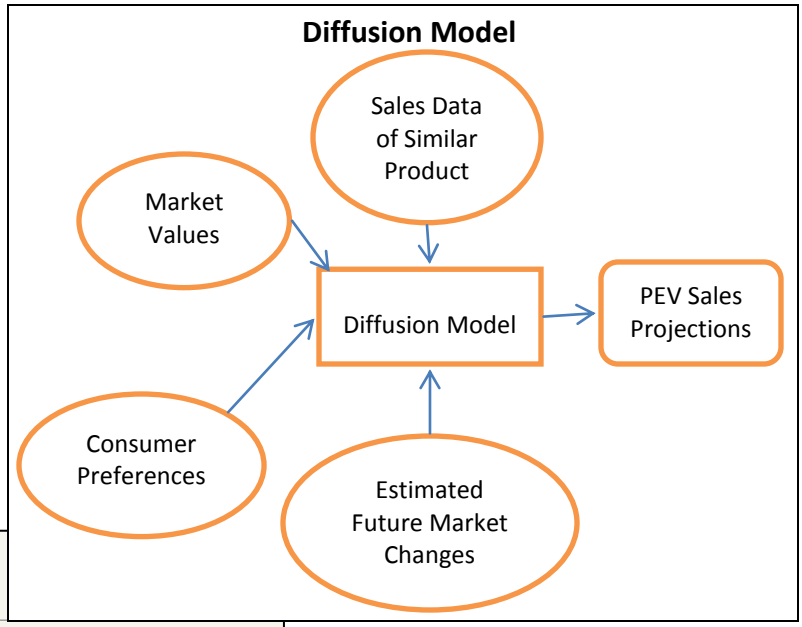
Split Two Phase Intersection Geometry

performance of the proposed unconventional geometric arrangement. Future work will include the investigation of an approach-based methodology utilizing adaptive signal control.

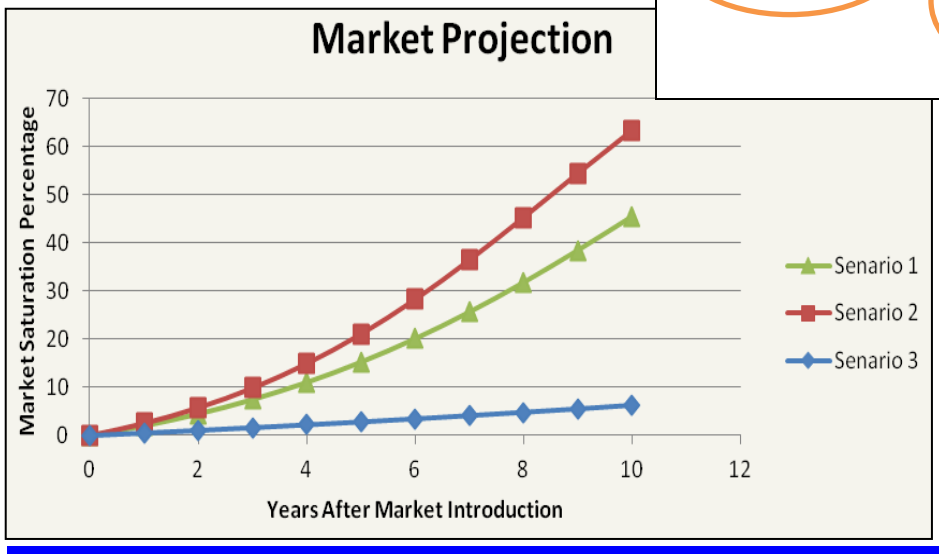
A Diffusion Model to Study the Greater PEV Market

Aaron Cordill, Graduate Student, University of Akron, Civil Engineering

As support for Plug In Electric Vehicles (PEVs) grows, the question as to how well these vehicles will do in the consumer market has been raised. The answer is critical for several reasons: determining the number of required charging stations, projections of the economic and environmental benefits, and guidance for government policy development. Previous models failed to account for the consumer and market side issues and the interaction between the two. A diffusion model has been proposed to address these issues.



The proposed model addresses the consumer aspect of the market by examining values that factor into a consumer's decision to purchase a PEV such as vehicle cost, fuel cost, etc. The market aspect is investigated to examine the effects of how well those values are fulfilled based on variable market conditions. In order to project long-term stability, both early and late adoption consumers are accounted for in the model. Methodology that mimics the interaction from both consumer and market aspects based on hybrid sales data was integrated. Three market scenarios are proposed to simulate the effects of changes in the marketplace.



