



**A USDOT NATIONAL  
UNIVERSITY TRANSPORTATION CENTER**

**Carnegie Mellon University**



THE OHIO STATE UNIVERSITY



**Program Progress Performance Report  
for University Transportation Centers**

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Office of the Assistant Secretary for Research and Technology  
University Transportation Center Program

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Project Title: Mobility21, A National University Transportation Center for Improving  
Mobility of People and Goods

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Signature:

<b>1. ACCOMPLISHMENTS: What was done? What was learned?</b>
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*What are the major goals of the program?*

The primary goal of Mobility 21, a National University Transportation Center for Improving Mobility is to develop and deploy technologies, policies, incentives and training programs for improving the mobility of people and goods in the 21st century efficiently and safely. We will accomplish this through a comprehensive program of interdisciplinary research; education and workforce development with a focus on diversity; collaboration with university, deployment, and government partners; and technology transfer and leadership efforts.

#### **Research Metrics**

- Faculty scientific leadership as reflected by the number of publications and citations of faculty work in transportation-related areas
- The number of staff, faculty and students involved in leadership positions in academic, industry and government transportation organizations
- New research collaborations in fields related to this work
- Successful technology deployments and their impact
- Patents and start-ups.

#### **Education and Workforce Development Metrics**

- Number of transportation-related courses
- Students participating in transportation research projects
- Advanced degree programs funding Mobility21 UTC students
- Mobility21 UTC-funded graduate students
- Mobility21 UTC-funded students who receive degrees
- Institutional educational partnerships
- Participants in workforce and educational programs.

#### **Technology Transfer Metrics**

- Simple adoption of the innovation by a transportation operator, company or public, to more formalized outcomes such as licensing, patents, commercialization, and spin-off companies
- Quantify numbers of meetings, attendance, publications, and social media and website activity

#### **Collaboration Metrics**

- Number and diversity of members of both the Mobility21 Consortium and Advisory Council
- Number and impact of deployments achieved through collaboration

*What was accomplished under these goals?*

#### **Research**

Twenty-one research projects were active during this report period. In addition to the more traditional research projects, there was an intentional call for projects which would allow research to extend to non-urban areas, the Smart Mobility Challenge. Of the 21 projects, 6 of the projects are targeted to this non-urban thrust which include: Millvale Mobility: Connecting Millvale to the River and the Region, Integration of parking data across mixed-density suburban communities in the Allegheny County municipalities of Mt. Lebanon and Dormont, Video analytics for bike and pedestrian counting in Greensburg and Bethel Park, Building a pilot peer-to-peer platform for ride-sharing in Lawrence County, and Real-time traffic monitoring and prediction for Cranberry Township.

In November 2017, a call for new Mobility21 UTC research proposals was released and in February a set of 15 new projects were peer reviewed and selected for a July 2018 start.

### **Education and Workforce Development**

We view research and education as two sides of the same coin. We cannot educate for future generations without exposing them to research, development and deployment. On the other hand, we cannot do successful research, development and deployment without the input of future generations. Since Traffic21 and the UTCs have emerged on campus it has generated interest among faculty and students, bringing exposure to real-world problems, and engaging faculty and students on multiple projects. As a consequence, courses and class projects are multiplying as well. We have and will focus on education and workforce development in equal and complementary measure to research, development and deployment. Below are some highlights of education and workforce development accomplishments:

March 28, 2018 - UTC Researcher and assistant professor for the Institute for Software Research Fei Fang presented a seminar to Mobility 21 students and faculty on her research, “Integrating Machine Learning with Game Theory for Societal Challenges.” Fang discussed her application, which uses game theory and machine learning-based models and algorithms to inform, predict, and prescribe solutions to those dealing with security and sustainability challenges.

March 26, 2018 - Six teams in the User-Centered Research and Evaluation (UCRE) class presented their concept posters on solutions to the commuting and public transportation challenges for CMU students. Taught at the Human-Computer Interaction Institute, the UCRE class introduces students to the field of human-computer interaction; this year’s topic was on transportation, and what solutions might be needed if Pittsburgh’s transit system cut bus services. Team posters included ideas to subsidize UberPOOL rides, and create enclosed waiting stations with wifi and USB ports.

March 19th, 2018 - Traffic21 Executive Director Chris Hendrickson spoke to a Heinz College class on Public Expenditure Analysis about transportation infrastructure planning and forecasting.

March 2, 2018 – Mobility21 Executive Director Stan Caldwell provided a guest lecture on vehicle automation to a CMU Architecture and Design Studio looking at impact of vehicle automation on urban design.

On January 6, 2018, Mobility21 student, Amanda Johnson of Carnegie Mellon University, won the U.S. DOT’s Outstanding Student of the Year Award. She was recognized for her achievements and accomplishments in the field of transportation at the Council of University Transportation Centers Banquet during the annual meeting of the Transportation Research Board and presented a scholarship award.

Bob Koch from the Community College of Allegheny College and Stan Caldwell from CMU presented at the Penn State Transportation Safety and Engineering Conference on Mobility21 UTC education initiatives to attract new and diverse students to transportation.

Mobility21 researcher and Traffic21 Director Chris Hendrickson presented his research at Odyssey Day in Oakdale, PA. The event was hosted by Pittsburgh Regional Clean Cities and the Community College of Allegheny County. Odyssey day is an annual event that brings together community college students and focuses on leading edge research promoting alternative fuels and advanced technology vehicles. Activities included Ride-n-Drives, vehicles displays of a Chevy BOLT and Chrysler Pacifica, workshops, demonstrations of mobile refueling and electric boom lift, panel discussions and more.

On December 11, 2017 Chris Hendrickson also spoke at a CMU student forum on Workforce and Mobility.

