Mobility21

A USDOT NATIONAL UNIVERSITY TRANSPORTATION CENTER

Carnegie Mellon University

Penn — UNIVERSITY of PENNSYLVANIA

THE OHIO STATE UNIVERSITY   CCAC

Semi-Annual Progress Performance Report for University Transportation Centers

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Signature:

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
Fifty-one research projects were active during this report period. On November 12, 2019, a call for proposals was released for CMU researchers to propose projects for the July 1, 2020 – June 30, 2021 period. Twenty-four proposals were received, totaling more than $2.2 million in requests. Representatives from our Advisory Council and the UTC management team participated in the review of the proposals. Sixteen 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 on July 1, 2020.

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 will be entertained. The proposals are due in October and funding awards will be announced in November.

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 (SPC), a regional MPO, has been helping promote the challenge to their regional communities and public transit operators. On September 30, 2020, Mobility21 UTC Program Manager, Lisa Kay Schweyer was invited to give a presentation during the SPC Commission meeting. She also gave presentations to their Transit Operators Committee and their Transportation Technical Committee earlier in September.

During this reporting period, three UTC faculty meetings were also held (scheduled twice during each of the spring and fall semesters with an additional meeting during the summer). 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. The meetings transitioned to a virtual platform starting in the spring.

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 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:

- September 18, 2020 - Mobility21 UTC researcher Yang Cai and his student team have been chosen to advance to the final phase of the CHARIoT Challenge in the category "*Build Augmented Reality for First Responders.*"
- August 25, 2020 - Mobility21's Robotics Institute Summer Scholars, Beverley-Claire Okogwu and Fausto Vega completed their projects. Beverly-Claire's project was titled, "*Development of a Multi Agent Environment Trained with MADDPG Algorithm.*" Beverley-Claire was mentored by UTC researcher Ding Zhao of the Carnegie Mellon University Safe AI Lab. View Beverley-Claire's poster and video. Fausto Vega's project was titled, "*Effective Collision Avoidance for Unmanned Aerial Vehicles.*" Fausto was mentored by UTC researcher, Dr. Sebastian Scherer. View Fausto's poster and video. The Carnegie Mellon Robotics Institute Summer Scholars program connects students from across the country and world to contribute to robotics research alongside top CMU researchers. With 43 scholars from 11 countries and 33 home universities, the 2020 RISS cohort is the largest cohort since the inception of the program in 2006. Forty percent of the 2020 participating scholars are from communities underrepresented in STEM.
- August 18, 2020 - The Women in Transportation Seminar, Pittsburgh Chapter, awarded the Leadership Legacy Graduate Scholarship to CMU student Kathryn Schlesinger. *"Although originally hailing from sunny, south Florida, Ms. Schlesinger considers Pittsburgh to be her second home after living here for nearly ten years.*

After graduating from the University of Pittsburgh in 2014 with a dual B.A. and GIS Certificate…earned her LEED Green Associate accreditation and began the Master of Public Management program at Carnegie Mellon University's Heinz College in January 2018. She will be graduating in December 2020."

- August 12, 2020 - Mobility21 UTC researcher Corey Harper hosted a webinar, "*Choosing Between Academia and Industry*," to discuss the pros and cons choosing a career path.

- July 30, 2020 - Mobility21 UTC welcomed Traffic21 Women in Transportation Fellow for 2020-2022, Hajra Shahab. Hajra Shahab grew up in Karachi [Pakistan], one of the largest and most populated cities in the world. During her time at Carnegie Mellon University she plans to continue to understand how users interact with cities and transportation systems, specifically. Hajra says, *"It is an honor to have earned the Traffic21 Women in Transportation Fellowship. I strongly believe that this fellowship has brought me a step closer to my career aspirations in transportation and mobility. Traffic21 is steering discussion around transportation in the 21st century, and I believe this futuristic approach will provide me with unparalleled exposure to cutting edge research, mentoring, and technological advancements."*