Preparing Infrastructure and Consumers for Plug-in Electric Vehicle Adoption

*November 2011 "UTC Spotlight Newsletter" article

Ping Yi, Professor, University of Akron; Aaron Cordill, Graduate Student, University of Akron and Yudhveer Kandukuri, Graduate Student, University of Akron

As the United States races to put 1 million plug-in electric vehicles (PEVs) on the road by 2015, several questions remain unanswered. Where will these vehicles be charged? Can our electrical grid handle the increase in demand? How will these vehicles impact the economy? Partnered with FirstEnergy, Akron Metropolitan Area Transportation Study (AMATS), NorTech, and others, the University of Akron's (UA) PEV Rollout Coalition is searching for answers to these questions and more. Yi's *Plug-in Electric Vehicle (PEV) Readiness* study is evaluating market growth and the economic impact of PEVs, green transportation, and energy (including "smart grid" and battery technology), and the best charging station locations.

FirstEnergy is working with the UA Coalition and others to create a microgrid testing facility to evaluate the potential grid impacts that large adoption of PEV technology would pose to Ohio's electric infrastructure. UA, FirstEnergy, and the Electric Power Research Institute (EPRI) are investigating the best approaches to developing "smart charging" technologies that will minimize the impact of PEVs on the electrical power grid during peak usage (figure 1).