November 3, 2017 - Awardees of the Smart Mobility Challenge, Alexandre Jacquillat, Bernardo R. Pires, and Sean Qian, spoke to CMU students and faculty about how innovative technology can improve mobility. This was the first event of the new Smart Mobility Connection forum, a bi-weekly series to connect faculty and students interested in transportation sponsored by Mobility21. The Smart Mobility Connection continued through the fall and spring semesters and became a popular gathering of faculty and students at Carnegie Mellon who are interested in transportation.

On November 8<sup>th</sup> Stan Caldwell participated in the fourth annual ITS University Workshop sponsored by the US DOT ITS-JPO Professional Capacity Building program to discuss how UTCs can better align ITS education with industry needs. Stan has participated in two previous workshops as well.

March 23, 2018 – Mobility21 Program Manager Lisa Kay Schweyer and a student of Mobility21 Director Raj Rajkumar hosted a table and research poster at a STEM event for high school students at CMU organized by the National Society of Black Engineers.

### **Technology Transfer**

Below are some highlights of technology transfer accomplishments:

As part of the Data-driven Network Models for Analyzing Multi-modal Transportation Systems project three roadway, transit and parking networks were integrated by creating a comprehensive multi-modal network. The multi-modal network model embeds a nested-logit-based modal split model among three transportation modes, the public transit, solo-drivers and carpoolers. It models the choice probabilities for each single user in the network. It also adopts multi-class LWR model to capture the dynamics of mixed vehicles and dynamic queuing on the network. The spatio-temporal multi-modal traffic flow can then be formulated in a Variational Inequality (VI) problem and solved efficiently. This research has been presented to PennDOT, the City of Pittsburgh, the City of Philadelphia, Cranberry Township, McKees Rocks Borough, Pittsburgh Parking Authority and the Port Authority of Allegheny County. The resultant models and tools have great potential to impact the decision making of those public agencies.

The Using Municipal Vehicles as Sensor Platforms to Monitor the Health and Performance of the Traffic Control System project obtained several hours of video clips from The Ohio State University Transportation and Traffic Management, the operators of OSU's Campus Area Bus Service. They first obtained over 80 hours of video clips recorded by the two cameras and semi-manually processed a subset of the clips with the graphical user interface (GUI) previously developed. Based on preliminary trials with the GUI-based processing, the GUI was modified for faster and more accurate identification of vehicles as they pass and for more precise identification of the location of the digitized vehicles in relation to the bus. As a side effect of downloading extensive video clips from buses (substantially more than is typically done in response to incidents), researchers helped TTM identify unreliable cameras that led to the determination of certain camera installation issues that the video camera system provider addressed. In addition to the graduate student working on this project, five undergraduate students have assisted in data processing. Finally, researchers presented the general concept of this research in two offerings of an undergraduate Civil Engineering course that serves as an overview transportation engineering and analysis course in the Civil Engineering program. These two offerings totaled over 200 students.

On March 28<sup>th</sup> Mobility21 faculty member and Traffic21 Director Chris Hendrickson presented Mobility21 research and related spin off companies to the Canadian Consular Transportation Technology Summit held in Pittsburgh. This event was intended to bring together Canadian companies doing business in the US with researchers and companies in Pittsburgh working on smart transportation technology.

Karen Lightman was hired as the first Executive Director of CMU's Metro21: Smart Cities Institute, which is now an umbrella encompassing Traffic21 and Mobility21. Karen has been actively promoting UTC research at major events including the Consumer Electronics Show in Las Vegas on January 9<sup>th</sup> and hosting a CMU booth at the Detroit Auto Show on January 23<sup>rd</sup>.

On November 16, 2017 - Mobility21's Chris Hendrickson spoke at the American Society of Engineers' (ASCE) Annual Sustainability Conference. Chris was joined for a panel on 'Sustainability and Innovation in the Pittsburgh Region' by the City of Pittsburgh's Director of Mobility and Infrastructure Karina Ricks, PennDOT Deputy Secretary of Planning Jim Ritzman, and Michael Baker Senior Vice President Dan Cessna.

### **Collaboration**

At the core of our efforts, is collaboration. An example of collaboration is when Mobility21 Executive Director Stan Caldwell spoke at the Ohio Transportation Engineering Conference in Columbus Ohio. Caldwell participated in a panel on the Smart Belt Coalition, a first-of-its-kind collaboration between transportation and academic partners from Michigan, Ohio, and Pennsylvania that seeks to enhance emerging technologies across state lines.

Mobility21 students and staff have been instrumental in starting and running the Pittsburgh Chapter of the Women's Transportation Seminar. Mobility21 sponsored the March 15<sup>th</sup> Scholarship Gala purchasing a table for UTC students, faculty and community partners.

Mobility21 Director Raj Rajkumar hosted a visit on March 15<sup>th</sup> to CMU from a group from NASA Ames Research Center to discuss UTC research and potential collaboration. Professor Rajkumar also hosted a visit to CMU from Blackberry in October to discuss potential collaboration.

Stan Caldwell, Mobility21 Executive Director, participated in the University of Pittsburgh Annual Transportation Forum on March 14<sup>th</sup> to pursue potential collaboration on transportation research and pilot deployments in Pittsburgh.

Mobility21 Professor Sean Qian made a presentation of his Mobility Data Analytics Center research to various staff of the City of Pittsburgh Department of Mobility and Infrastructure to identify collaborative activities for research pilot deployment in the city.

### *How have the results been disseminated?*

Updates on the projects and results are distributed in Breaking in Smart Transportation, a weekly newsletter that highlights UTC research and efforts in the news as well as industry news. With over 2,100 subscribers (an increase of over 300 people since the last report), and the readership represents a wide range of interests.

Before the updates are sent out in the newsletter, they appear as individual updates/articles on the website, and are also posted through our Facebook and Twitter accounts.

All Mobility21 sponsored seminars are advertised on the website for the general public as well.