- July 29, 2020 - Graduate students from Carnegie Mellon University met with Pennsylvania Department of Transportation (PennDOT) Secretary Yassmin Gramian and members of her executive team, to present a comprehensive policy study titled *"Mobility, Accessibility, and Connectivity: Assessments and Recommendations Concerning Rural Transportation Equity in Pennsylvania."* Under the guidance of Traffic21's Executive Director and Heinz College Adjunct Associate Professor Stan Caldwell and Traffic21 Founder Rick Stafford, CMU graduate students Blair Chen, Erick Shiring, and Marcus Robinson of Heinz College and Ziyu Dai of the College of Engineering were able to apply their knowledge and experiences to inspire real world policy change for future progress. Included in the report was a review of key national findings, an analysis of rural equity as a systemic concern in Pennsylvania, strategies and practices from around the U.S., and the students' recommendations to implement a rural transportation council. As a first–of-its-kind rural transportation model, the council would identify research and information needs, as well as recommend and advocate for policy and program initiatives to enhance the mobility, connectivity, and accessibility of Pennsylvania's rural communities and become a model for other states. Also involved in the project was former Traffic21 Women in Transportation Fellow Ngani Ndimbie, executive policy specialist for PennDOT. For more information and details, the full report can be accessed here.

- July 20, 2020 - Mobility21 Executive Director Stan Caldwell met with Brad Moore, District Director for Congressmen Glenn Thompson PA-15, Venango County Commissioner Chip Abramovic, and Tim Heffernan, founder of the PA Rural Robotics Initiative to discuss the STEM activity between Mobility21 and PA Rural Robotics and its impact on Pennsylvania rural workforce development.

- July 8, 2020 - The Ohio State University doctoral candidates Rajakumar Deshpande and Shobhit Gupta work with Mobility21 UTC academic partner, the Ohio State University's Center for Automotive Research. *"…Rajakumar Deshpande and Gupta are doctoral candidates in Mechanical Engineering at The Ohio State University. Their work on the ARPA-E NEXTCAR* project at the Center for Automotive Research (CAR) is shaping their studies, their future careers, and the future of connected and automated vehicles…The project aims to improve connected vehicle technologies and ultimately improve hybrid-electric vehicles' fuel economy by 20 percent."* Read more here.

- June 30, 2020 – "With COVID-19 school closures, the continuity of education for the majority of Pennsylvania's students is at risk. Inequities of resources, staffing, and lack of Internet connectivity are making online learning inaccessible for some of our most at-risk communities. This decrease in classroom learning time, both in-person and virtual, is leaving some students further behind and threatens to deepen the chasm in learning outcomes and opportunities. Public-private partnerships are emerging to create just-in-time educational resources to support communities and families. RobotWits LLC, and the PA Rural Robotics Initiative, both Mobility21 deployment partners, and WQED public television partnered to create the accessible STEM instructional resources, the Robot Doctor, for high school students and teachers." Mobility21 Women in Transportation Fellow, Carlee Benhart interned with this initiative over the summer.

- June 25, 2020 - Stan Caldwell, Mobility21 Executive Director, participated in the Southwestern Pennsylvania Commission Transportation and Operations Forum and discussed the importance of workforce training for intelligent transportation systems workers through community colleges and universities.

- June 25, 2020 - ITS America has named University of Pennsylvania, a Mobility21 UTC academic partner, as the winner of the America's region of the Emerging Leaders Program Global Challenge with their inclusive mobility plan for Philadelphia. "*Move, Philadelphia! is an inclusive mobility model for the city that includes*

multiple strategies to limit private vehicle use within the city using the latest technologies and direct diverted funds to the city's flailing public transit system." UTC researchers Erick Guerra and Megan Ryerson provided assistance to the student team.

- May 27, 2020 - Carnegie Mellon students from the School of Computer Science have formed a team to compete in this year's Roborace, an international competition involving autonomous, electrically powered vehicles. Read the full story here.

- May 12, 2020 - Mobility21 UTC Executive Director Stan Caldwell and Program Manager Lisa Kay Schweyer participated in the final class project presentation by CMU Remaking Cities Institute students. The students' project was "Planning by Design: Campuses, Waterfronts, Districts, and Cities."

