

Mobility21

A USDOT NATIONAL
UNIVERSITY TRANSPORTATION CENTER

Carnegie Mellon University



THE OHIO STATE UNIVERSITY



Semi-Annual Progress Performance Report for University Transportation Centers

Agency: US Department of Transportation
Office of the Assistant Secretary for Research and Technology
University Transportation Center Program

Federal Grant Number: 69A3551747111

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

Program Director: Professor Raj Rajkumar, Director, Mobility21 National UTC
rajkumar@cmu.edu, 412-268-8707

Submitting Official: Stan Caldwell, Executive Director, Mobility21 National UTC
stancaldwell@cmu.edu 412-268-9505

Submission Date: April 30, 2021
DUNS Number: 05-218-4116
EIN Number: 25-0969449
Recipient Organization: Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213

Recipient ID Number: 40459.x.1080266
Project Grant Period: 11/30/2016 – 9/30/2022
Reporting Period End Date: March 30, 2021
Report Term or Frequency: Semi-Annual

Signature:

A handwritten signature in brown ink, appearing to read "Stan Caldwell".

1. ACCOMPLISHMENTS: What was done? What was learned?

What are the major goals of the program?

The primary goal of Mobility21, 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

In addition, as part of our Technology Transfer Plan (dated July 31, 2018) the following Research Performance Measures were established:

	Research Performance Measure	Annual Target
Output #1	Annual Number of Journal Publications	35
Output #2	Annual Number of Research Pilot Deployments	10
Outcome #1	Annual Number of Media Stories Referencing UTC Research, Faculty, or Spinoff	80
Outcome #2	Annual Number of Instances Providing Exposure to Transportation, Science and Technology for Practitioners, Teachers, Young people, or Other Members of the Public	50
Impact #1	Annual Number of Instances of Technology Adoption or Commercialization	3
Impact #2	Annual Number of Instances of Research Changing Behavior, Practices, Decision Making, Policies (Including Regulatory Policies), or Social Actions	3

What was accomplished under these goals?

Research

Forty-three research projects were active during this report period.

In July 2020, a call for proposals was released for CMU researchers to propose BIG IDEA projects. Projects that demonstrate significant promise and impact on mobility, transforming mobility using ground-breaking ideas, an interdisciplinary approach, and an 18 month schedule (January 2021 – June 30, 2022) period were entertained. Nine proposals were received, totaling more than \$1.2 million in requests. Representatives from our Advisory Council and the UTC management team participated in the review of the proposals. Three of the projects were selected based on the available funding. Mobility21 UTC management personnel worked with the PIs to ensure all US DOT & project requirements were met so the projects could start January 1, 2021.

A separate call was released in September 2020 inviting representatives of municipalities and public transit operators in southwestern PA to request research assistance by submitting their real-world mobility problem to be considered for the Third Smart Mobility Challenge. Challenge Partner, the Southwestern Pennsylvania Commission, a regional MPO, has been helping promote the challenge to their regional communities and public transit operators. Four project proposals were received. These proposals were paired with PIs for development into a full project proposal to be submitted as part of the annual call for proposals (described below). Three of the projects were developed into proposals. The fourth was better suited to be addressed as a class project.

On October 5, 2020, the annual call for proposals was released for CMU researchers to propose projects for the July 1, 2021 – June 30, 2022 period. Twenty-four proposals were received, totaling more than \$2.05 million in requests. Representatives from our Advisory Council and the UTC management team again participated in the review of the proposals. Fourteen of the projects were selected based on the available funding (including all 3 of the Smart Mobility Challenge projects). Mobility21 UTC management personnel are working with the PIs to ensure all US DOT & project requirements were met so the projects can start on July 1, 2021.

During this reporting period, three UTC faculty meetings were held (scheduled twice during each of the spring and fall semesters). The meetings are held to provide the faculty updates on the Mobility21 UTC, share information among the four UTC academic consortium partners, and present research being conducted.

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 UTC have emerged on CMU's campus they have generated interest among faculty and students, bringing exposure to real-world problems, and engaging faculty and students with **165** deployment partners.

At Carnegie Mellon University, a student transportation club also convenes throughout the fall and spring semesters, of which the Mobility21 Women in Transportation Fellows help lead, and the UTC supports. The UTC also actively engages student groups at its partner universities and colleges.

Highlighted Education Initiatives:

- March 25, 2021 - Five CMU MSPPM-DM students – Thomas Hurley, Akshay Oza, Karunya Manoharan, Yue Wu, and Yuran Zhu – presented an overview of their capstone project Traffic Dashboard for Colorado Springs, a CMU/US-Ignite Solution. The project, led by UTC researcher Beibei Li, is developing a real-time dashboard for base personnel to reduce traffic congestion at the Fort Carson army base. The team will continue the work on this project, refining the dashboard, and adding predictive analytics features. Mobility21 Program Manager, Lisa Kay Schweyer attended and provided feedback to the team.
- March 19, 2021 - MS research assistant Devin White has been awarded an internship at the US Department of Transportation in the Federal Highway Administration Center for Accelerating Innovation. Devin is advised by Traffic21 Director Chris Hendrickson and UTC researcher Dr. Corey Harper.
- March 16, 2021 - Mobility21 UTC supported CMU's Department of Engineering and Public Policy's undergraduate capstone project course on Local and National Implications of Vehicle Electrification. Stan Caldwell serves on the project team's advisory board and provided feedback and insights from his UTC research for the students' mid-term research project presentation.

- January 6, 2021 - Camille Boggan was honored as Mobility21 University Transportation Center's "Student of the Year" at the Council of University Transportation Center's annual awards banquet. Camille Boggan is a current city planning graduate student at the University of Pennsylvania's Weitzman School of Design. She graduated Phi Beta Kappa from Miami University (Ohio) in 2019 with a bachelor's degree in Sociology. Camille has worked as a graduate research assistant in Dr. Megan Ryerson's Smart Mobility Lab, supporting research efforts on transportation safety and wayfinding. In 2020 she interned with the City of Philadelphia's Office of Transportation and has served on the transit steering committee of 5th Square.
- December 18, 2020 - Mobility21 UTC research assistant Erick Shiring participated in a graduate Capstone course and recent study of Mt. Lebanon's brick roads. The team presented their results to the Mt. Lebanon Board of Commissioners. This study was led by Anna Siefken of the Scott Institute, along with graduate students Yunxi Hu, Rachel Bukowitz, and Shunyu Rao. [Read the article here.](#)
- December 8, 2020 - Students of the CMU Heinz College engage in semester long "Capstone Projects" to apply coursework to real-world scenarios. The projects featured today included the following transportation related project: Team Port Authority: Changes in Transportation During COVID-19 in Allegheny County.
- December 8, 2020 - Students made final project presentations at the Traffic21 supported CMU graduate course Smart Cities: Growth and Intelligent Transportation Systems taught by Mobility21 Professors Sean Qian and Stan Caldwell. This course exposes an interdisciplinary group of students to new transportation technology and policy issues and career opportunities in the ITS industry. Multiple UTC faculty members and deployment partners provided guest lectures on their related research throughout the course.
- November 3, 2020 - Traffic21 Women in Transportation Fellow Carlee Benhart Kukula started as a communications and policy intern for Robowitz in June of 2020, but found the work so exciting that she stayed on through the fall semester. "Equity in western Pennsylvania is extremely important to me," said Carlee. "I grew up in a rural county and knew that issues of rural access and equity were close to my heart. Before this summer, I never saw myself necessarily working to help support education, but I was so excited to see how Robowitz stepped up to create 'The Robot Doctor' program to address gaps in STEM education during the pandemic that I immediately knew I was working with the right people." Carlee is helping to partner with schools and other organizations which serve students who are underrepresented in STEM. Carlee presented at the Pennsylvania TRIO conference and is scheduled to present at TEEAP, and to Intermediate Units.
- October 30, 2020 - Dominick Fiorentino, Carnegie Mellon University Master of Science in Public Policy and Management Candidate is interning this academic year (2020 – 2021) with the American Public Transportation Association. His internship in the Policy Department involves work on various transit issues including mobility innovation, public-private partnerships, and mobility recovery and restoration in context of the COVID-19 pandemic (looking at each of these areas from a sustainability and equity lens). Dominick was an active member of the CMU Transportation Club during 2019 – 2020 and through his involvement with Mobility21, was introduced to APTA (a Mobility21 UTC Deployment Partner) and secured this internship.
- October 28, 2020 - Broadcast on TV to 5,000,000 Households PA-Wide: RobotWits & WQED's Robot Doctor Series Reaches Students & Families. Educational organizations, libraries, and community centers across Pennsylvania are beginning to leverage The Robot Doctor resources created by Mobility21 Deployment Partner RobotWits LLC & public television station WQED. Downloadable, streamable, and available for offline learning, student videos can be accessed at www.robotwits.com/education.
- October 6, 2020 - Mobility21 Diversity Fellow Allanté Whitmore was a panelist on The Equitable Future of Transportation seminar held by the CMU and University of Pittsburgh Local Government Club. She discussed the role of equity in transportation, next-generation transportation technologies, and local municipalities' decision-making.