### *What do you plan to do during the next reporting period to accomplish the goals?*

- We are currently planning the First Annual Mobility Summit, to be held in April in Washington, DC. The National Mobility Summit will bring together industry, community, workforce, and academic

thought leaders around our country to explore ‘New Frontiers and Opportunities for 21st Century Mobility.’ We look forward to hearing from attendees so we can take back the real-world transportation challenges, technological and policy innovations, successful deployments, and workforce training needs and incorporate that into our center’s work.

- We continue to support our research, development and deployment initiatives, advance research through technology transfer, collaborate with partners and continue our efforts in education and workforce development.

**2. PRODUCTS:** What has the program produced?

***Publications, conference papers, and presentations***

*Journal publications:*

<b>Title</b>	<b>Citation</b>	<b>Type</b>	<b>Date</b>
Understanding and predicting highway travel time with spatio-temporal features of network traffic flow, weather and incidents	Shuguan Yang, Sean Qian. (2018) Understanding and predicting highway travel time with spatio-temporal features of network traffic flow, weather and incidents, submitted to IEEE Intelligent Transportation Systems Magazine	Peer-reviewed Journal	
Beyond Mobility	Cervero, Robert, Erick Guerra, and Stefan Al (2017). Beyond Mobility: Planning Cities for People and Place. Washington, D.C.: Island Press.	Trade/Professional	2017-12-31
Where Do Bike Lanes Work Best? A Bayesian Spatial Model of Bicycle Lanes and Bicycle Crashes.	Kondo, Michelle C., Christopher Morrison, Erick Guerra, Elinore J. Kaufman, and Douglas J. Wiebe (2018). Where Do Bike Lanes Work Best? A Bayesian Spatial Model of Bicycle Lanes and Bicycle Crashes. Safety Science 103 (March): 225–33.	Peer-reviewed Journal	2018-03-01
Statistical inference of probabilistic origin-destination demand using day-to-day traffic data	Wei Ma, Sean Qian. (2018) "Statistical inference of probabilistic origin-destination demand using day-to-day traffic data", Transportation Research Part C, Vol.88, pp. 227-256	Peer-reviewed Journal	2018-02-01
A Generalized Single-Level Formulation for Origin–Destination Estimation Under Stochastic User Equilibrium	Wei Ma, Sean Qian. (2018) A Generalized Single-Level Formulation for Origin–Destination Estimation Under Stochastic User Equilibrium, Transportation Research Record, accepted and forthcoming	Peer-reviewed Journal	2018-03-01
A Mixed Traffic Capacity Analysis and Lane Management Model for Connected Automated Vehicles: A Markov Chain Method	Amir Ghiasi, Omar Hussain, Sean Qian, Xiaopeng Li. (2017) "A Mixed Traffic Capacity Analysis and Lane Management Model for Connected Automated Vehicles: A Markov Chain Method", Transportation Research Part B, Vol.106, pp. 266-292	Peer-reviewed Journal	2017-10-01

A Stochastic Optimal Control Approach for Real-time Traffic Routing Considering Demand Uncertainties and Travelers' Choice Heterogeneity	Xidong Pi, Sean Qian. (2017) "A Stochastic Optimal Control Approach for Real-time Traffic Routing Considering Demand Uncertainties and Travelers' Choice Heterogeneity." Transportation Research Part B, Vol.104, pp.710-732.	Peer-reviewed Journal	2017-07-01
On the Variance of Recurrent Traffic Flow for Statistical Traffic Assignment	Wei Ma, Sean Qian. (2017) "On the Variance of Recurrent Traffic Flow for Statistical Traffic Assignment", Transportation Research Part C, Vol.81, pp.57-82	Peer-reviewed Journal	2017-05-01
User-centric interdependent urban systems: using time-of-day electricity usage data to predict morning roadway congestion	Pinchao Zhang, Sean Qian. (2018) User-centric interdependent urban systems: using time-of-day electricity usage data to predict morning roadway congestion, submitted to Transportation Research Part C, under 2nd round review	Peer-reviewed Journal	
"Space-Time Graph Modeling of Ride Requests Based on Real-World Data"	The AAAI-17 Workshop on "AI and Operations Research for Social Good" at Thirty-First AAAI Conference on Artificial Intelligence	Peer-reviewed Journal	2017-02-04
"Data Driven Analysis of the Potentials of Dynamic Ride Pooling"	IWCTS 2017: Tenth ACM SIGSPATIAL International Workshop on Computational Transportation Science, Redondo Beach, California, USA, 7 November 2017	Peer-reviewed Journal	2017-11-07
"On the Real-Time Vehicle Placement Problem"	31st Conference on Neural Information Processing Systems (NIPS 2017), Long Beach, CA, USA.	Peer-reviewed Journal	2017-12-04
"Smooth: improved short-distance mobility for a smarter city,"	X. Fu, M. Vernier, A. Kurt, K. Redmill and U. Ozguner, "Smooth: improved short-distance mobility for a smarter city," Proceedings SCOPE '17 Proceedings of the 2nd International Workshop on Science of Smart City Operations and Platforms Engineering, Pages 46-51, Pittsburgh, PA, April 18 - 21, 2017.	Trade/Professional	2017-04-18
"Agent-based microscopic pedestrian interaction with intelligent vehicles in shared space,"	D. Yang, A. Kurt, K. Redmill, Ü. Özgüner, "Agent-based microscopic pedestrian interaction with intelligent vehicles in shared space," Proceeding SCOPE '17 Proceedings of the 2nd International Workshop on Science of Smart City Operations and Platforms Engineering, Pages 69-74, Pittsburgh, PA, April 18 - 21, 2017.	Trade/Professional	2017-04-18
Efficient Learning of Stand-up Motion for Humanoid Robots with Bilateral Symmetry	H. Jeong and D. D. Lee, "Efficient learning of stand-up motion for humanoid robots with bilateral symmetry," 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Daejeon,	Trade/Professional	2016-10-09