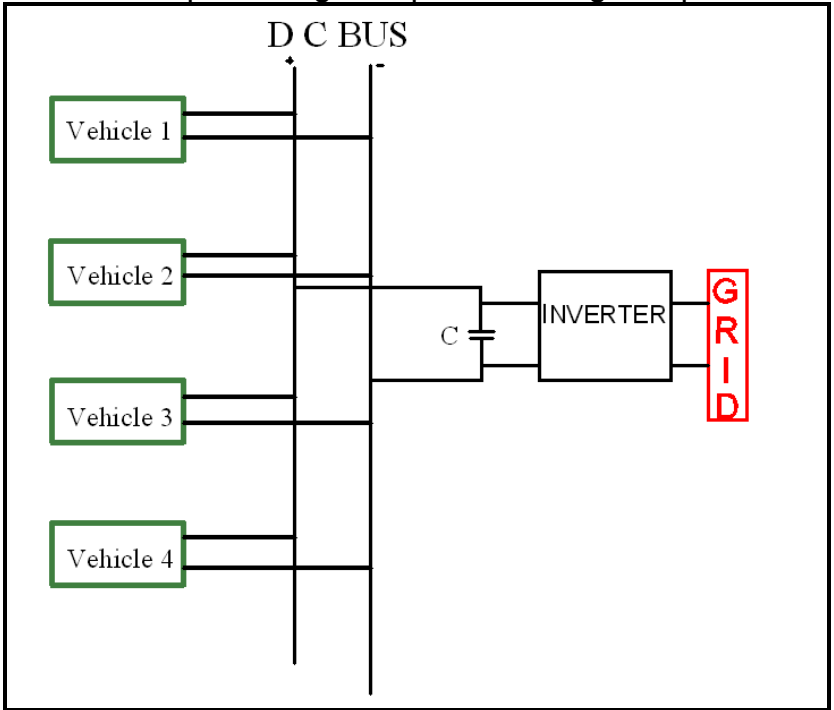


Fig. 1: PEV Impact on Electrical Grid

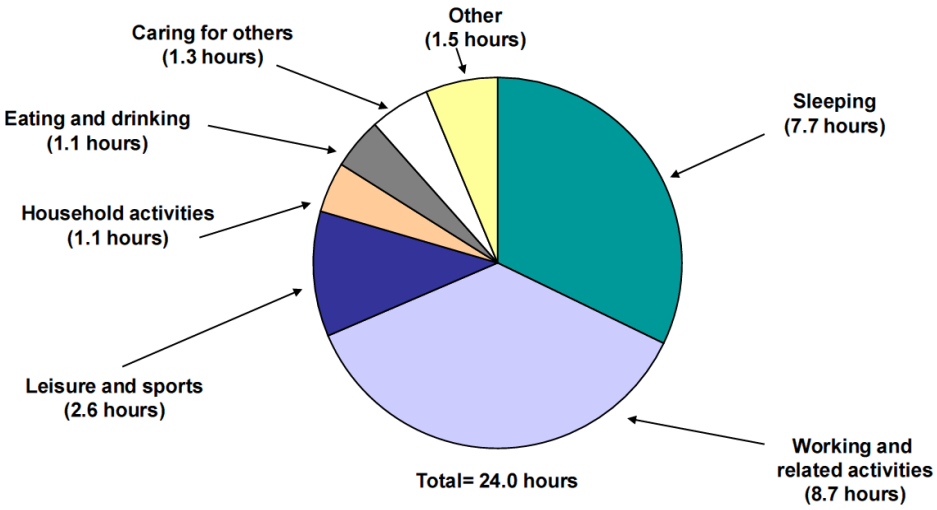
Charging Levels

The power demand for Level I charging is 110–120 volts and 16 Amps with a recharge time of approximately 8–10 hours; this is ideal for home charging. Level II charging

requires 240 volts and 30 amps. This increase in power demand leads to a decrease in charging time (4–8 hours). Level II charging can be used either at home or in locations where people spend a substantial amount of time, such as parking lots near work places. Level III, or direct charge, helps consumers maintain their busy schedule by recharging a depleted battery in roughly 15–30 minutes. This level consumes 480 volts and 125 amps of power. Ideal locations for level III stations include shopping malls, department stores, and restaurants where people spend a relatively short amount of time.

PEVs generally can travel approximately 40–100 miles per charge, as opposed to 300–400 miles per fill-up for conventional gasoline vehicles. Thus to make PEVs practicable, easy and convenient recharging must be ensured, and the deployment of recharging stations must encourage adoption of PEVs and support fast market growth. Dr. Yi's research team is preparing and testing a methodology that maps charging station installation using a layered intersection of demographic and transportation data that may be applicable to all U.S. urban areas.

Using the U.S. Bureau of Labor Statistics information (figure 2), a facility location model was developed to identify charging station locations that would best serve recharging needs. Land-use data was used to identify work-related activities and parking needs for level II charging stations. In addition to land-use data, roadway network and traffic data were also used to determine locations for level III charging stations. The objective of the maximization in the model is to increase the utilities for users while addressing the constraints of geographic coverage of PEV demand, power grid capacity, and available budget (figure 3). In order for a full-scale adoption of PEVs to occur, PEV education



NOTE: Data include employed persons on days they worked, ages 25 to 54, who lived in households with children under 18. Data include non-holiday weekdays and are annual averages for 2009.