Technology Transfer

As the nature of transportation continues to evolve, Carnegie Mellon University has students and faculty conducting transportation related research in data analytics, robotics, public policy, engineering, architecture and design, and more. Since not all of these efforts are co-located in the same building, or even the same department or college, there was a need to help building a "community space" to bring together people interested in transportation on CMU's campus. This was the impetus for Mobility21's launching of the Smart Mobility Connections (SMC) seminar series. One of the UTC faculty is featured at each hour long session; half of the time is reserved for questions and answers as well as networking. All Mobility21 SMC seminars are advertised on the DOT webinar website, UTC website and publicized through faculty, student and government and industry partner distribution lists. Recordings of each session are saved to our YouTube channel and links posted to the Mobility21 UTC website's *What's Happening* section. Below are the SMCs held during this reporting period.

- March 12, 2021 – CMU researcher Jeremy Michalek discussed his project, “*Uber/Lyft Implications: Vehicle Ownership, Transit, Electrification, Air Emissions, Traffic Externalities, and Equity.*” Watch his presentation [here](#).
- February 19, 2021 – CMU researchers Maxine Eskenazi, Alan Black and Yulan Feng discussed their project, “*GetGoing and Better Mobility for All.*” Watch their presentation [here](#).
- February 5, 2021 – University of Pennsylvania researcher [Rahul Mangharam](#) spoke on his project, “*F1Tenth Autonomous Racing.*” Watch his presentation [here](#).
- December 4, 2020 – CMU researcher Carlee Joe-Wong. Carlee discussed her project, “*Incentivizing Taxi Movement for Balanced City-Wide Services.*” Watch her presentation [here](#).
- November 13, 2020 – CMU researcher Peter Zhang discussed his project, “*Gaps and Opportunities in School Bus Transportation.*” Watch his presentation [here](#).
- October 30, 2020 – Ohio State University Professor Mark McCord discussed his project, “*Time-of-Day Traffic Volumes Using Video Imagery Obtained from Transit Buses in Regular Operations,*” which is co-authored by Rabi Mishalani, and Benjamin Coifman. Watch his presentation [here](#).
- October 9, 2020 – Jon Peha, Professor at Carnegie Mellon University, in the Dept. of Engineering & Public Policy and the Dept. of Electrical & Computer Engineering, discussed “*Spectrum Policies for Connected Vehicles.*” Watch his presentation [here](#).

As both a workforce development and technology transfer initiative, the UTC is launching a new Managing Artificial Intelligence in Transportation executive education Certificate Program in collaboration with CMU’s Heinz College. The virtual bootcamp will be offered in May 2021 to provide transportation managers with a practical guide to getting started with Artificial Intelligence and understanding how to manage the impact of this disruptive technology to the organization. The curriculum in this 5-day intensive bootcamp will explore critical areas that are required for breaking down organizational barriers and understanding how managing Artificial Intelligence can benefit key stakeholders.

On March 26, 2021, transportation industry leaders presented a preview of the upcoming executive education program Managing Artificial Intelligence in Transportation. Stan Caldwell, Executive Director of Traffic21/Mobility21 UTC, Mark Kopko, Director of the Office of Transformational Technology for PA Department of Transportation, Summer Fowler, Chief Information Officer at Argo AI and Allanté Whitmore, a Ph.D. candidate earning a joint Ph.D. in Civil Engineering and Engineering and Public Policy at Carnegie Mellon University discussed how AI is impacting all facets of transportation as well as the challenges and opportunities that private and public sector professionals face in managing this new technology. View the presentation [here](#).

Collaboration

At the core of our efforts, is collaboration. During this reporting period Stan Caldwell and Lisa Kay Schweyer had several meetings with each of the Mobility21 leads at the University of Pennsylvania, the Ohio State University and Community College of Allegheny County, to ensure continued collaboration among UTC academic partners.

Additional Collaboration Activity report period:

- March 26, 2021 - Stan Caldwell and Lisa Kay Schweyer participated in the Morgan State University Urban Mobility & Equity Center’s Day of Webinars on Urban Mobility.
- March 25, 2021 - Stan Caldwell represented UTC interests and the Research Division in the first meeting of the American Road & Transportation Builders Association Workforce Development Council. The 17 ARTBA members in attendance, representing multiple divisions, shared their recent experiences in workforce activities. Jorge Quezada of Granite Construction and Nick DiBartolo of the Rogers Group are co-chairs. Karen Bobo and Clark Martin of the Federal Highway Administration’s Highway Construction Workforce Partnership, and Julie Davis of the Association of Equipment Manufacturers, developer of her association’s new Workforce Solutions Toolkit, briefed the group.
- March 10, 2021 - Mobility21 Director Raj Rajkumar recently joined the US DOT National Highway Traffic Safety Administration’s AV TEST Initiative which provides a publicly accessible tool where automated driving systems developers and states can voluntarily submit information about automated vehicles and testing. CMU is considered a birthplace of AV technology going back the 1980s and Professor Rajkumar has been conducting AV on-road testing since 2013.

- March 5, 2021 - Mobility21 Executive Director Stan Caldwell was appointed to serve on the ITSA Broadband Deployment Task Force, which held their inaugural meeting. The ITS American Broadband Deployment Task Force is developing broadband policy for FAST Act reauthorization to support the 21st century connected, automated, shared, on-demand, and electrified transportation system. The task force's programmatic activities focus on ITS and edge device data to aid in the increase of safety and mobility and be the infrastructure pillar to bridge the rural and urban digital divide and advance public safety efforts.
- March 3, 2021 - Through Mobility21 Executive Director Stan Caldwell's UTC work on emerging transportation technology with the Greater Pittsburgh Chamber of Commerce, he participated in a meeting with Wisconsin Congressman Mike Gallagher and a small group hosted by the Great Lakes Metro Chambers Coalition for a discussion on "*Designing Infrastructure Policies for the 21st Century*."
- March 1, 2021 - Mobility21 Executive Director, Stan Caldwell was appointed to serve on the Intelligent Transportation Society of America (ITSA) FAST Act Reauthorization Task Force, where earlier today, he participated in the first meeting to discuss policy recommendations.
- February 26, 2021 - Mobility21 UTC researcher Destenie Nock participated in a Scott Institute Engineering program highlighting black engineers, which featured alumni, faculty and a student who shared their origin stories about why they chose to go into the field of engineering.
- February 17, 2021 - Today the Southwestern Pennsylvania Commission's Transit Operators Committee meeting was held. Lisa Kay Schweyer, Program Manager for Mobility21 UTC participated in the meeting, which included updates from the Federal Transit Administration/PennDOT, regional transit operators, amendments & administrative actions to the FFY2019-2022 TIP, presentations on the SmartMoves Connections, Port Authority NEXtransit, and CommuteInfo Reimagined.
- February 9, 2021 - Stan Caldwell has been appointed chair of the Emerging Technologies Standing Committee of the Intelligent Transportation Society of America and was joined by Vice Chair Andrew Liu from AECOM in hosting the inaugural committee meeting. Committee members will participate in task forces for program and policy development of emerging ITS technologies.
- January 5-6, 2021 - The Council of University Transportation Centers held their winter meeting, followed by the Annual Awards Banquet. The Council of University Transportation Center's winter meeting brings together the nation's leading transportation professionals from academia and industry along with U.S. DOT and other transportation agency officials. Raj Rajkumar, Director, Stan Caldwell, Executive Director and Lisa Kay Schweyer, Program Manager of Mobility21 participated in the meeting.
- December 11, 2020 - Mobility21 Executive Director Stan Caldwell spoke at the recent Union Internationale des Transports Publics (UITP) Research in Mobility Committee meeting, led by Ms. Jill Hough of North Dakota State University. The topic of the session was "*Role of Technology to Support Innovation and Shape the Future of Urban Mobility Post-COVID*."
- December 3, 2020 - Mobility21 UTC researcher and University of Pennsylvania professor Erick Guerra provided his expertise to Penn Today on how cities are handling a public health crisis, systemic racism, severe partisanship, and climate change all at once. Read the full article here.
- December 1, 2020 - Traffic21 Director Chris Hendrickson's paper, "*Technology Revolutions: Bringing Tomorrow Here Today*," co-authored by Johanna Zmud, was published by TR News.
- November 19, 2020 - Benjamin Schmidt, Co-Founder and President of Roadbotics, Inc., a CMU UTC spinout company was named honoree at the Pittsburgh Smart 50 Awards. The Pittsburgh Smart 50 Awards recognize the top executives of the 50 smartest companies in the Greater Pittsburgh region for their ability to effectively build and lead successful organizations.
- November 18, 2020 - Stan Caldwell participated in the quarterly meeting of the Pennsylvania State Transportation Innovation Council which was led by PennDOT Secretary Yassmin Gramian and FHWA PA Division Administrator Alicia Nolan. The group discussed innovative applications in the state including the new Automated Work Zone Speed Enforcement program.
- November 12, 2020 - Chris Hendrickson, Faculty Director of Traffic21 and researcher in Mobility21, attended the Transportation Research Board's Special Projects and Policy Committee. A wide range of issues were discussed, including strategic plans, the critical issues documents and future policy studies.
- November 12, 2020 - Mobility21 UTC researchers and Scott Institute Energy Fellows Costa Samaras and Destenie Nock are partnering with Google researchers to characterize energy equity in the U.S. as part of their Award for Inclusion Research program.
- November 11, 2020 - Chris Hendrickson, Director of Traffic21, attended the National Research Council's Governing Board meeting November 10-11 in his role as Chair of the NRC Transportation Research Board

Division Committee. Topics of discussion included approval of the NRC budget and further work on developing a strategic plan for the NRC.