	2016, pp. 1544-1549. doi: 10.1109/IROS.2016.7759250		
Intention Estimation for Ramp Merging Control in Autonomous Driving	Dong, C., Litkouhi, B., and Dolan, J.M., Intention Estimation for Ramp Merging Control in Autonomous Driving, Proceedings of the 2017 IEEE Intelligent Vehicles Symposium, pp. 1584-1589, Redondo Beach, California (June 2017).	Peer-reviewed Journal	2017-06-13
Lane-Change Social Behavior Generator for Autonomous Driving Car by Non-Parametric Regression in Reproducing Kernel Hilbert Space	Dong, C., Zhang, Y., and Dolan, J.M., Lane-Change Social Behavior Generator for Autonomous Driving Car by Non-Parametric Regression in Reproducing Kernel Hilbert Space, Proceedings of the 2017 IEEE International Conference on Intelligent Robots and Systems (IROS), pp. 4489-4494, Vancouver, Canada (September 2017).	Peer-reviewed Journal	2017-09-26
Interactive Ramp Merging Planning in Autonomous Driving: Multi-Merging Leading PGM (MML-PGM)	Dong, C., Dolan, J.M., and Litkouhi, B., Interactive Ramp Merging Planning in Autonomous Driving: Multi-Merging Leading PGM (MML-PGM), Proceedings of the 2017 IEEE International Conference on Intelligent Transportation, pp. 2186-2191, Yokohama, Japan (October 2017).	Peer-reviewed Journal	2017-10-18
Computer-Aided Design for Safe Autonomous Vehicles	O'Kelly, Matthew et al. "Computer-aided design for safe autonomous vehicles." 2017 Resilience Week (RWS) (2017): 90-96.	Peer-reviewed Journal	2017-07-15
Computer-Aided Design for Safe Autonomous Vehicles	O'Kelly, Matthew et al. "Computer-aided design for safe autonomous vehicles." 2017 Resilience Week (RWS) (2017): 90-96.	Peer-reviewed Journal	2017-07-15
Relaxed decidability and the robust semantics of Metric Temporal Logic	Houssam Abbas, Matthew O'Kelly, and Rahul Mangharam, "Relaxed decidability and the robust semantics of Metric Temporal Logic", Proceedings of the 20th ACM International Conference on Hybrid Systems: Computation and Control. 2017.	Peer-reviewed Journal	2017-10-14
Safe At Any Speed: A Simulation-Based Test Harness for Autonomous Vehicles	Houssam Abbas, Matthew O'Kelly, Alena Rodionova and Rahul Mangharam, "Safe At Any Speed: A Simulation-Based Test Harness for Autonomous Vehicles", Lecture Notes on Computer Science, Special Issue on Cyber-Physical Systems, 2018, accepted and in press.	Peer-reviewed Journal	2018-04-10

*Books or other non-periodical, one-time publications:*

Nothing to report.

Identify for each one-time publication:

Nothing to report

Other publications, conference papers and presentations:

<b>Title</b>	<b>Event</b>	<b>Type</b>	<b>Attended</b>	<b>Date</b>
Mobility Data Analytics	Cranberry Township	Seminar-Professional	5	2018-02-07
Mobility Data Analytics	McKees Rocks	Seminar-Professional	5	2018-01-22
Mobility Data Analytics	CMU smart mobility connection	Seminar-Professional	30	2017-10-18
Peer-to-peer ridesharing options for enhanced mobility in rural areas	CMU Smart Mobility Challenge	Workshop-Academic	30	
How Innovative Technology Can Improve Mobility, Featuring the Awardees from the Smart Mobility Challenge	2017-2018 Smart Mobility Connection Forum	Seminar-Academic	30	2017-11-03
Does Increasing Neighborhood Density Mean Safer Streets?	ACSP Annual Meeting	Conference-Academic	20	2017-11-01
Does Increasing Neighborhood Density Mean Safer Streets?"	Penn Injury Science Center	Workshop-Academic	15	2017-11-30
Statistical inference of probabilistic origin-destination demand using day-to-day traffic data	INFORMS TSL conference	Conference-Academic	200	2017-07-27
Statistical inference of probabilistic origin-destination demand using day-to-day traffic data	TRB annual meeting	Conference-Professional	200	2018-01-09
Statistical inference of probabilistic origin-destination demand using day-to-day traffic data	INFORMS annual meeting	Conference-Academic	30	2017-10-24
Statistical inference of probabilistic origin-destination demand using day-to-day traffic data	COTA international Conference of Transportation Professionals	Conference-Professional	300	2017-07-07
Mobility Data Analytics	the City of Philadelphia	Seminar-Professional	5	2017-12-01
Mobility Data Analytics	PennDOT District 6	Seminar-Professional	15	2017-12-01
Mobility Data Analytics	CMU/UPitt student activities	Seminar-Professional	50	2017-10-16
Mobility data analytics	PennDOT District 6	Seminar-Professional	15	2017-12-01
Mobility data analytics	Cranberry Township	Seminar-Professional	5	2018-02-08
"Human Mobility Analytics and Services"	Traffic21 Seminar	Seminar-Academic	70	2016-11-17
"Human Mobility Modelling"	Traffic21 Seminar	Seminar-Academic	60	2017-04-27
"Space-Time Graph Modeling	AAAI'17	Workshop-	50	2017-02-04

of Ride Requests Based on Real-World Data"		Professional		
"Data Driven Analysis of the Potentials of Dynamic Ride Pooling"	IWCTS'17	Workshop-Professional	50	2017-11-07
"On the Real-Time Vehicle Placement Problem"	NIPS'17	Conference-Professional	100	2017-12-04
Keynote: Smart Cities: An Intelligent Vehicles Perspective	IEEE ITS Conference		500	
Keynote Speech: Unified, Scalable and Replicable Connected and Automated Driving for a Smart City	Sae International: From ADAS to Automated Driving Symposium	Symposium-Professional	200	2017-10-11
Bayesian Q-learning with Assumed Density Filtering	Neural Information Processing Systems Workshop	Workshop-Academic	100	2017-12-08
AV's Blindspot: Detecting Pedestrians and Bicyclists	The Promise and Challenges of Automated Technologies organized by the UNC Highway Safety Research Center	Seminar-Professional	150	2017-08-16
F1/10 Autonomous Racing Course and Competition	International Conference on Automotive Engineering	Symposium-Academic	120	2018-02-28
A Driver's License Test for Driverless Vehicles	International Conference on Automotive Engineering	Symposium-Professional	120	2018-02-28