- April 29, 2020 - Students of the CMU Heinz College engage in semester long *"Capstone Projects"* to apply coursework to real-world scenarios. Students shared the results of their semester long research projects during a poster fair including the transportation related project: *"Price Prediction Project with QL2 Software."*

- April 28, 2020 – Mobility21 supported 2 regional high schools (Frazier and Norwin) as they competed in the Autonomous Innovative Vehicle Design Challenge. The Square One Education Network (Square One) is a Michigan-based non-profit K-12 STEM educational organization, annually reaching nearly 12,000 students and 500 teachers with hands on, project based STEM programming. This year, Square One partnered with ITS America to offer their Autonomous Innovative Vehicle Design Challenge to kids across the United States. Mobility21 continues to work with each school to find ways to increase student exposure to Carnegie Mellon University, Traffic21 Institute and Mobility21 UTC.

- April 6, 2020 - "Allanté Whitmore [Mobility21 UTC Diversity Fellow] guides the conversation naturally, as though there weren't a studio microphone between her and Shena Marshall, her current interview subject. The two eagerly swap stories in a soundproof studio about how they came to graduate school at Carnegie Mellon University. Whitmore will take the recording and send it to an editor, who will shape it into an episode of her podcast "Blk+ In Grad School," which recently released its 100th episode." Read the article here.

Technology Transfer

During this reporting period Mobility21 is pleased to announce a new company that that has spun out of CMU as a direct result of UTC funded research. UTC researcher Professor Sean Qian is CEO of TraffiQure which applies machine learning and data analytic tool developed through the research in his Mobility Data Analytics Center.

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, 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 linked posted to the Mobility21 UTC website's *What's Happening* section.

- September 25, 2020 - Dr. Corey Harper, Mobility21 UTC researcher and Incoming Assistant Professor of Civil and Environmental Engineering and Heinz School of Public Policy at Carnegie Mellon University discussed "*Advancing Towards a Smarter and More Sustainable Transportation System*." Watch here.

- September 11, 2020 - Megan Ryerson, Mobility21 UTC researcher, UPS Chair of Transportation, an Associate Professor of City & Regional Planning and Electrical & Systems Engineering and the first Associate Dean for Research at University of Pennsylvania's Weitzman School of Design spoke on *"Building Novel Traveler-Centric Metrics to Design Safe and Efficient Transportation Infrastructure Systems."* Watch here.

- April 24, 2020 - Srinivasa Narasimhan and Robert Tamburo, CMU Principal Project Scientists and Mobility21 UTC researchers discussed their UTC project, *"Visual Understanding of Traffic at Intersections: Access to real-time information."* Watch the full video here.

- April 17, 2020 - Christoph Mertz, a Mobility21 UTC researcher discussed his UTC project, *"Bus on the edge: Continuous monitoring of traffic and infrastructure,"* and how transit buses are now routinely recording their surroundings with cameras for security and liability reasons. Watch 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.

On September 30, 2020, Business Managers representing faculty across Carnegie Mellon University attended a session to learn more about Traffic21 and Mobility21 UTC funding. During the event, Lisa Kay Schweyer, Program Manager for Mobility21, Heather Depasquale of the Research Accelerator, and Olivia Wells of the Heinz College reviewed the funding sources and shared some tips with the business managers including UTC compliance.

On April 29, 2020, Stan Caldwell, Mobility21 Executive Director and Lisa Kay Schweyer, Program Manager met with Jeff Thomas, Dean of Academic Affairs and Bob Koch, Automotive Technology Instructor from the Mobility21 academic partner, the Community College of Allegheny County. This semi-annual check-in meeting provided an opportunity to share updates and discuss a new way to connect CCAC with the UTC's deployment partners.