- November 9, 2020 - Stan Caldwell participated in the Stakeholder Panel review of the Pittsburgh Bus Rapid Transit Final Design. Port Authority of Allegheny County's Downtown-Uptown-Oakland-East End BRT service plan calls for a "core" route that runs east-west between downtown and Oakland with three branches that go to Greenfield, Highland Park and through several Mon Valley communities.
- November 7, 2020 - Chris Hendrickson, Director of Traffic21, attended the virtual American Society of Civil Engineers Editors Workshop. During the workshop, he received the Torrens Best Editor Award for 2020. The workshop was an opportunity to discuss new technology and both administrative and ethical issues in organizing peer reviews for thousands of ASCE submission.
- November 3, 2020 - Traffic21 Director Chris Hendrickson recently helped review the Federal Railroad Administration Research & Development Program. The Transportation Research Board formed the Committee for a Review of the Federal Railroad Administration's R&D Program at the request of FRA's Office of Research, Development, and Technology for strategic feedback on the program. [Access the full report here.](#)
- October 27, 2020 - Mobility21 Executive Director Stan Caldwell participated in the 5G Automotive Association showcase of C-V2X Deployment on US Roads, which provided information on existing C-V2X projects, as well as a panel discussion focused on the state of play and the future of ITS in the US.
- October 26, 2020 - Stan Caldwell was one of a select group of industry stakeholders recruited to provide feedback on the *NCHRP Report 17-91 Assessing the Impacts of Automated Driving Systems (ADS) on the Future of Transportation Safety through a series of three virtual summit sessions.*
- October 21, 2020 - Mobility21 UTC researcher Rahul Mangharam and his team, which includes Kuk Jang, Yash Pant and Alena Rodionova, wrote a paper on *Learning-to-Fly RL*, which won the Best in Session Award at the Digital Avionics Conference. [Watch the video here.](#)
- October 1, 2020 - As a member of the American Road & Transportation Builders Association Research & Education Division, Stan Caldwell joined the joint Planning & Design and Research Divisional Meeting which featured Guest Speaker Diana Furchtgott-Roth, Deputy Assistant Secretary, Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation.
- October 1, 2020 - Mobility21 Executive Director Stan Caldwell participated in the inaugural Megaregions Transportation Policy Symposium which brought together industry practitioners, academic professionals, and policy experts to lead the conversation on technologies, policies, and trends in the field of transportation that will promote Megaregion development.
- Mobility21 UTC Director Raj Rajkumar continues his work as part of the Partners for Automated Vehicle Education (PAVE) which aims to provide members with advice and recommendations on matters related to AV technology and its societal effects, as well as collaborating with members on research, evaluation and polling.

How have the results been disseminated?

A blog and weekly e-newsletter that highlights UTC research and efforts in the news as well as smart transportation industry news, *The Smart Transportation Dispatch*, is distributed to 4,350 subscribers. The readership represents individuals in industry, government, academia and community organizations from 17 countries.

A monthly e-publication is also distributed, called *What's Happened at Traffic21?* This e-publication, sent to the same distribution list as *The Smart Transportation Dispatch*, as well as the Council for University Transportation Centers' list-serve, specifically highlights the UTC impacts, accomplishments, student work, involvement in conferences, and other news.

Before updates are sent out in either publication, they appear as individual updates/articles on the website, and are also posted through our Facebook and Twitter social media accounts. 623 articles were posted in this reporting period.

During this report period, we began submitting newly published final research reports to the TRB e-newsletter for inclusion in the *University Research News Section*. Eight reports were submitted and were mentioned in the e-newsletter.

We also publish *Research Recaps*. The recaps are easily digestible one-page overviews of the UTC funded research that describe the research project's purpose, approach, key findings, conclusions, contact information for the

Research Recap **Mobility21**
UNIVERSITY TRANSPORTATION CENTER

Understanding and Guiding Pedestrian and Crowd Motion

Purpose: To observe pedestrian behavior and their interactions with automated vehicles in areas with limited space to find ways to improve the reaction time of automated vehicles and improve pedestrian safety.

Approach: The team considered areas where first-mile and last-mile transportation could be deployed, and where there are a lot of pedestrians.

Key Findings:
Social Distancing: By using the social force model that was designed for crowd motion analysis, the team was able to first observe pedestrian behavior and their interactions with automated vehicles in areas with limited space to find ways to improve the reaction time of automated vehicles and improve pedestrian safety. The team then introduced a low speed vehicle to observe how the patterns of pedestrians changed in response to the vehicle.
Conclusion: The team took into consideration that pedestrians have certain constraints that play a role in their reactions – when an area becomes more populated with pedestrians, they will slow down, when a car dangerously approaches a pedestrian, they will immediately move out of the way, when there are no cars nearby, pedestrians will walk at a comfortable pace. These constraints helped guide the research in generating better decisions for autonomous vehicles in crowded areas.
Details: The team created a dataset that provides real pedestrian behavior in crowded street space areas to support the study of interactions.
Pedestrian Detection: By utilizing a combination of various processor cameras, LiDAR, and other sensors, the team was able to measure the pedestrian movement around the vehicle.
Conclusion: The researchers proposed a framework that combines the pedestrian behavior modeling with pedestrian detection, scenario prediction, and driving efficiency improvement in pedestrian detection analysis. In the future, this framework will be a valuable project, they will explore and develop their approaches and measure their studies that will demonstrate how to apply the proposed model into driving safety.

Research Team:
• Udit Chughan | Principal Investigator | Udit.Chughan@ucyber.ucy.edu
• Udit.Chughan@ucyber.ucy.edu
• Udit.Chughan@ucyber.ucy.edu
• Udit.Chughan@ucyber.ucy.edu

Follow Us:
• www.facebook.com/traffic21ust
• [@Traffic21UM](https://twitter.com/Traffic21UM)

The contents of this Research Recap reflect the views of the lead researcher or report authors, who are responsible for the facts and the accuracy of the information presented. This document is disseminated under the sponsorship of the U.S. Department of Transportation's University Transportation Centers Program, in the interest of advancing the state-of-the-art in transportation research and the U.S. Government assumes no liability for the information and its use.

research team and a link to the final research report. During this report period, the following recaps were distributed through our *What's Happened at Traffic21?* publication and posted to our Mobility21 website:

- Bus on the Edge: Continuous Monitoring of Traffic and Infrastructure
- Latest Generation Data Portal for the Intelligent Mobility Meter
- Modeling and Enhancing Freight Mobility in the Philadelphia Region
- Travel Impacts of a Complete Street Project in a Mixed Urban Corridor
- Cost-Effective Designs of Smart City Technologies for Vehicular Communications
- Utilizing School Bus Meals to Deliver Meals to Families in Need

We held our annual Advisory Council meeting and Deployment Partner Consortium events on Wednesday, November 18 (Advisory Council), Thursday, November 19 and Friday, November 20 (Deployment Partner Consortium Symposium).



A talented group of national leaders, comprising the Carnegie Mellon University Traffic21 Institute and Mobility21 National University Transportation Center Advisory Council, attended their annual Advisory Council November 18.

Mobility21 UTC Director, Raj Rajkumar welcomed the group and provided an overview of update of activities and plans at the centers.

The remaining time was spent by the Advisory Council members leading “dinner table” conversations for the entire group on (leader/topic):

- Jim Misener: Communications is a Mode of Transportation
- Rebecca Brewster: Where’s My Stuff?
- Paul Skoutelas: Transit – Where is My Ride?
- Robin Chase: I can’t drive and don’t have access to a car right now
- Ashley Hand: City Streets: Social Cost-Benefit + Vision Zero

The Traffic21/Mobility21 Deployment Partner Consortium is engaged 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.

Putting our research, development and deployment approach into action – the annual deployment partner symposium provides an opportunity for interaction and discussion among researchers, students and deployment partners.

In 2020, the Traffic21/Mobility21 University Transportation Center Deployment Partner Consortium Symposium was held virtually on Thursday, November 19 from 11 AM – 2:30 PM eastern, followed on Friday, November 20 with a UTC Academic and Research Showcase.