*Website(s) or other Internet site(s)*

<b>URL for Internet site(s) that disseminates the results of the research and/or program activities</b>	<b>Short description of the site</b>	<b>Metrics</b>
<a href="http://mobility21.cmu.edu/">http://mobility21.cmu.edu/</a>	The Carnegie Mellon University's Mobility21 National University Transportation Center website	New Posts: 530  * A new way to track website metrics has been added to the site, and starting with the next report, will allow for more robust reporting.
<a href="https://www.facebook.com/traffic21.tset">https://www.facebook.com/traffic21.tset</a>	The Carnegie Mellon University's Facebook Page for the Technologies for Safe and Efficient Transportation National University Transportation Center and Mobility21, A National	Likes: 98

	University Transportation Center for Improving Mobility of People and Goods	
<a href="https://www.youtube.com/user/Traffic21TSET">https://www.youtube.com/user/Traffic21TSET</a>	The Carnegie Mellon University's YouTube Page for the Technologies for Safe and Efficient Transportation National University Transportation Center and Mobility21, A National University Transportation Center for Improving Mobility of People and Goods	Videos: 5 Views: 404
<a href="https://twitter.com/Traffic21_TSET">https://twitter.com/Traffic21_TSET</a>	The Carnegie Mellon University's Twitter Page for the Technologies for Safe and Efficient Transportation National University Transportation Center and Mobility21, A National University Transportation Center for Improving Mobility of People and Goods	Followers: 871 Following: 1,628 Tweets: 5,660

In addition:

- The Building a pilot peer-to-peer platform for ride-sharing in Lawrence County project has developed a "Lawrence County Ride-sharing" platform to facilitate the ridesharing.
- The built environment and pedestrian safety in the Philadelphia region project has developed a new website, <http://crashphilly.erickguerra.net>
- The Intelligent Mobility Meter - Portable Fine-Grained Data Collection and Analysis of Pedestrian, Cyclist, and Motor Vehicle Traffic project has a new project website: <http://www.andrew.cmu.edu/user/bpires/imm/index.html>
- The Autonomous Racing Course and Competition project's new website is: <http://f1tenth.org>.

### ***Technologies or techniques***

#### *Inventions, patent applications, and/or licenses*

A core focus from the beginning of Traffic21 has been to apply university research and technology to real-world mobility problems. This process began by first talking with transportation professionals, identifying real-world problems, and then sharing those problems with researchers. As technologies prove successful, Mobility21 staff work with researchers and government and industry partners to advance the application of that technology. This may result in agencies, such as the City of Pittsburgh, adopting a technology such as Surtrac adaptive traffic signals, commercialization with an industry partner, such as Delphi, or spinning off a company, such as RoadBotics. Following is an example of a developing technology.

The Optimizing Snow Plowing Operations in Urban Road Networks project, has accomplished developing an (1) In-Vehicle app - The in-vehicle app for providing turn-by-turn instructions was re-engineered to rely on Map Box as the underlying mapping tool to overcome limitations in the interface to Google maps. Extensions were also made to implement a "skip"; button, for purposes of deviating from the planned route in the event that it is

impassible (e.g., due to an abandoned vehicle). When invoked the system will reroute the vehicle back onto the planned route as soon as possible. In January 2018, the app was successfully pilot tested with a City of Pittsburgh vehicle driver from Division 3 - driving a current City route in division 3. (2) Dynamic route planner - Further improvements were made to the dynamic route planning system that we have developed, and infrastructure was developed to import City of Pittsburgh route and vehicle data for use in generating routes. Using city data used to generate the City's current snow plow routes for the Greenfield neighborhood, an initial performance analysis of the CMU route planner was performed. With both sets of routes using three 10-ton vehicles, the CMU planner was able to generate routes that finish 13 minutes sooner than the current City routes (1h/27m versus 1h/40m), with one fewer u-turn than the City routes. Primary routes are cleared 12 minutes earlier; secondary routes about 11 minutes earlier.

Both the successful field test of the in-vehicle app and the comparative improvement shown by the CMU route planner over the City's current snow plow routes demonstrate the potential for significant improvement of City operations. Whereas our initial comparison of generated routes already shows approximately a 13% reduction in plowing time, we expect to be able to significantly improve over these initial results as we further refine the CMU planner's heuristics.

It is the team's intention to transition this technology to a commercial enterprise and bid on the City of Pittsburgh's current outstanding RFP for route optimization capability.

*Other products*

Nothing to report.