Additional Collaboration Activity report period:

- September 25, 2020 – "University of Illinois team has received grants and support from the National Science Foundation (NSF) and the Discovery Partners Institute (DPI) to plan the establishment of the National Institute for Artificial Intelligence (AI) in Construction…Additional team members from Carnegie Mellon University are [UTC researcher] Burcu Akinci and Pingbo Tang." Source: University of Illinois.
- August 27, 2020 - The US Department of Transportation National Transportation Library Repository & Open Science Access Portal pulled together a small group of frequent users, including Lisa Kay Schweyer, Program Manager from the Mobility21 UTC to join a feedback group to gather information about the development of a new data submission form for research reports and data sets.
- August 19, 2020 - Chris Hendrickson, Faculty Director of the Traffic21 Institute and Mobility21 UTC researcher, attended the Transportation Research Board's Executive Committee Meeting August 17-19, 2020. Hendrickson made a presentation as Chair of the TRB Division Committee, reporting on committee activities and statistics on diversity of TRB volunteers.
- August 13, 2020 - Mobility21 Executive Director Stan Caldwell presented "A*utonomous Vehicles: Why Now and Why Pittsburgh*" at a webinar hosted by the Pittsburgh Chapter of the Women's Transportation Seminar. This presentation on Caldwell's University Transportation Center funded research highlighted industry and technology trends and public policies aimed put in place to enable innovation and mitigate risk.
- August 12, 2020 - The Region 1 UTC, Transportation Infrastructure Durability Center at the University of Maine, featured Stan Caldwell from Carnegie Mellon University's Mobility21 National UTC as keynote speaker on disruptive transportation technologies and infrastructure durability.
- August 6 - 7, 2020 - The National Research Council's Governing Board had its first ever virtual meeting with Mobility21 researcher Chris Hendrickson participating. Strategic planning and rapid responses to COVID-19 were major topics of discussion.
- July 23, 2020 - Stan Caldwell participated in the AASHTO/ITE/ITSA Vehicle-to-Infrastructure (V2I) Deployment Coalition - Strategic Initiatives Working Group Quarterly Meeting, to discuss connected vehicle to connected infrastructure technology applications.
- July 22, 2020 - Stan Caldwell, Mobility21 Executive Director, participated in Pennsylvania Department of Transportation Federal Highway Administration's State Transportation Innovation Council, where the group discussed and adopted new transportation innovation deployment projects.
- July 16, 2020 - Stan Caldwell, Executive Director of Mobility21 UTC, was appointed to the Pennsylvania Automated Vehicle Summit Planning Committee and participated in the meeting. The Pennsylvania Departments of Transportation and Community & Economic Development have hosted the PA AV Summits annually since 2017. See the Summit website here.
- July 16, 2020 - Mobility21 UTC Executive Director Stan Caldwell and Program Manager Lisa Kay Schweyer have been actively participating on the American Public Transportation Association's (APTA) Mobility

Recovery and Restoration Task Force since May. "*The results of the Task Force will include 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 will wrap up their work and present their recommendations to APTA leadership.

- June 16, 2020 - Traffic21 Institute Director and Mobility21 Researcher Chris Hendrickson met with new Transportation Research Board Cooperative Research Program staff to discuss the role of the TRB Division Committee in reviewing panel members and reports, and ensuring diversity and inclusion on panels.

- June 16, 2020 - Stan Caldwell participated in the Pennsylvania Transportation Alliance hosted by Disability Rights PA. Stan provided information to the group of 25 on autonomous delivery vehicles in response to discussion of pending state legislation to allow these vehicles in Pennsylvania.

- June 10, 2020 - Stan Caldwell participated in the quarterly meeting of the Smart Belt Coalition. The coalition includes universities and state transportation agencies in Michigan, Ohio and Pennsylvania to further develop a multi-state connected and automated vehicle real-world testing environment. Stan is a founding member of the coalition.

- June 9 & 10, 2020 - The Annual Council of University Transportation Center's summer 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.

- June 9, 2020 - Traffic21 Founder Rick Stafford and his Heinz College masters student, Demitra Kourtzidis, participated in the quarterly meeting of the Keystone Transportation Funding Coalition (KTFC) to engage with Pennsylvania transportation policy stakeholders. Rick and Demitra are conducting research on past and future transportation funding alternatives.