Over 250 registrants from academia, community, government, and industry joined 30+ speakers for the 2 day event. **Thursday, November 19, 2020, 11 AM - Welcome & Program Updates** [Watch the video here.](#)

11:45 AM - Panel One: Transportation & Equity – How to address systemic challenges [Watch the video here.](#)

- Sofia Gallo, Special Assistant for Policy, Office of the Secretary of Transportation



- Carol Wright, Director of Easter Seals Transportation Group and co-director of the National Aging and Disability Transportation Center
- Jill Hough, Program Director, Small Urban and Rural Center on Mobility, Upper Great Plains Transportation Institute, North Dakota State University
- Mariah S. Stanley, National Program Manager, Conference of Minority Transportation Officials

1:15 PM - Panel Two: COVID-19 – How has mobility changed and impacted deployment? [Watch the video here.](#)

- Yassmin Gramian, Secretary of Transportation, Pennsylvania Department of Transportation (PennDOT)
- Chuck Hammel, CEO, Pitt OHIO
- Larry Rilett, Distinguished Professor, Keith W. Klaasmeyer Chair in Engineering and Technology, Director of the Nebraska Transportation Center and the Mid-America Transportation Center
- Vincent Valdes, CEO, Southwestern Pennsylvania Commission
- Connie McGee, Board President, Association for Commuter Transportation

Friday, November 20, 2020 - UTC Research and Education Showcase - 11 AM – Noon: [Watch the Video Here.](#)

- Autonomous Logistics Services
- Spectrum Policy for Connected Vehicles
- Real-Time Obstacle Detection and Traffic Analytics
- Development of A Safe, Profitable, and Fair Robotaxi Deployment Strategy
- INCEPTS: Software for Determining Optimal Placement of Electric Vehicle Chargers

12:15 PM – 1:15 PM: [Watch the video here.](#)

- Using LGSVL and Apollo Simulator to Assess HMI Needs While in Self-driving mode
- Improving Short-term Travel Speed Prediction with High Resolution Spatial and Temporal Rainfall Data
- Pedestrians on the Roadway
- What the heck is a “Choice Rider” anyway? A theoretical framework and empirical findings from the Philadelphia region.
- Leveraging Data Sources to Assess Effects of a Mileage Based User Fees in Pennsylvania (attachment 1, attachment 2)

1:30 PM – 2:30 PM: [Watch the video here.](#)

- Estimating Traffic Volumes from Bus-based Video Imagery Obtained during Regular Transit Operations
- Towards More Accessible Trip Planning Dialog System
- Bus on the edge: Continuous monitoring of traffic and infrastructure
- Mobility Data Analytics Center
- School Bus Sharing

2:45 PM – 3:45 PM: [Watch the video here.](#)

- Women in Transportation Fellowship
- Mentoring Emerging Scholars in Robotics
- F1Tenth Autonomous Racing: Community, Competitions and Courses
- Virtual Racing



The next annual meeting of the Advisory Council and Deployment Partner Consortium will be in November 2021.

Additional Dissemination Activity:

- March 9, 2021 - Mobility21 UTC researcher Scott Matthews was featured on Mileage-Based User Fee Alliance Radio to discuss the existing ways that transportation revenues are collected and disbursed, and ideas on what is needed to move more states from plans to pilots to programs.
- February 25, 2021 - Mobility21 UTC researcher Rick Grahn presented the project, “Travel Impacts of a Complete Street Project in a Mixed Urban Corridor” at the Southwestern PA Commission’s Operations & Safety Meeting.
- December 9, 2020 - Mobility21 UTC researcher Jon Peha presented his work on “*Spectrum Policy for Intelligent Transportation Systems*” at an international meeting organized by the United Nations’ International Telecommunications Union, and the Communications and Information Technology Commission of Saudi Arabia.

- November 17, 2020 – Mobility21 UTC researcher Jon Peha, along with Alexandra Ligo, presented their work on “*Comparison of Vehicle-to-Everything (V2X) Technologies for Road Safety*” at the Transportation Research Board Transit Safety and Security Conference.
- October 21, 2020 - Stan Caldwell presented findings from his automated vehicle policy white paper “*Are We There Yet? Deployment of Connected and Automated Vehicles in the U.S.*” co-authored by Chris Hendrickson at an UIC Urban Forum Panel Discussion. Caldwell was joined by Austin Lannes Brown Executive Director of the Policy Center for Energy, Environment and the Economy at UC Davis and moderated by P.S. Sriraj Director, Urban Transportation Center, University of Illinois at Chicago. A recording of the webinar can be found at this link: <https://urbanforum.uic.edu/forum-white-papers/white-paper-presentation-webinar/>.
- October 7, 2020 - Mobility21 UTC researcher Sean Qian along with Mike Turley and Ryan Fonzi of North Huntingdon Township presented findings of the Mobility21 UTC Smart Mobility Challenge Project *Smart Multi-modal Transportation Solution for North Huntingdon Township in Response to Roadway Construction Projects on Route-30* to PennDOT officials and project consultants. Lisa Kay Schweyer, Program Manager for the Mobility21 UTC also participated by sharing information about the Smart Mobility Challenge.

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

Up until the federal government prohibited gatherings of more than 10 people and the Commonwealth of PA required residents in Allegheny County to shelter in place, we had been continuing to plan for the 3rd Annual National Mobility Summit of UTCs which was scheduled to be held on April 2, 2020. Due to the restrictions put in place to mitigate the impact of COVID-19, this event was rescheduled for April 15, 2021. At the time of postponement over 130 people had registered representing over 80 organizations. It is anticipated that the program will be preserved and everyone will get a chance to hear from the federal perspectives panel, the community and industry panel and discuss research opportunities. Planning continued for the April 15, 2021 event.

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS: Who has been involved?

What organizations have been involved as partners?

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.

The list of partners is continually updated on the Mobility21 website based on the research projects being conducted, <https://mobility21.cmu.edu/about/leadership/deployment-partners/>. There are currently 165 deployment partners.

The list on below and on the next page indicates **new** partners added this reporting period.

Partner Organization Name	Location	Contribution to the Project				
		Financial support	In-kind support	Facilities	Collaborative research	Personnel exchanges
Common Caches	Charlottesville, VA		X		X	
DriveSally	Long Island City, NY		X		X	
Greater Pittsburgh Chamber of Commerce	Pittsburgh, PA		X		X	
Panasonic	Newark, NJ		X		X	
Puget Sound Regional Council	Seattle, WA		X		X	
Quality Counts, LLC	Tigard, OR		X		X	
Radium	Toronto, Ontario		X		X	
Technische Universität Clausthal	Clausthal-Zellerfeld, Germany		X		X	
Three Rivers Optics Lab	Pittsburgh, PA		X		X	

Have other collaborators or contacts been involved?

The UTC also utilizes a distinguished Advisory Council of national leaders to provide strategic guidance and counsel. We sought to achieve modal and demographic diversity. The individual members provide significant collaboration opportunities with their extensive professional affiliations. In October, PA Department of Transportation Secretary Yassmin Gramian joined the Mobility21 UTC Advisory Council as its newest member. The list of Advisory Council

members can be found on our website, mobility21.cmu.edu/about/leadership/advisory-council/.