**3. PARTICIPANTS & COLLABORATING ORGANIZATIONS: Who has been involved?**

*What organizations have been involved as partners?*

Partner Organization Name	Location	Contribution to the Project				
		Financial support	In-kind support	Facilities	Collaborative research	Personnel exchanges
Bloomfield Development Corporation	Bloomfield, PA				X	
Borough of McKees Rocks	McKees Rocks, PA			X	X	
City of Philadelphia	Philadelphia, PA				X	
City of Pittsburgh Department of Mobility and Infrastructure	Pittsburgh, PA			X	X	
City of Pittsburgh Mayor's Office	Pittsburgh, PA				X	
Clemson University	Clemson, South Carolina				X	
Cranberry	Cranberry, PA			X	X	

Township						
Delaware Valley Regional Planning Commission	Philadelphia, PA				X	
Florida Atlantic University	Florida				X	
Mathworks	Natick, MA				X	
Michelle Kondo, Scientist					X	
USDA Forest Service	Philadelphia, PA				X	
Nvidia Autonomous Driving	Santa Clara, CA				X	
Philadelphia Streets Department	Philadelphia, PA				X	
Pittsburgh Parking Authority	Pittsburgh, PA			X	X	
Port Authority of Allegheny County	Pittsburgh, PA			X	X	
Transportation and Traffic Management at The Ohio State University	Columbus, OH				X	
University of Modena, Italy	Modena, Italy				X	
University of Pennsylvania Center for Clinical Epidemiology and Biostatistics	Philadelphia, PA				X	
University of Pennsylvania Injury Science Center	Philadelphia, PA				X	
University of Porto, Portugal	Porto, Portugal				X	

*Have other collaborators or contacts been involved?*

Within the past year, the CMU's Metro21: Smart Cities Institute launched. Metro21 takes a forward-looking creative approach to bringing people, technology and policy together to significantly improve the quality of life for metropolitan area citizens. The multidisciplinary effort employs research, development and deployment tactics with key partners to create and test smart city solutions. Traffic21 and the Mobility21 UTC now fall under the Metro21 umbrella and work closely in collaboration.

Our Deployment Partner Consortium is utilized for identifying real-world transportation needs, research project development and deployment, technology licensing and commercialization, student recruitment for jobs and internships, class and capstone projects. Our consortium members include:

- AASHTO
- Access Transportation Systems
- Accessible Transportation & Workforce Interagency Cooperative
- ALCO Parking
- Allegheny Conference on Community Development
- Allegheny County
- APTA
- Beth's Barricades
- Bike Pittsburgh
- Bombardier
- Booz Allen Hamilton
- Bosch Research & Technology Center
- City of Philadelphia
- City of Pittsburgh
- Community College of Allegheny County
- Conference of Minority Transportation Officials
- Delaware River Port Authority
- Delaware Valley Regional Planning Commission
- General Motors Global Research & Development
- IBM
- Innovation Works
- ITS America
- Open Roads
- PennDOT
- Pennsylvania Motor Truck Association
- PITT OHIO Express
- Philadelphia Port Authority
- Pittsburgh Technology Council
- Port Authority of Allegheny County
- Port of Pittsburgh Commission
- Southeastern Pennsylvania Transportation Authority
- Southwestern Pennsylvania Commission
- Takata
- Three Rivers Workforce Investment Board
- Uber
- University of Pittsburgh
- Women's Transportation Seminar

And lastly, the UTC also has a distinguished Advisory Council of national leaders that provides strategic guidance and counsel. We sought to achieve modal and demographic diversity. The individual members provide significant collaboration opportunities with their extensive professional affiliations. The following prominent transportation professionals serve on the Council:

- Allen Biehler, Recently retired from CMU as Distinguished Service Professor and Executive Director of the University Transportation Center, formerly Secretary of Pennsylvania Department of Transportation.
- Raymond T. Betler, President and CEO of the American Transportation Research Institute
- Rebecca M. Brewster, President and Chief Operating Officer of the American Transportation Research Institute
- Deborah Butler, Former Executive Vice President and Chief Information Officer, Norfolk Southern

Corp.

- Joseph M. Casey, Former General Manager, Southeastern Pennsylvania Transportation Authority
- Douglas I. Foy, President of Serrafix; former Secretary Office of Governor Romney
- Charles L. Hammel III, President and owner, PITT OHIO Express
- Ashley Hand , Co-founder CityFi; formerly Transportation Technology Strategist Fellow for Los Angeles
- John M. English, Former Chief Executive Officer of the Utah Transit Authority
- Jane Lappin, Director, Public Policy & Government Affairs, Toyota Research Institute
- Dr. Michael D. Meyer, Senior Advisor to Parsons Brinckerhoff, Inc and former Director of the Georgia Transportation Institute
- William W. Millar, Past President of American Public Transportation Association
- James A. Misener, Director of Technical Standards at Qualcomm and former Director of UC Berkley PATH
- Leslie Richards, Secretary of the Pennsylvania Department of Transportation
- Robert E. Skinner Jr., Former Executive Director of Transportation Research Board
- Kirk T. Steudle, Director of the Michigan Department of Transportation and past president of AASHTO and ITS America

**4. IMPACT:** What is the impact of the program? How has it contributed to transportation education, research and technology transfer?

*What is the impact on the development of the principal discipline(s) of the program?*

The efforts conducted as part of this center have resulted in impacts, including where our center leadership and researchers are sought to comment on current events or their research is highlighted in local, national or international media. Some examples:

- March 26, 2018 - Examples of How AI Can Make Cities Smarter article in Government CIO, featured “Surtrac, using technology patented by the Robotics Institute at Carnegie Mellon University, claims its technology can produce 25 percent reductions in travel time and 40 percent reductions in time spent waiting at intersections.” <https://www.governmentciomedia.com/4-examples-how-ai-can-make-cities-smarter>.
- March 16, 2018 – an article The partnerships enabling disabled city residents to better explore their surroundings, mentioned that “...researchers at Carnegie Mellon University developed an artificial intelligence-operated adaptive traffic signal system, Surtrac, that detects traffic and changes the lights accordingly instead of relying on pre-programmed light cycles. Pittsburgh piloted the system at dozens of intersections and found that traffic flowed better, but pedestrians initially weren’t taken into account. The research team tweaked the system based on feedback and also developed a complementary app for people with disabilities to communicate with the system and receive more time to cross the street. The changes proved beneficial not just for people with disabilities, but for all pedestrians.
- One targeted innovation for which researchers at Ohio State University seek more partnerships is a road paint that reacts with specially-designed tips on canes for the visually impaired. The team is testing standard street paint with added light-converted oxides, which have the ability to convert one wavelength of light to another wavelength.” <https://www.smartcitiesdive.com/news/the-partnerships-enabling-disabled-city-residents-to-better-explore-their-s/519029/>.
- February 13, 2018 - Researcher Costa Samaras Drone Delivery Emissions Paper Covered by National

Media. News outlets including The Guardian, Forbes, and Wired wrote about UTC researcher Constantine Samaras' paper, "Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery." Says Samaras in Wired, "It's pretty clear that companies are interested in doing this... What's important is understanding the ways that policy makers could guide the beneficial outcomes now before there are a bunch of drones in the sky delivering packages." Two of the research paper's authors also wrote an op-ed for The Conversation that you can read here.