- June 4, 2020 - Mobility21 Executive Director Stan Caldwell was a featured panelist for the ITS America Webinar, "Technology and the post COVID-19 Transportation Roadmap." The session explored the changes that may be seen with transportation after COVID-19, as well how to build the transportation system in the 21st century. View the full webinar here.

- June 3, 2020 - Stan Caldwell participated in the Pennsylvania's Autonomous Vehicle Policy Task Force quarterly meeting. Caldwell and Raj Rajkumar, Mobility21 Director, serve on task force and provide both the Pennsylvania Department of Transportation and the State Legislature's Transportation Committees counsel on automated vehicle policy.

- May 19, 2020 - Mobility21 Executive Director Stan Caldwell participated in the Port Authority of Allegheny County's NEXTransit Advisory Group Meeting. "The goal of the NEXTransit Advisory Group is to create a [long-term] plan for an improved transit system that will attract more riders, enhance mobility, and support community development and redevelopment initiatives throughout Allegheny County."

- April 28, 2020 - Mobility21 UTC Director Raj Rajkumar has been named to the Partners for Automated Vehicle Education (PAVE) Academic Advisory Council, which aims to provide PAVE members with advice and recommendations on matters related to AV technology and its societal effects, as well as collaborating with PAVE members on tasks such as research, evaluation and polling. PAVE is a coalition of partners dedicated to educating policymakers and the public about automated vehicles and the increased safety, mobility and sustainability they can bring.

- April 22, 2020 - "Carnegie Mellon University is playing a key role in Pennsylvania Governor Tom Wolf's planning efforts to re-open the state's economy." CMU Traffic21 founder Rick Stafford and UTC researchers Lee Branstetter, Peter Zhang, and Hai Wang will be part of this team providing assistance to state decision-makers during COVID-19 pandemic. Read more here.

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 3,931 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.   677 articles were posted in this reporting period.

The Traffic21 Smart Transportation Podcast. The podcast series includes interviews and stories from UTC faculty, students, industry and government leaders, community members and academic partners.   Those interviewed share their thoughts on the future of transportation, intelligent technology systems, shared mobility, and more. The *Traffic21 Smart Transportation Podcast* is hosted and produced by Mobility21 UTC Diversity Fellow Allanté Whitmore.

- April 24, 2020 – This episode features Bonnie Fan, who is the 2018 – 2020 Traffic21 Women in Transportation Fellow as she describes her experiences as a graduate student and on the Traffic21 student leadership team: Listen here.

Additional Dissemination Activity:

- September 29, 2020 - Mobility21 UTC Researcher and University of Pennsylvania Professor Rahul Mangharam released a new video today on "*F1Tenth Autonomous Racing and How It Can Help with Machine Learning Research for Perception, Planning and Control*." Watch his talk here.

- September 23, 2020 - Mobility21 UTC researchers Sean Qian and Rick Grahn joined Lynn Manion and Amy Mathieson, community partners from RideACTA and Lisa Kay Schweyer, Program Manager for the Mobility21 UTC met to share the results of the *Smart Mobility Challenge project, Data-driven mobility service design: a case study for Moon Township*. Over 60 people representing departments of transportation, transportation associations, and community organizations from across the country signed up to join the session to hear the presentation. Learn more about the project by reviewing the research recap here. You can also watch the recording of the presentation here.

- September 23, 2020 - Mobility21 UTC researcher Ray Gastil moderated a panel discussion on *"COVID-19 and the Future of Our Cities: The Future of Work."* The discussion highlighted how "The current pandemic accelerates profound societal shifts that will have lasting effects on how we work going forward. With many employers successfully transitioning to remote work, we can expect more companies to shift an increasing part of their workforce to remote working models…"

- September 22, 2020 - Mobility21 Executive Director Stan Caldwell discussed his UTC research on disruptive transportation technology trends at the inaugural Bus Technology Summit in a session titled, "*Embracing Technology Disruptions with Cautious Optimism in the COVID Era*." This summit was presented by School Transportation News.