3. OUTPUTS: What new research, technology or process has the program produced?

Publications, conference papers, and presentations

Title	Citation	Type	Date
Improving Short-Term Travel Speed Prediction with High-Resolution Spatial and Temporal Rainfall Data	Harper, C. D., Qian, S., & Samaras, C. (2021). Improving Short-Term Travel Speed Prediction with High-Resolution Spatial and Temporal Rainfall Data. <i>Journal of Transportation Engineering, Part A: Systems</i> , 147(3), 04021004.	Peer-reviewed Journal	3/1/2021
Predicting Pedestrian Crossing Intention with Feature Fusion and Spatio-temporal Attention	Dongfang Yang, Haolin Zhang, Ekim Yurtsever, Keith Redmill, Umit Ozguner, "Predicting Pedestrian Crossing Intention with Feature Fusion and Spatio-temporal Attention", Submitted to 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) on 2/28/2021.	Other	2/28/2021
Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities	Vadakpat, G. S.F. Smith, Z.B. Rubinstein, and M. Bernardine Dias, "Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities", <i>Public Roads</i> , 84(4): 17-21, Winter, 2021.	Trade/Professional	2/15/2021
New Rules for Old Roads	Ryerson, Megan S., Carrie S. Long, Joshua H. Davidson, and Camille M. Boggan. "New Rules for Old Roads." <i>Issues in Science and Technology</i> 37, no. 2 (Winter 2021).	Other	2/1/2021
Towards Automatic Route Description Unification In Spoken Dialog Systems	Yulan Feng, Alan W Black, Maxine Eskenazi, Towards Automatic Route Description Unification In Spoken Dialog Systems, Proc. 8th IEEE Spoken Language Technology Workshop (SLT 2021).	Other	1/21/2021
Photorealism in Driving Simulators: Blending Generative Adversarial Image Synthesis with Rendering for Computer Graphics	Ekim Yurtsever, Dongfang Yang, Ibrahim Mert Koc, Keith A. Redmill, "Blending Generative Adversarial Image Synthesis with Rendering for Computer Graphics", submitted to IEEE Trans on Intelligent Transportation Systems on 1/5/2021.	Peer-reviewed Journal	1/5/2021
A Vision-based Social Distancing and Critical Density Detection System for COVID-19	Dongfang Yang, Ekim Yurtsever, Vishnu Rendnathan, Keith Redmill, Umit Ozguner, "A Vision-based Social Distancing and Critical Density Detection System for COVID-19", submitted to IEEE Trans Emerging Topics in Computational Intelligence on 12/19/2020.	Peer-reviewed Journal	12/19/2020
Accelerating Decarbonization of the U.S. Energy System	National Academies of Sciences, Engineering, and Medicine. (2021). <i>Accelerating Decarbonization of the U.S. Energy System</i> , National Academies Press. doi: https://doi.org/10.17226/25932 .	Peer-reviewed Journal	12/15/2020
CMU Informedia at TRECVID 2020: Activity Detection with Dense Spatio-temporal Proposals	Yu, Lijun, Yijun Qian, Wenhe Liu, and Alexander G. Hauptmann. "CMU Informedia at TRECVID 2020: Activity Detection with Dense Spatio-temporal Proposals." In <i>NIST TREC Video Retrieval Evaluation (TRECVID) 2020 Workshop</i> . 2020.	Peer-reviewed Journal	12/9/2020
Travel Impacts of a Complete Street Project in a Mixed Urban Corridor	Grahn, R., Hendrickson, C., Matthews, H. S., Harper, C., & Qian, S. (2020). Travel Impacts of a Complete Street Project in a Mixed Urban Corridor. <i>ASCE J. of Infrastructure Systems</i> .	Peer-reviewed Journal	10/30/2020
Travel Impacts of a Complete Street Project in a Mixed Urban Corridor	Grahn, R., Hendrickson, C., Matthews, H. S., Harper, C., & Qian, S. (2020). Travel Impacts of a Complete Street Project in a Mixed Urban Corridor. <i>ASCE J. of Infrastructure Systems</i> .	Peer-reviewed Journal	10/30/2020
Technology Revolutions: Bringing Tomorrow Here Today	Hendrickson, Chris and Johanna Zmud (2020) 'Technology Revolutions: Bringing Tomorrow Here Today,' <i>TR News</i> , September-October 2020.	Trade/Professional	10/30/2020
Snow Plow Route Optimization: A Constraint Programming Approach	Kinable, J., W. Van Hoave, and S.F. Smith, "Snow Plow Route Optimization: A Constraint Programming Approach", <i>IISE Transactions</i> , DOI: 10.1080/24725854.2020.1831713, October 2020	Peer-reviewed Journal	10/15/2020

A Multi-State Social Force Based Framework for Vehicle-Pedestrian Interaction in Uncontrolled Pedestrian Crossing Scenarios	Yang, Dongfang, Keith Redmill, and Ümit Özgüner. "A Multi-State Social Force Based Framework for Vehicle-Pedestrian Interaction in Uncontrolled Pedestrian Crossing Scenarios." accepted by 2020 IEEE Intelligent Vehicles Symposium (IV), Las Vegas, NV, United States, 2020.	Other	10/7/2020
Optical flow based visual potential field for autonomous driving	Linda Capito, Umit Ozguner, and Keith Redmill, "Optical flow based visual potential field for autonomous driving", Presented at IEEE Intelligent Vehicles Symposium, October 2020, pp. 885-891.	Other	10/1/2020
Integrating Deep Reinforcement Learning with Model-based Path Planners for Automated Driving	Ekim Yurtsever, Linda Capito, Keith Redmill, and Umit Ozguner, "Integrating Deep Reinforcement Learning with Model-based Path Planners for Automated Driving", Presented at IEEE Intelligent Vehicles Symposium, October 2020, pp.1311-1316.	Other	10/1/2020
Visual potential field based control for autonomous navigation in unseen environment	Linda Capito, Umit Ozguner, and Keith Redmill, "Visual potential field based control for autonomous navigation in unseen environments." Submitted to Automated Vehicle Symposium 2020.	Other	10/1/2020

Other publications, conference papers and presentations:

Title	Event	Event Type	Attendance	Date
GetGoing and Better Mobility for All.	Smart Mobility Connection	Seminar-Academic	50	2/19/2021
Real-time Activity Detection in Unknown Facilities with Dense Spatio-temporal Proposals	Workshop on Human Activity Detection in multi-camera, Continuous, long-duration Video (HADCV 21)	Workshop-Academic	200	1/5/2021
Spectrum for Intelligent Transportation Systems (ITS)	United Nations' International Telecommunications Union Workshop on Radio Spectrum for IMT-2020 and beyond: Fostering Commercial and Innovative Use	Symposium-Professional	50	12/9/2020
CMU Informedia at TRECVID 2020: Activity Detection with Dense Spatio-temporal Proposals	NIST TREC Video Retrieval Evaluation (TRECVID) 2020 Workshop	Workshop-Academic	200	12/9/2020
Estimating Traffic Volumes from Bus-based Video Imagery Obtained during Regular Transit Operations	Traffic21/Mobility 21 Deployment Partner Consortium Symposium	Symposium-Professional	100	11/20/2020
Spectrum Policies for Connected Vehicles	Traffic 21 / Metro 21 Symposium	Conference-Professional	35	11/20/2020
Bus on the Edge: Continuous monitoring of traffic and infrastructure	Deployment Partner Consortium Symposium	Symposium-Professional	100	11/20/2020
School Bus Sharing	Traffic21/Mobility21 UTC Deployment Partner Consortium Symposium	Symposium-Professional	250	11/20/2020
Comparison of Vehicle-to-Everything (V2X) technologies for road safety	Transportation Research Board (TRB) Transit Safety and Security Conference	Conference-Professional	51	11/17/2020
Gaps and Opportunities in School Bus Transportation	Smart Mobility Connection	Seminar-Academic	30	11/13/2020
Smart Right-of-Way Permitting System for Cranberry Township: coordination, pricing and enforcement	Seminar	Seminar-Professional	5	11/11/2020
Photogrammetry and Neural Networks to Detect Form Changing Slope Conditions	Landslide Capacity Building Virtual Seminars	Seminar-Professional	50	11/6/2020
Time-of-Day Traffic Volumes Using Video Imagery Obtained	Mobility 21/Carnegie Mellon University, Smart Mobility Connections Seminar Series	Seminar-Academic	30	10/30/2020

from Transit Buses in Regular Operation				
Breaking the Impasse on Spectrum for Intelligent Transportation Systems	Alliance for Automotive Innovation	Seminar-Professional	23	10/16/2020
Spectrum Policies for Connected Vehicles	Smart Mobility Connection Seminar Series	Seminar-Academic	65	10/9/2020

Website(s) or other Internet site(s)

URL for Internet site(s) that disseminates the results of the research and/or program activities	Short description of the site	Metrics
https://traffic21.heinz.cmu.edu	The Carnegie Mellon University's Traffic21 Institute website	New Posts: 623
http://mobility21.cmu.edu/	The Carnegie Mellon University's Mobility21 National University Transportation Center website	New Posts: 623
https://www.facebook.com/traffic21.tset	The Carnegie Mellon University's Facebook Page for Mobility21, a National University Transportation Center for Improving Mobility of People and Goods, and the former Technologies for Safe and Efficient Transportation National University Transportation Center	Followers: 231
https://www.youtube.com/user/Traffic21TSET	The Carnegie Mellon University's YouTube Page for Mobility21, a National University Transportation Center for Improving Mobility of People and Goods, and the former Technologies for Safe and Efficient Transportation National University Transportation Center	Videos: 61 Views: 3,121
https://twitter.com/Traffic21_CMU	The Carnegie Mellon University's Twitter Page for Mobility21, a National University Transportation Center for Improving Mobility of People and Goods, and the former Technologies for Safe and Efficient Transportation National University Transportation Center	Followers: 1,159 Following: 1,738

Technologies or techniques

- Starting in October, Luke Lyle, a postdoctoral researcher in the College of Engineering at Carnegie Mellon University and a Swartz Center 2020 – 2021 Innovation Fellow began working with Mobility21 and the Swartz Center for Entrepreneurship to commercialize this technology. He completed his MS and PhD in Materials Science and Engineering at CMU and also holds a BS and BA in Physics and Mathematics from the University of Buffalo. The focus of his doctoral research was gallium oxide, a wide bandgap semiconducting material for high power electronic applications. In these applications, gallium oxide is poised to have vastly higher efficiencies than competing materials. This material is critical for developing renewable energy technology by increasing the efficiency of power electronics in electric vehicles, wind turbines, solar cells, and batteries. He is working on commercializing this technology with the development of an industrially scalable, novel technique to grow gallium oxide aiming to leverage this material for use in renewable energy systems.

Inventions, patent applications, and/or licenses

Three UTC related intellectual property disclosures were filed:

- Adaptive HMSS: Hybrid Model-enabled Sensing System for Mobile Fine-Grained Air Pollution Estimation
- Learning to Recommend Signal Plans Under Incidents With Real-time Traffic Prediction
- Strategic and Operational Design for First-Mile-Last-Mile Public Transit Services

Discuss the performance measures (a minimum of two) for research outcome your Center identified in your Technology Transfer Plan Report and the targets (goals) for each measure.