- February 8, 2018 - The U.S. Department of Transportation hosted a webinar to provide an update on Mobility21 researcher Steve Smith's project that is part of the Accessible Transportation Technologies Research Initiative (ATTRI): the Safe Intersection Crossing project being developed by Carnegie Mellon University.
- February 7, 2018 - Massachusetts City Looks at Smart Traffic Light Software to Ease Congestion article in Gov Tech says "... the city is looking at using the new software, likely from a company called Surtrac, for areas such as the Hancock Street corridor, the Wollaston area and Southern Artery. The city hopes the software eases traffic, which is one of the most common complaints among Quincy resident. Surtrac was created by researchers at Carnegie Mellon University. The team behind it says studies showed the system reduced traffic on some main roads in Pittsburgh by 25 percent. Cassani, who took over as director of the city department at the start of the year, said every few minutes shaved off people's commutes is important. <http://www.govtech.com/fs/infrastructure/Massachusetts-City-Looks-at-Smart-Traffic-Light-Software-to-Ease-Congestion.html>.

Following are some highlights outside of the media:

In 2017 Mobility21 researchers and staff led a National Science Foundation advanced wireless proposal, Open Pittsburgh wireless Research Accelerator (OPERA). OPERA is a proposed advanced wireless testbed, bringing together the public and private sector with academia to deploy advanced at-scale wireless infrastructure to create opportunity for innovation and growth. In the Fall of 2017 NSF selected OPERA as one of five finalists and conducted a site visit. Earlier deployment of UTC research enabled the infrastructure platform for OPERA.

The SmartShuttle: Model based design and evaluation of automated on-demand shuttles for solving the first-mile and last mile problem in a smart city project impact is on demonstrating a scalable and replicable low speed autonomous shuttle solution for smart cities, especially for the smaller companies that dominate that area. The resulting impact will be more widespread use of autonomous shuttles in smart cities and more mobility choices especially for the first-mile and last-mile problem. The project work until now has already had an impact. Prof. Levent Guvenc and Prof. Bilin Aksun Guvenc were members of the Autonomous Electric Vehicles working group of Smart Columbus and informed group members in Columbus and in OSU of the potential benefits and the accompanying problems of autonomous shuttles used in geo-fenced areas as first and last mile solutions. The project results were helpful in making Smart Columbus and OSU leaders understand more about the capabilities of existing autonomous shuttles and make more informed decisions. We shared project results and the resulting expertise with the OSMI (Ohio State Mobility Initiatives) group where Prof. Levent Guvenc was a member. This, among other developments, led recently to Ohio Department of Transportation's DriveOhio smart mobility program which is one of the results of the continuation of the OSMI group effort.

Researchers heading up the project, The Built Environment and Pedestrian Safety in the Philadelphia Region have presented findings to members of the Delaware Valley Planning Commission and the Philadelphia Mayor's Office of Transportation and Information Systems. Erick Guerra (PI) has also been invited to serve on two safety-related committees: City of Philadelphia Policy Advisory and Data and Prioritization Committee for Strategic Transportation Plan. This summer Lufeng Lu, a master's student, will work with the city and Professor Guerra to identify and map racial disparities in traffic safety outcomes in the city.

The Prediction and Behaviors for Driver Assistance and Socially Cooperative Autonomous Driving project's impact is improved ability of an autonomous car to deal safely with merging traffic in highway or urban situations. The use of existing ACC systems would lead to a 17% collision rate on the NGSIM dataset, whereas the research method reduces this to around 2%. Researchers are currently investigating improvements to this method that can further reduce this number, whether by increased sophistication of the algorithm, or by the introduction of heuristics dealing with the pathological cases, if these can be categorized in an exhaustive manner. They are also planning to add in the next reporting period the consideration of vehicle behaviors when navigating traffic circles, or roundabouts.

The F1/10 Autonomous Racing Course and Competition project completed the course development, open-source software and reference hardware platform for the racecar. Following this, they plan to conduct the 2nd F1/10 Autonomous Racing Competition in Porto, Portugal (co-located with Cyber-Physical Systems Week) on April 10-11, 2018. The competition is expected to draw teams from Korea, Czech Republic, and Sweden.

*What is the impact on other disciplines?*

- Mobility21 continues to take a leadership role in the Smart Belt Coalition, which is comprised of CMU, The Ohio State University, University of Michigan, Penn State University, Kettering State, PennDOT, ODOT, MDOT, and Pennsylvania and Ohio Turnpike officials. The coalition was initiated by the Mobility21 UTC faculty and has created the first multi-state connected and automated vehicle test bed for research, deployment of technologies, and policy development.
- Raj Rajkumar, Mobility21 Director, and Stan Caldwell, Mobility21 Executive Director continue to serve on Pennsylvania's Autonomous Vehicle Policy Task Force and provide both the Pennsylvania Department of Transportation and the State Legislature's Transportation Committees counsel on automated vehicle policy.
- The Risk, Liability and Insurance framework for Autonomous Vehicles project has engaged law professionals and insurance experts in identifying the scale and type of product liability autonomous vehicles represent, as opposed to human-driven vehicles. A series of working papers starting with "MOBILITY21: Strategic Investments for Transportation Infrastructure & Technology" has engaged folks in the Computer Research Association (CRA) and Whitehouse administration. This effort has engaged law professionals to investigate AV safety and risk within a new framework. It was the topic of presentation at the Inaugural Junior Faculty Forum, Penn Law.  
[https://www.law.upenn.edu/newsevents/calendar.php#!event\\_id/55094/view/event](https://www.law.upenn.edu/newsevents/calendar.php#!event_id/55094/view/event).