- September 17, 2020 - Stan Caldwell presented his Mobility21 research on automated vehicle industry trends along with Mark Kopko, PennDOT Director of Transformational Technology, to industry and community transportation professionals at a webinar hosted by the Transportation Management Association of Chester County.

- September 11, 2020 - Mobility21 UTC researcher Christoph Mertz was a featured speaker at the University of Pittsburgh Landslide Capacity Building Seminar discussing applying technology to landslides, including techniques such as photogrammetry, LiDAR, interferometric synthetic radar, laser scanning and neural networks.

- September 8, 2020 - Mobility21 UTC researcher Erick Guerra of the University of Pennsylvania co-authored the article "*Beyond Mobility: Planning Cities for People and Places,*" which was also recently reviewed by the Journal of Planning Education and Research. The paper explores the consequences of cities designed with a primary goal of moving people around quickly.

- August 31, 2020 - Mobility21 UTC researcher Ding Zhao and his team held the 2nd Annual Workshop of Safe AI Lab, where they presented findings and highlights of their work on the design, implementation, analysis, and evaluation of statistical, optimization, and machine learning models for making AI safer for real-world development. Watch here.

- August 13, 2020 - The Inter-American Development Bank Transport held their 11th virtual session "Designing Safe Autonomous Systems," which featured Mobility21 UTC researcher Dr. Rahul Mangharam of the University of Pennsylvania. In this talk, Dr. Mangharam discussed the main difficulties in the development of safe autonomous systems and new approaches that are needed to bound and minimize the risk of autonomous vehicles to the public, determine liability and insurance pricing, and ensure the long-term growth of the domain.

- August 6, 2020 - Mobility21 UTC researchers Costa Samaras and Corey Harper participated in the *"Reimagining Transportation Energy in 2020 for Equity and Efficiency"* panel to provide their take on what shifts we can expect on our transportation energy future post-COVID19. This session, hosted by *Carnegie Mellon University's Wilton E. Scott Institute for Energy Innovation,* is the eighth installment in the series, "*Energy, Resilience, and COVID-19 – Pivoting in 2020*", which highlights research, industry and innovation related to how COVID-19 is impacting the way we will do business and what it means to the energy systems we rely upon. You can watch the full webinar here.

- July 20, 2020 - Megan Ryerson, Associate Professor of City and Regional Planning and Electric and Systems Engineering and UTC researcher at the Mobility21 academic partner University of Pennsylvania, sat down with Penn Today to discuss her take on offsetting carbon emissions, one ton at a time. "*I've spent my career telling people to fly less. If you told me in the fall how few planes would be in the sky right now, I would have been shocked,*" says Megan Ryerson. Read the full article here.

- July 6, 2020 - Chris Hendrickson, Director of Traffic21, gave the keynote presentation today on "*Possibilities for Deep Decarbonization of US Transportation Modes*" to the International Society for Industrial Ecology Conference ISIE Americas 2020.   Over 90 people were in attendance for this presentation.

- July 3, 2020 - Megan Ryerson, Associate Professor of City and Regional Planning and Electric and Systems Engineering at the Mobility21 academic partner University of Pennsylvania, provided her input on how to navigate post-COVID19 with Politico magazine with her suggestion, *"Replace Short Flights with Buses."* Read the full article here.

- June 29, 2020 - Mobility21 UTC Researcher Venkat Viswanathan and colleague Parth Vaishnav, along with doctoral students Aniruddh Mohan and Shashank Sripad, were published in the most recent issue of *Nature Energy* where they explored how adding self-driving capability to electric vehicles might affect range. Access the article here.

- June 25, 2020 - Mobility21 UTC Researcher Costa Samaras was interviewed by Gizmodo to discuss the increase of electric trucks and how crucial they will be in California in the future. *"'California has always been a leader in advancing clean transportation technology,' Costa Samaras, an associate professor of civil and environmental engineering at Carnegie Mellon University, told Earther. 'It's a huge deal.'"* Read here.