SOURCE: Bureau of Labor Statistics, US

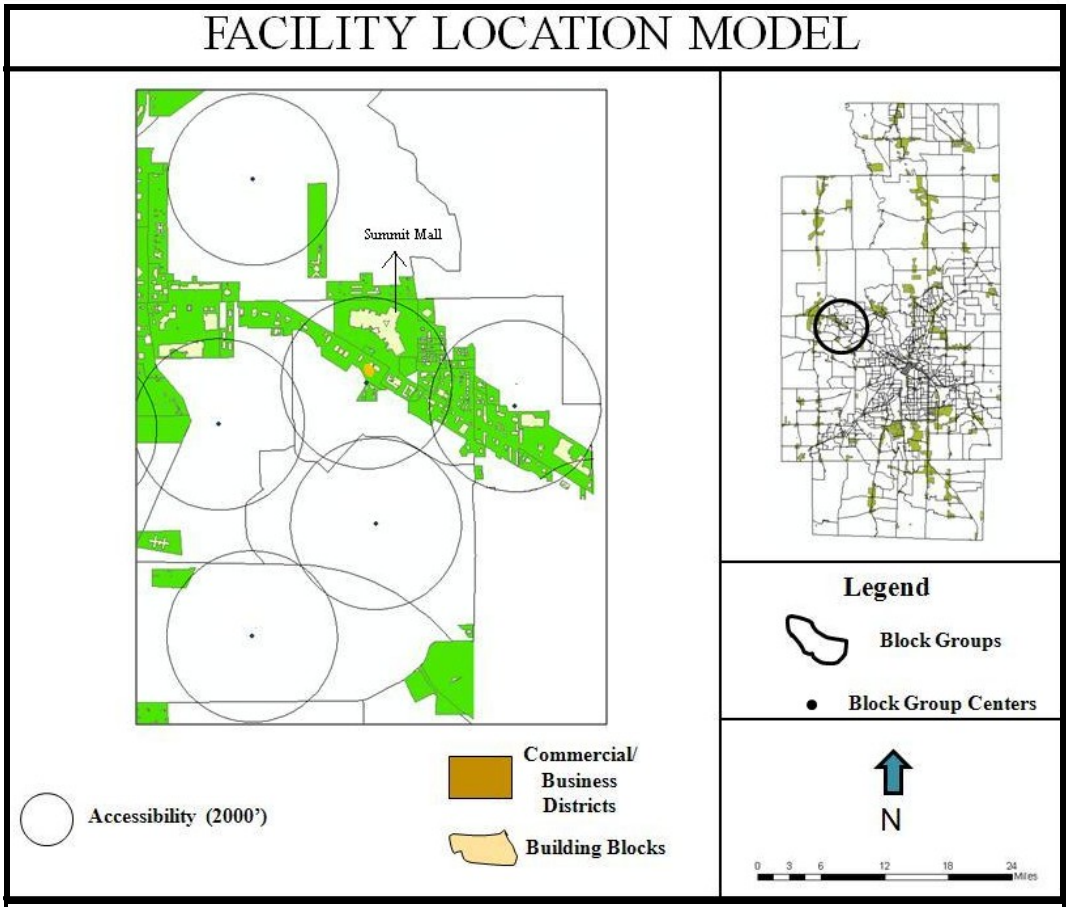
Fig. 2: Average Time Spent by Americans on Primary Activities

*"**PEV**" continued on page 14*

*"**PEV**" continued from page 13*

must be provided to future consumers. UA is collaborating with a number of area schools and colleges to develop such curriculums. In 2010, UA, Lorain County Community College, and Stark State College entered into an unprecedented alliance that will accelerate educational efficiency by combining the resources of a number of community colleges with a research university. This consortium offers an opportunity to share curriculums for electric automobile safety training, which will speed deployment. Safety training (fire, police), which is currently offered in community colleges, will play an important role in PEV-readiness needs in the region.

Additionally, a hybrid-electric, 12-seat, handicap-accessible bus is being purchased through the assistance of EPRI as a UA "Roo Express" university shuttle in collaboration with The City of Akron and FirstEnergy, each of which will use it for various shuttle purposes. Plans are to download energy usage data and savings for curriculum use in the Akron Public Schools middle schools. These students, who will reach driving age at about the same time electric vehicles are projected to be widely available, will learn about electric power generation, energy conservation, and environmental sustainability.



Source: The University of Akron

FIGURE 3: Global Information System (GIS) Based Potential Charging Station Location Map Showing Block Groups and Centroids

Publications

Research Papers

Bakula, C. , Schneider IV, W., Roth, J. (2011). "A Probabilistic Model Based on the Effective Range and Vehicle Speed to Determine Bluetooth MAC Address Matches from Roadside Traffic Monitoring." *Accepted ASCE Journal of Transportation Engineering.*

Farzaneh, M., Schneider IV, W., Zietsman, J. (2010). "A Field Evaluation of CO_2 Emissions at High Speeds." *Journal of the Transportation research Record,* No. 2191.

ICCTP: Critical Issues in Transportation System Planning, Development, and Management. (2009). P. Yi, ed., ASCE Publishing, Washington DC.

ICLEM 2010. (2010). *Logistic Engineering and Management*, P. Yi, ed., ASCE Publishing, Washington DC.

Wang, B., Yi, P. (corresponding) (2010). "Enhance Traffic Safety at High-Speed Intersections Through Vehicle Tracking.", *ICCTP-ASCE*, August.

ICTIS 2011. (2011). *Multimodal Approach to Sustained Transportation Development – Information, Technology, Implementation*, P. Yi, ed., ASCE Publishing, Washington DC.

Moore, D., Schneider IV, W., Savolainen, P., Farzaneh, M. (2011). "Mixed Logit Analysis of Bicyclist Injury Severity Resulting from Motor Vehicle Crashes at intersection and non-Intersection Locations." *Accident analysis and Prevention*, Vol.43, Issue 3.