	Research Performance Measure	Annual Target	This Reporting Period
Output #1	Annual Number of Journal Publications	35	17
Output #2	Annual Number of Research Pilot Deployments	10	8

Please see “Section #3 Publications” for examples of publications.

Some examples of these research pilot deployments include:

- *Machine Learning Helps Reduce Food Insecurity During COVID-19* – “Researchers in Carnegie Mellon University’s Robotics Institute were able to use machine learning technology to reduce food insecurity in Pennsylvania communities during the pandemic....The team leveraged advanced analytics tools to create cost-effective bus routes that allow nonprofit organizations to deliver meals to senior citizens, as well as K-12 students and families who would otherwise rely on schools for free meals. The machine learning tools identified ideal distribution locations to reach as many people as possible, three days a week....The program began in July, and nearly 6,000 meals are delivered each month.”
- As part of the Smart Glasses for Improving Mobility of Low Vision People project, in addition to their current tasks, they responded to a call from their collaborator Dr. Paul Freeman, the head of Low-Vision Lab in Allegheny General Hospital, to find a solution to help the low-vision patients to do visual training with bioptic glasses. The researchers prototyped a 3-camera system that can stream live videos from a moving vehicle to the computer at the doctor’s office wirelessly.
- Researchers designed a general, technical tool to screen the benefit of school districts collaborating to improve transportation efficiency as part of the joint optimization of school bus routes and last mile services project.
- The Bus on the edge: Continuous monitoring of traffic and infrastructure project included installation of an edge computing system on an actual transit bus. They are working to refine the system, thoroughly test its functionality by running various applications on it and evaluate its performance. In February they took a major step by successfully installing the hardware on a Freedom Transit bus. While the bus is driving, the edge computer looks for traffic signs and sends the corresponding images to a central server. There the images are checked with a more powerful detector and the final result is displayed on an interactive map on a webpage.
- The project team for Wearable neurotechnology for inferring the driver's attention for assistive driving, has deployed a preliminary version of wearable EEG clips at the University of Pittsburgh Children’s Hospital, in their Epilepsy Unit.

4. OUTCOMES: What outcomes has the program produced? How are the research outputs described in section (3) above being used to create outcomes?

Outcomes are the application of outputs; any changes made to the transportation system, or its regulatory, legislative, or policy framework, resulting from research and development outputs.

Discuss the performance measures (a minimum of two) for research outcomes your Center identified in your Technology Transfer Plan Report and the targets (goals) for each measure.

	Research Performance Measure	Annual Target	Current Reporting Period
Outcome #1	Annual Number of Media Stories Referencing UTC Research, Faculty, or Spinoff	80	39
Outcome #2	Annual Number of Instances Providing Exposure to Transportation, Science and Technology for Practitioners, Teachers, Young people, or Other Members of the Public <i>(other publications, conference papers and presentations)</i>	50	73

Some examples of the Media Stories Referencing UTC Research, Faculty, or Spinoff:

- *March 29, 2021 - Is A Mileage-Based User Fee A Likely Replacement For The State's Gasoline Tax?* – “Nobody likes the state’s 59-cent-a-gallon gasoline tax, one of the highest in the nation, and with more electric and fuel-efficient cars, the gas tax is not bringing in the revenue to repair our roads... ‘It’s actually pretty simple to think about which is instead of paying by the gallon, you pay by the mile you drive,’ says Carnegie Mellon University professor Scott Matthews.”
- *March 26, 2021 - Study reveals plunge in lithium-ion battery costs* – “The new study looks back over three decades, including analyzing the original underlying datasets and documents whenever possible, to arrive at a clear picture of the technology’s trajectory... ‘Battery costs determine price parity of electric vehicles with internal combustion engine vehicles,’ says Venkat Viswanathan, an associate professor of mechanical engineering at Carnegie Mellon University, who was not associated with this work.”
- *March 26, 2021 - H. Scott Matthews and Prithvi S. Acharya: Nothing is certain, except for the death of fuel taxes* – “Gov. Tom Wolf recently announced a commission to study the phaseout of Pennsylvania’s gasoline tax. Achieving Mr. Wolf’s vision is possible, and quickly, but will require tough compromises in the Pennsylvania Legislature and a commitment to an entirely new way of getting transportation revenue. The result will be a sustainable funding strategy, based on vehicle miles driven, rather than on the outdated metric of gallons consumed, which embraces technology in modern cars...”
- *March 23, 2021 - If Tesla is the Apple of electric vehicles, VW could be the Samsung* - “VW announced it plans to build six battery factories across Europe by 2030, which Bloomberg estimates would cost about \$29 billion.... Venkat Viswanathan, an associate professor at Carnegie Mellon University and an EV expert, also thinks Tesla’s drivetrains comprising both batteries and electric motors are four or five years ahead of the competition...”
- *March 15, 2021 - Electric Cars Are Coming. How Long Until They Rule the Road?* – “So policymakers may need to consider additional strategies to clean up transportation, experts said. That could include policies to buy back and scrap older, less efficient cars already in use. It could also include strategies to reduce Americans’ dependence on car travel, such as expanding public transit or encouraging biking and walking, so that existing vehicles are driven less often.... ‘There’s an enormous amount of inertia in the system to overcome’” said Abdullah Alarfaj, a graduate student at Carnegie Mellon University who led a recent study that examined how slow vehicle turnover could be a barrier to quickly cutting emissions from passenger vehicles.”
- *March 15, 2021 - The end of another Sidewalk Labs-linked project highlights smart city sticking point* - “‘People are worried about their privacy. There’s a lot of distrust out there,’ said Karen Lightman, executive director of the Metro21: Smart Cities Institute at Carnegie Mellon University.”
- *March 5, 2021 - The world’s first driverless water taxi has been built in Tennessee* - “‘Autonomous ship applications have advanced rapidly because vessels on waterways have less potential conflicts to navigate than vehicles on roadways, especially city streets,’ says Stan Caldwell, adjunct associate professor of transportation and public policy at Carnegie Mellon, and executive director of the university’s Traffic21 Institute.”
- *February 16, 2021 - Roads, transit and tech: How Buttigieg plans to localize the federal transportation agenda* – “[Buttigieg] has pledged new federal automotive fuel economy standards to reduce greenhouse gas emissions and install 500,000 electric vehicle charging stations nationwide by 2030. He wants to move forward on long-awaited federal rules governing autonomous vehicles.... ‘He’s going in the same direction as we are,’ said Stan Caldwell, adjunct associate professor of transportation and public policy at Carnegie Mellon University. ‘He understands the impact of transportation not just as the movement of people and goods but as community and economic development for a city, and how important it is to a city and a region,’ Mr. Caldwell said.”
- *February 24, 2021 - When Planning Smart Cities, Don’t Forget About Accessibility in Mobility* – “There are many successful use cases where smart cities are implementing mobility projects, using machine learning and AI to analyze data patterns and improve life for their residents. For example, in 2012, Pittsburgh’s city implemented Surtrac, an intelligent traffic signaling system, reducing travel times and emissions by optimizing vehicles’ movement through intersections. Analysis of the project found that the average travel times reduced by 25%, and cars spent up to 40% less time idling. This affected not only citizens’ quality of life but also the environment by reducing emissions.”
- *February 19, 2021 - The Auto Industry Bets Its Future on Batteries* - Carmakers are engaged in an intense race to acquire the chemical recipe that will deliver the most energy at the lowest price and in the smallest package. G.M.’s announcement last month that it would go all electric by 2035 was widely considered a landmark moment by policymakers and environmentalists.... ‘This was the last in a wave of big announcements that very clearly signaled that electric vehicles are here,’ said Venkat Viswanathan, an associate professor at Carnegie Mellon University who researches battery technology.”