*What is the impact on the development of transportation workforce development?*

This grant has expanded workforce development efforts through a partnership with Community College of Allegheny County's Automotive Technician Training Program. This program provides students with the education to maintain vehicles. Their coursework involves integrating safety system alignments, and computer assisted diagnostics. The new components being added as a result of research, will need to be maintained and these students are learning how to do that. CCAC trained 211 automotive credit students from fall 2017 - spring 2018 (August - April). Out of that 28 students will receive an Associate Degree in Science - Automotive, or a Certificate of Completion – Automotive. 136 students will have received a Pennsylvania certification license to safety inspect vehicles or emission inspect vehicles. 47 students are 1st year students who are continuing through our automotive programs. In addition, CCAC trained 624 automotive non-credit students from fall 2017 - spring 2018 (August - April). Out of that: 564 students took a 3 hour emission re-certification course to keep their emission certification license. 56 students took a 4 hour safety re-fresher course to keep their safety inspection license. 4 are currently taking the CDL Class A

training.

Students who want to learn more about The Ohio State University's role as a smart campus in the heart of a smart city recently filled a classroom to hear from the leaders of the effort...Smart Campus, a student organization partnering with the university's Center for Automotive Research, hosted leaders from the city of Columbus, Smart Columbus, CAR, the university's Technology Commercialization Office and the Transportation Research Center this month in Scott Laboratory."

<https://news.osu.edu/news/2018/03/05/smart-cities-talk-shows-the-future-role-of-a-connected-campus/>.

On March 20, 2018, Vibhanshu Abhishek, assistant professor of information systems at Carnegie Mellon University's Heinz College was featured on NBC news discussing Why millennials should start considering truck driving "... I am certain that the whole trucking experience will change such that it will be appealing to young truck drivers. They'll be attracted to the technology, and because the truck has so many safety features, they won't need as much experience. I also think that it will open the market up to more women," said Abhishek. "It could really help solve this shortage, which is not just an American problem, but a global problem. Solving it could grow the economy worldwide." <https://www.nbcnews.com/business/economy/why-millennials-should-start-considering-truck-driving-it-s-almost-n857301>.

On March 8, 2018, Smart Cities Talk shows the future role of a connected campus. "Students who want to learn more about The Ohio State University's role as a smart campus in the heart of a smart city recently filled a classroom to hear from the leaders of the effort...Smart Campus, a student organization partnering with the university's Center for Automotive Research, hosted leaders from the city of Columbus, Smart Columbus, CAR, the university's Technology Commercialization Office and the Transportation Research Center this month in Scott Laboratory." <https://news.osu.edu/news/2018/03/05/smart-cities-talk-shows-the-future-role-of-a-connected-campus/>.

In addition on November 16, 2017, members from the Mifflin Academy of Science and Technology and the Mifflin County School District toured robotics labs and met with Mobility21 faculty from CMU and the Community College of Allegheny County for advice on their curriculum and plans to prepare rural high school students for jobs in vehicle automation.

*What is the impact on physical, institutional, and information resources at the university or other partner institutions?*

January 22, 2018 - "DriveOhio," housed within the Ohio Department of Transportation, will offer manufacturers and researchers one point of contact to coordinate state agency assistance in developing driverless vehicles, "smart" roads and other technology. Ohio State University's Center for Automotive Research and the Transportation Research Center along Rt. 33 is also offer testing and research opportunities into "smart mobility." <http://www.record-courier.com/article/20180118/NEWS/301189812>.

*What is the impact on technology transfer?*

One example of how that collaboration takes place is on March 26, 2018, at the Southwestern Pennsylvania Commissions Chairman's Workshop in California, Mobility21 Executive Director Stan Caldwell spoke about the challenges faced by public officials in ensuring that connected and autonomous technologies are being deployed safely. More about that presentation can be found here:

[https://observer-reporter.com/news/localnews/autonomous-vehicles-part-of-discussion-at-southwestern-pa-commission-workshop/article\\_d06a77d4-30f9-11e8-978b-67bf86094a9e.html](https://observer-reporter.com/news/localnews/autonomous-vehicles-part-of-discussion-at-southwestern-pa-commission-workshop/article_d06a77d4-30f9-11e8-978b-67bf86094a9e.html).

Another example was on December 18, 2017, when Mobility21 Researchers provided a field demonstration of Surtrac adaptive traffic signal research to the Pittsburgh Complete Streets Committee and discussed urban applications of connected and adaptive signals for all modes of transportation.

*What is the impact on society beyond science and technology?*

Through research, development, and deployment, the end goal is increasing mobility for all users of the transportation system.

One example is the system of metrics and GIS-based web application that allow visualization of the bikeability scores which were developed through the Building an Accessible, Low-stress, Safe, and Sustainable, Bicycle Infrastructure Network for the City of Pittsburgh project.

Another example is the development of an open-source software package that implements work zone related traffic simulation and estimates mobility and safety implications for future work zone scenarios through the Wearable DSRC Devices for Workers project – impacting the people working in the work zones and the motorists travelling through them.

## **5. CHANGES/PROBLEMS**

*Changes in approach and reasons for change*

Nothing to report.

*Actual or anticipated problems or delays and actions or plans to resolve them*

Nothing to report.

*Changes that have a significant impact on expenditures*

Nothing to report.

*Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards*

Nothing to report.

*Change of primary performance site location from that originally proposed*

Nothing to report.

## **Additional information regarding Products and Impacts**

Nothing to report.

## **6. SPECIAL REPORTING REQUIREMENTS**

Nothing to report.