Scneider IV, W., Savolainen, P. (2011). "Comparision of Motorcyclist Injury Severity among Various Crash Types." *Journal of the Transportation research Record,* accepted for publication, February.

Schneider IV, W., Savolainen, P., Moore D. (2010). "Examining the Effects of Horizontal Curvature on single – Vehicle Motorcycle Crashes along rural Two-lane Highways." *Journal of the Transportation research Record,* No. 2194.

Shao, C., Yi, P. (corresponding), Alhomidan, A. (2010). "High and Low Deer-Vehicle Collision Roadway Sections - What Makes Them Different?" *The Open Transportation Journal*, Vol. 4, 87-94.

Tsapakis, I., Schneider IV, W. (2011). "Discriminant Analysis for Assigning Short-term Counts to Seasonal Adjustment Factor Groupings." *Journal of the Transportation research Record,* accepted for publication, February.

Tsapakis, I., Schneider IV, W., Nichols, A. (2011). "Improving the Estimation of Total and Directional Based Heavy-duty Annual Average Daily Traffic (AADT)." *Transportation Planning and Technology*, Vol.34, No.2.

Van Boxel, D., Schneider IV, W., Bakula, C. (2011). "Innovative Real-Time Methodology for Detecting Travel Time Outliers on Freeways and Urban Arterials." *Journal of the Transportation Research Record*, accepted for publication, February.

Outstanding Accomplishments (continued)

Yi, P. (2011). "Application of IntelliDrive Information System to Enhance High-Speed Intersection Safety", *Journal of Transportation Research Board,* No. 2215, pp105-112.

Yi, P., et al. (2009). "Investigating the Effect of Detector Spacing on Midpoint Based Travel Time Estimation", *Journal of Intelligent Transportation Systems*, 13(03) pp 149-159.

Yi, P., et al. (2009). "Investigation of Peak Hour Variations--Preliminary Field Studies", *Journal of Transportation Research Board*, No. 2130.

Zhang, Y., Yi, P. (corresponding), et. al. (2010). "Modeling Network Impact in Area Surrounding Activity Center Due to Special Events", *Journal of Transportation Research Board,* No. 2183, pp77-84.

Project Reports

Kandiah, R. (2010). "On-Road Mobile Source Pollutant Emissions: Identifying Hotspots and Ranking Roads."

Kaplan, D. H. (2010). "Linking Sustainable Transportation in a University Community."

McAvoy, D. S. (2011). "Work Zone Speed Reduction Utilizing Dynamic Speed Signs."

Sargand, S. (2011). "Feasibility of Using Cone Penetrometer Truck (CPT) to Install Time Domain Reflectometry (TDR) and Fiber Optic Slope Failure Detectors in Pavement Structures."

Wei, H., Yi, P., Eustace, D. (2011). "Optimal Loop Placement and Models for Length-based Vehicle Classification and Stop-and-Go Traffic."

Zeng, X. (2010). Developing an Economical and Reliable Test for Measuring the Resilient Modulus Poisson's Ratio of Subgrade."

Pan, E., Sangghaleh, A., Zhao, Y., Wang R., Yi, P. (2011). "An Efficient and Accurate Genetic Algorithm for Backcalculation of Flexible Pavement Layer Moduli." ODOT.

Presentations

Abbas, A. (2011) "Improved Characterization of Truck Traffic Volumes and Axle Loads for Mechanistic Empirical Pavement Design.", Presented to Ohio Department of Transportation, October 2011.

Pan, E., Wang, R., Sangghaleh, A., Green, R. (2011) "Back-calculation of Multi-layered Pavement Properties Using GA Method.", Presented to US National Congress on Computational Mechanics –11, Minnesota, July 2011.

Ping Yi (2011), "Application of IntelliDrive Information System to Enhance High-Speed Intersection Safety", presented at the 2011TRB Annual Meeting, Washington DC

Heng Wei, et al.(2011), "Quantifying Dynamic Factors Contributing to Dilemma Zone at High-Speed Signalized Intersections", presented at the 2011 TRB Annual Meeting, Washington DC

Qingyi Ai, et al.(2011), "Length-Based Vehicle Classification Models Using Dual-Loop Data Against Stop-and-Go Traffic Flow", presented at the 2011 TRB Annual Meeting, Washington DC