- May 20, 2020 - Mobility21 Executive Director Stan Caldwell was an invited by Benjamin Schmidt, President of Roadbotics (a UTC spinoff company) to present as part of Roadbotics web discussion on lessons learned through the COVID-19 pandemic about the need for more resilient transportation organizations and cities. Watch the full web discussion here.

- May 19, 2020 - UTC Researcher Fei Fang presented *Saving Wildlife through A.I.* at yesterday's CMU Faculty Dialogues Webinar. Professor Fang and her team at the Institute of Software Research developed PAWS, exploring how A.I. can change the world for the better.

- May 19, 2020 - Mobility21 UTC Researcher Yang Cai presented *"Engineers Respond To COVID-19: Engineering Reopening and Renaissance"* as part of the IEEE Pittsburgh Seminar Services.

- May 14, 2020 - Mobility21 Executive Director Stan Caldwell presented the Mobility21 UTC project *"Changing Hunger: CMU Works with 412 Food Rescue and Allies for Children to Deliver School Lunches to Children due to COVID-19"* during today's Research, Education, and Training Reauthorization Coalition (RETRC) virtual spotlight for Congressional Offices and Transportation Stakeholders. There were 85 registrants for the webinar, including 15 from Department of Transportation, 25 from congress, and 40 transportation stakeholders. Also presenting as part of the webinar were several other university representatives discussing how they are monitoring the impacts of COVID-19, working with health care and policymakers to address COVID-19's effects, and helping public transportation agencies to address the challenges of the pandemic now and in the future.

- May 11, 2020 - Mobility21 Executive Director Stan Caldwell moderated the presentation for the Association for Pennsylvania Municipal Management titled "*Ready or Not, Here it Comes: How Disruptive Technologies coming out of the Pittsburgh region will impact our communities and what local governments can do to*

prepare for and utilize these innovations to deliver more efficient and smarter services to its residents." Also on the panel were Greg Barlow, CTO/Founder of Rapid Flow Technologies (*a Mobility21 spin-out company);* Tom Musgrove, Government Affairs Manager for Crown Castle; Stew Frick, Partner Success Lead for Robotics (*a Mobility21 spin-out company)*; and Aaron Bibro, Manager of Hatfield Township.

- May 7, 2020 - Mobility21 Executive Director Stan Caldwell was interviewed by WTAE-TV on the impact that COVID-19 has had on the flow of traffic in Pittsburgh and how people's commute may change in the future. Watch the segment here.

- May 5, 2020 - Co-authors Chris Hendrickson, Director of Traffic21 and Laurence Rilett, Director of the Nebraska Transportation Center and the Mid-America Transportation Center are both US DOT University Transportation Center funded faculty. Their article "The Covid-19 Pandemic and Transportation Engineering" will appear in the July edition of the Journal of Transportation Engineering, Part A: Systems.

- April 28, 2020 - UTC Researcher Venkat Viswanathan recently wrote an article for the online platform *Medium* about the potential for using batteries in flying cars. Read the full article here.

- April 24, 2020 - CMU Master of Language Technologies Student Yulan Feng contributed to the 2020 CMU Symposium on AI & Social Good by presenting on "*CMU GetGoing: Dialogue System Designed for Seniors*." Yulan works with Mobility21 UTC Researcher Maxine Eskenazi on the project "*CMU GetGoing Dialogue System*."

- April 24, 2020 - UTC researcher Stephen Smith closed out the 2020 CMU Symposium for AI & Social Good with his discussion on *"Smart Infrastructure for Future Urban Mobility*."

- April 23, 2020 - CMU Professor and UTC Researcher Jon Peha gave a keynote speech at the 2020 IEEE Wireless Telecommunications Symposium today. His keynote, entitled "*Spectrum Policy for Intelligent Transportation Systems,"* investigates how much spectrum should be allocated to ITS, whether ITS spectrum not used for safety communications should be shared with unlicensed devices, and if so how much.

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. An invitation was sent by the end of April 2020 to all those who were registered for the 2020 event.

We also began planning for our annual Advisory Council meeting and Deployment Partner Consortium events. They will be held virtually on Wednesday, November 18 (Advisory Council), Thursday, November 19 and Friday, November 20 (Deployment Partner Consortium Symposium).