- February 17, 2021 - *Biden's push for electric vehicles puts US in international race to electrify* – “The stakes of the electric vehicle race are about more than economic opportunity and bragging rights. ‘Transportation is now the largest source of carbon pollution in the United States, and over the last 10 years the grid has gotten a lot cleaner, there’s been a lot more renewables added to the grid. And so the grid has gotten about 33% cleaner over the last 10 years, while gasoline has remained the same old dirty gasoline,’ said Constantine Samaras, an associate professor of civil and environmental engineering at Carnegie Mellon University.”
- January 27, 2021 - *Philly transportation needs a universal way to measure racial equity* | Opinion – “In Philadelphia, the city and the Southeastern Pennsylvania Transportation Authority (SEPTA) consider equity in their transportation plans, but they lack a standard method to analyze results and sufficient coordination between entities, resulting in a fractured approach. To remedy this, the city needs a universal transportation equity measure that can be used across transportation projects. Having a universal measure can not only help to better identify vulnerable communities but establish the foundation for a coordinated citywide process for considering equity in city transportation projects...”
- January 20, 2021 - *Uber is bringing its EV and public transit features to more cities* – “Uber Green, the feature that allows customers to request rides in electric vehicles, is coming to more cities. After initially launching in 15 cities last September, the ride-hail company is bringing the feature to 1,400 additional cities and towns in North America. The new markets include Austin, Calgary, Houston, Miami, New York City, Tucson, Winnipeg, Washington, DC, and hundreds more... Uber has been linked to rising car congestion and increased pollution in cities. A new study from Carnegie Mellon found that the benefit from people ditching their cars to use ride-hailing services is negated by new vehicles added to the road by aspiring Uber and Lyft drivers.”
- January 18, 2021 - *CMU team to examine autonomous vehicles for people with disabilities* – “John Tague, chairman of the Pennsylvania Transportation Alliance, uses a wheelchair and understands the daily mobility challenges faced by people with disabilities.... That’s why Mr. Tague is excited that a team from Carnegie Mellon University has received a grant to develop a prototype system for autonomous vehicles that will allow anyone to control most vehicle functions — from summoning the vehicle to their location to controlling the windows and the temperature of the air conditioning — from their cellphones... The team, based in CMU’s Human-Computer Interaction Institute, was among 10 across the country that received \$300,000 grants last week from the federal Department of Transportation to continue developing their ideas to make autonomous vehicles more practical for people with disabilities... The grant is part the DOT’s Inclusive Design Challenge, a competitive program to improve mobility for people with disabilities. Three finalists will split \$2 million to produce their product.”
- January 13, 2021 - *When Uber and Lyft enter cities, vehicle ownership increases* – “When ridesourcing companies Uber and Lyft show up in urban areas, vehicle registrations per capita increase by 0.7% on average, increasing even more in car-dependent cities.... ‘I would have expected people to own fewer vehicles once they gain access to this alternative transportation mode,’ says Jeremy Michalek, a professor of engineering and public policy at Carnegie Mellon University and co-author on the study. ‘But that’s not what we see in the data. One possible explanation could be that there’s an effect on the other side, where somebody who was on the verge of being able to afford a vehicle now has an incentive to buy one and earn some money with it. So vehicle adoption by Uber and Lyft drivers may outweigh the effect of riders getting rid of their personal vehicles.’”
- January 13, 2021 - *How Much Will Electric Cars Cost In 2025* – “A recently released auto industry report by the Economist publication has shown that consumers will pay far less to purchase an electric car by 2025... According to the Open Grid Scheduler, prices of electric vehicles will soon rival the regular vehicle prices. All this should happen once the battery prices fall below \$100 per kilowatt-hour.... Many auto industry gurus are convinced that it will happen by 2025. The Carnegie Mellon University team, led by Venkat Viswanathan, first developed a model used to calculate EV battery costs. The model breaks down the individual component costs and subsequently predicts the changes over time.”
- January 13, 2021 - *The pandemic cost public transit dearly. Will Pittsburgh-area riders return in 2021?* – “Stan Caldwell, executive director of the Traffic21 Institute at Carnegie Mellon University, noted that many people still don’t feel safe enough to use transit.... ‘In my opinion, both locally and nationally, it’s a clear reluctance for people to be in close proximity to other people in an enclosed environment,’ Caldwell said. ‘So we are seeing people taking other modes of transportation, and we are seeing vehicle miles traveled going back up to pre-pandemic levels here in the state of Pennsylvania and nationally.’...”
- December 7, 2020 - *Can Biden's climate plan spark cooperation in Pa.? Some see possible common ground in jobs, infrastructure* – “Climate change is one of the four major crises President-elect Joe Biden hopes to tackle after he’s sworn into office in January.... ‘If we can figure out a way to do decarbonization in Pennsylvania,

especially — a place that has legacy fossil fuel history — we can do it anywhere,’ said Costa Samaras, an associate professor of civil and environmental engineering at Carnegie Mellon University.”

- November 18, 2020 - *How the ‘Dead Zone’ Could Help This Car Take on Tesla* – “According to Carnegie Mellon University electric vehicle researchers Shashank Sripath and Venkat Viswanathan, who track the relative efficiencies of various electric powertrains and have been analyzing the Lucid Air over the past several weeks, the new car scores 218 watt-hours per mile in overall efficiency—factoring in the car’s stated range, weight, drag, frontal area, and rolling resistance—while the Tesla Model S requires 250. ...”
- November 13, 2020 - *VIRGIN HYPERLOOP HITS AN IMPORTANT MILESTONE: THE FIRST HUMAN PASSENGER TEST* – “In 2017, Virgin Hyperloop’s top executives told The Verge they expect to see ‘working hyperloops around the world... by 2020.’ That deadline was later pushed to 2021, the year they believe the hyperloop will be ready for human passengers....There are still a lot of safety questions that need to be answered, said Constantine Samaras, associate professor of civil and environmental engineering at Carnegie Mellon University. ‘A hyperloop vehicle will travel much faster than high-speed rail, maybe even reaching 760 mph,’ Samaras said in an email. ‘Maintaining safety at such high speeds is very important, and all of the unforeseen disasters need to be engineered into the system.’”
- November 3, 2020 - *It’s Time for Smart Traffic Lights* – “The mayhem was—only partially—tamed by the invention of the four-way, three-color traffic light 100 years ago in 1920 by Detroit policeman William Potts....By digitizing the traffic light and getting it fully into the world of Big Data, companies like NoTraffic and Pittsburgh-based Surtrac say they can offer major environmental and congestion benefits. Surtrac, working with technology developed at Carnegie Mellon University (CMU), claims to be able to reduce travel times by 25 percent, signal wait times by 40 percent, stops by 30 percent and emissions by 20 percent.”
- October 26, 2020 - *Can Toyota succeed where Sidewalk Labs failed?* – “‘It’s exciting that Toyota recognizes that to have truly autonomous vehicles, they have to be connected to everything,’ said Karen Lightman, executive director of the Metro21: Smart Cities Institute at Carnegie Mellon University (CMU). ‘It means data being shared across sectors, with everything talking to everything.’”
- October 12, 2020 - *Will remote work change central business districts?* – “Karen Lightman, executive director of Metro21 Smart Cities Institute at Carnegie Mellon University, made the same point. ‘When you are coming up with novel new technology, there’s something about whiteboarding in a room with food that you are sharing,’ she said. “‘There is something about that energy and that trust that you cannot build over Zoom.’”
- October 7, 2020 - *Philadelphia’s traffic congestion was bad before the pandemic. It could get worse.* - Megan Smirti Ryerson, associate dean for research at the University of Pennsylvania Stuart Weitzman School of Design, is concerned about those who once chose SEPTA or PATCO over other options such as a private car, but now perceive public transportation as too risky.”
- October 6, 2020 - *Fewer Americans Driving During Coronavirus Pandemic* - “‘A pandemic is the worst possible way to reduce the emissions and improve the environment,’ said climate and energy expert Constantine Samaras...However, the decline in driving during the pandemic doesn’t just reflect more people working from home. It’s also the result of widespread unemployment, shuttered businesses, and other devastating economic consequences.”
- October 5, 2020 - *What Insurance Do I Need For Micro-Mobility?* - For anyone using a micro-mobility device like a skateboard, e-bike or scooter, health insurance will generally cover your injuries if you crash. If someone else crashes into you, you can potentially sue them (and get a payout from their liability insurance) for injuries and damage to your micro-mobile... ‘Micro-mobility presents operators, and their fellow sidewalk and road users, with new risks,’ says Stan Caldwell, executive director of the Traffic21 Institute at Carnegie Mellon University.”

Some examples of the instances providing exposure to transportation, science and technology for practitioners, teachers, young people, or other members of the public (other publications, conference papers and presentations):

- March 4, 2021 - As a member of the 2021 PA AV Planning Committee, Mobility21 Executive Director Stan Caldwell moderated a webinar on automated vehicle safety and validation with the following panelists: *Nat Beuse, Aurora; Maureen Brown, Munich Re; Amy Chu, Automated Vehicle Safety Consortium; and Jackie Erickson, Edge Case Research.*
- February 25, 2021 - Stan Caldwell presented his Mobility21 research on emerging transportation technology trends on a panel in the closing session of the International Parking and Mobility Institute Mobility and Innovation Summit which was attended by two hundred transportation professionals.

- February 23, 2021 - Metro21 Executive Director Karen Lightman was a featured panelist, along with other experts in the field of smart technologies, at the 5th Annual Smart Cities Virtual Symposium, where she discussed the topic, “*Smart City Solutions for a Riskier World.*”
- December 20, 2020 - Metro21 Executive Director Karen Lightman was invited to present as a co-panelist with Congressman Mike Doyle at the program *Our Region’s Business* with Bill Flanagan to discuss smart transportation and autonomous and electric vehicles. Watch the full discussion here.
- December 7, 2020 – Mobility21 Executive Director Stan Caldwell and Metro21 Executive Director Karen Lightman participated in a broadband roundtable discussion with southwestern Pennsylvania community and economic development leaders. Issues included equity and the relationship between transportation and broadband technology.
- October 20, 2020 - Mobility21 UTC researcher Dr. Maxine Eskenazi taught a course on “*Getting Around: Using Transportation Apps*” to a group of OSHER Lifelong Learning students. The two-session course included: using UBER and LYFT; presentations of the Tiramisu app, the Transit app, the Port Authority website, the pathVu app and the GetGoing phone intelligent agent.
- October 20, 2020 - Mobility21 Program Manager Lisa Kay Schweyer presented on the role of research in transportation at the T.I.R.E.S (Transportation, Information, Resources, Education and Services) of Western PA virtual event where over 60 transportation specialists from Southwestern PA were in attendance.
- October 8, 2020 - Mobility21 UTC researcher Aaron Steinfeld participated as a panelist to discuss the early roots of innovative, accessible transportation, as well as current and future challenges and opportunities in accessible self-driving car development and the larger quest for autonomy in transportation.

5. IMPACTS: What is the impact of the program? How has it contributed to improve the transportation system: safety, reliability, durability, etc.; transportation education; and the workforce?

What is the impact on the effectiveness of the transportation system?

- Argo AI and Rapid Flow Technologies partner to integrate tech to make driving more efficient. “Pittsburgh-based autonomous vehicle company Argo AI and Pittsburgh-based software company Rapid Flow Technologies partnered for a pilot project to integrate their technologies....Rapid Flow Technologies, a Carnegie Mellon University spinout, created an edge computing software called Surtrac. The platform uses video detectors at roadway intersections to collect data, such as the number of vehicles, pedestrians and other road users approaching a traffic light... ‘What we are trying to do with Argo is augment that information with actual route information,’ Schultz said. ‘If a vehicle can tell us its route through the next three intersections, then our software has more certain information and can make better optimization decisions.’ The two companies conducted the pilot over several weeks in 2020 with 15 of Argo AI’s self-driving test vehicles... ‘The system achieved a 40% reduction in delay, or time wasted sitting at red lights, demonstrating that with self-driving vehicles on roadways sharing information with smart infrastructure, cities can improve traffic flow and cut congestion even further,’ Browning wrote in the post.”

What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

- Mobility21 UTC Executive Director Stan Caldwell and Program Manager Lisa Kay Schweyer actively participated on the American Public Transportation Association’s (APTA) Mobility Recovery and Restoration Task Force since May of 2020. “*The results of the Task Force included a set of recommendations covering a wide range of issues critical to public transportation’s future success, including safeguarding employees and riders, public and rider confidence, and customer-focused operations, as well as resiliency, equity, and societal needs.*” The group wrapped up their work and presented their recommendations in October 2020.

What is the impact on the body of scientific knowledge?

- Mobility21 Research Informs NCHRP Study - Resulting from his UTC research in automated vehicle technology and policy, UTC Director Stan Caldwell was invited to participate as an expert panelist in a listening session on Current Research and Gaps in Automated and Connected Vehicles to support the research being performed under NCHRP Project 20-126(01) *Programmatic Strategies for State Transportation Agencies Dealing with*

Issues of Future System Performance.

- February 16, 2021 - The US Government Accountability Office recently released their report “[Ensuring a Skilled Workforce in the USDOT](#),” which includes insights from Traffic21 Director Chris Hendrickson. The report highlights steps that should be taken to ensure the workforce has the skills necessary to oversee safety.
- [December 18, 2020](#) - The UTC program has been referenced in the US General Accountability Office report on “*AUTOMATED TECHNOLOGIES: DOT Should Take Steps to Ensure Its Workforce Has Skills Needed to Oversee Safety.*” Mobility21 UTC Director Raj Rajkumar was part of the Carnegie Mellon University team interviewed and acknowledged as a *Selected Transportation Stakeholder Interviewed*. [Read the full report here.](#)

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

In addition to the transportation workforce development activities mentioned earlier, this grant has expanded workforce development efforts through a partnership with the Community College of Allegheny County’s Automotive Technician Training Program.

CCAC continues to engage students and industry partners about the various employment opportunities within Intelligent Transportation Systems, Advanced Driver Assist Systems and Connected & Autonomous Vehicles. They continued discussions with high school faculty, helping modify their curriculum to include ADAS and connected and autonomous vehicles. They also covered the theory and hands-on training for automotive technicians in CCAC courses that included; ADAS specific training and information to repair these systems.

In the Mechatronics program, 10 students participated in the virtual autonomous race. Students learned how to train a neural net pilot using simulated sensor data and race their pilot against each other.

CCAC’s Automotive and Mechatronics programs educated over 180 students with some ITS and ADAS information, and will graduate 53 with degrees or certificates this year. Their outreach events exposed many different groups to “Transportation & Transportation Related Careers and Information.” They also helped sponsor Odyssey Day (October 2, 2020) – a clean energy, alternative fuels event targeting alternative fuels for transportation and other renewable and sustainable fuels for transportation in conjunction with Pittsburgh Region Clean Cities. Odyssey Day drew 90 individuals and speaker’s discussed alternative fuel issues, and success stories. All the automotive students attended and the following week discussed what alternative fuel they felt has the most impact on their careers and why.

CCAC has also:

- October 6, 2020 - Discussed ITS career opportunities with Parkway West Career Technology Center (CTC) and administration during their advisory meeting.
- October 7, 2020 – Discussed ITS career opportunities with the Butler Area CTC faculty and administration.
- October 2020 - Attended Commonwealth Academy meeting to discuss employment opportunities in ITS.
- November 24, 2020 – Lordstown Motors provided tour and information to CCAC students about the design, benefits and operation of their all electric pick-up truck. Approximately 40 students had the opportunity to see, in person, the truck and ask questions of the Lordstown staff.
- November 24, 2020 - Promoted and discussed ITS and ADAS opportunities during the CCAC trade fair.
- February 26, 2020 - Attended National Alternative Fuels Training Consortium executive board meeting.
- February 18, 2020 - National Alternative Fuel Training Consortium (NAFTC) at West Virginia University Automotive faculty presented advanced driver assist systems (ADAS) to the automotive students in the ATE-160 advanced electronics courses. 43 students participated.
- March 9, 2020 - Discussed ITS career opportunities with Greater Altoona CTC and administration.
- Worked with the ITS PCB staff to acquire the CAVe-in-a-box simulator. CCAC instructors will work through the end of April assembling and testing the simulator, then in May, introduce it to students in lab settings.

In addition, on October 29, 2020, Mobility21 UTC Researcher Ray Gastil was a featured speaker for the #SMARTer Together Webinar Series. The first in the series discussed the future workforce and how it may be affected by the COVID-19 pandemic. Link to the webinar: <https://www.youtube.com/watch?v=AQQq0OEBb4I>

And on October 7, 2020, Lisa Kay Schweyer, Program Manager for the Mobility21 UTC, Bob Koch, Professor at the Community College of Allegheny County Automotive Technology Program, Missy Blair, Program Manager/Certified MSF RiderCoach and Traffic Survival School Instructor of the Pima County Community College Center for Transportation Training and member of the Pacific Southwest Region UTC and Robert Brown, Head of Public Affairs and Government Relations for TuSimple presented “*Cultivating Readiness for the Transportation Workforce of Tomorrow*” at the National Council of Workforce Educators National Conference. They discussed partnerships that demonstrate how industry, workforce developers, and academic partners are working together to prepare workers for this evolving future.

Discuss the performance measures (a minimum of two) for research outcome your Center identified in your Technology Transfer Plan Report and the targets (goals) for each measure.

	Research Performance Measure	Annual Target	Current Reporting Period
Impact #1	Annual Number of Instances of Technology Adoption or Commercialization	3	2
Impact #2	Annual Number of Instances of Research Changing Behavior, Practices, Decision Making, Policies (Including Regulatory Policies), or Social Actions	3	4

In addition to what has been previously reported, additional examples of technology adoption and research changing behavior are:

- New PennDOT Law Allows Use of Bioptic Telescope Lenses to Obtain License - ACT 131, will allow people to use bioptic telescope lenses when testing for a driver’s license starting later in 2021. Mobility21 UTC project, *Smart Glasses for Improving Mobility of Low Vision People*, led by researcher Yang Cai, helped inform this new policy.
- Association for Commuter Transportation Adopts Diversity, Equity, and Inclusion Statement and Establishes Committee - At the November 2020 Association of Commuter Transportation Board of Directors meeting, 2 motions were unanimously approved to adopt an organizational Diversity, Equity, and Inclusion statement and establish a formal standing committee to continue D, E, & I efforts. The D, E, & I work will focus on how the organization fosters an environment of inclusion and how the work members do in their communities can provide *better journeys for everyone*. These motions were a culmination of the work completed by a 63 member Task Force, led by ACT Board Member and Mobility21 UTC Program Manager, Lisa Kay Schweyer.

6. 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

Following a survey of all UTC research in the previous reporting period, contingency plans were enacted for any expected projects impacts. We continue to closely monitor projects and check in with the faculty and no other anticipated impacts from COVID-19 have been reported.

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.

7. SPECIAL REPORTING REQUIREMENTS

Submission status of Final Research Reports: Ten reports have been submitted to the repositories as indicated in the Grants Deliverables and Reporting Requirements.