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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
Allegheny County	Pittsburgh, PA		X		X	

Allegheny General Hospital	Pittsburgh, PA		X		X	
Allies for Children	Pittsburgh, PA		X		X	
Azuga	San Jose, CA		X		X	
City of Seattle	Seattle, WA		X		X	

As previously reported, at our Traffic21 10-Year Anniversary and Deployment Partner Consortium held in November 2019, we embarked on the new challenge of *Improving Mobility for All*. So during this reporting period, some of the 165 deployment partners have been identified and engaged to also serve as Equity Deployment Partners. Each research project will work with one or more deployment and one or more equity partner to allow the research to be conducted through the community and equity lenses. The equity partners are:

- 412 Food Rescue
- AARP
- ACCESS
- Airport Corridor Transportation Association
- Allegheny Conference
- Allegheny County
- Allegheny General Hospital
- Allies for Children
- American Public Transportation Association
- Bike Pittsburgh
- Blind & Vision Rehabilitation Services of Pittsburgh
- Borough of Dormont
- Breathe Project
- Carnegie Mellon University, The Center for Atmospheric Particle Studies
- Center for Hearing & Deaf Services
- Children's Hospital of Philadelphia
- City of Greensburg
- City of Philadelphia
- City of Pittsburgh
- City of Seattle
- Community College of Allegheny County
- Conference of Minority Transportation Officials - Pittsburgh
- Cranberry Township
- Delaware Valley Regional Planning Commission
- Easterseals

- Economic Development South
- Freedom Transit
- Green Building Alliance
- HealthyRide
- Heritage Community Initiatives
- Hill District CDC
- Hillman Family Foundations
- Jackson Clark Partners
- Lawrence County
- Marshall Township
- MetroLab Network
- Mid-Ohio Regional Planning Commission
- Municipality of Monroeville
- Municipality of Penn Hills
- National Aging and Disability Transportation Center
- National Association of Area Agencies on Aging
- North Hills Community Outreach
- North Huntingdon Township
- Oakland Transportation Management Association
- OBID
- OSHER
- Partner4Work
- PA Department of Transportation
- Pennsylvania Rural Robotics Initiative
- Pittsburgh Community Reinvestment Group
- Pittsburgh Downtown Partnership

- Pittsburgh International Airport
- Port Authority of Allegheny County
- Port of Pittsburgh
- Public Parking Authority of Pittsburgh
- Quaker Valley Council of Governments
- Robotwits
- Ruby Ride
- SEPTA
- Southwestern Pennsylvania Commission
- Sustainable Pittsburgh
- The Heinz Endowments
- The League of American Bicyclists
- The Ohio State University
- TIRES
- Travelers Aid
- UPMC
- Uptown Partners
- Urban Redevelopment Authority of Pittsburgh
- Venango County
- Western PA Regional Data Center
- Western PA School for Blind Children
- Westmoreland Transit
- Women's Transportation Seminar

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. The list of Advisory Council members can be found on our website, https://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
A Generative Simulation Platform for Multi-agent Systems with Incentives	Wu, Z., Zhang, X., Xu, S., Chen, X., Zhang, P., Noh, H. Y., & Joe-Wong, C. (2020, September). A generative simulation platform for multi-agent systems with incentives. In Adjunct Proceedings of the 2020 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2020 ACM International Symposium on Wearable Computers (pp. 580-587).	Other	2020-09-10
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", IISE Transactions, Accepted for Publication, September 2020.	Peer Reviewed	2020-09-08
Leading the Way: A National Task Force on Connected Vehicles	Jon M. Peha, Leading the Way: A National Task Force on Connected Vehicles, Day One Project, Federation of American Scientists, 2020.	Other	2020-08-07
Safety Analysis for AI Systems	Yang Cai, Safety Analysis for AI System, Proceedings of HCII Conference, 2020	Trade	2020-07-31
Indoor Localization on Helmet	AHFE Conference, July 2020, Virtual	Trade	2020-07-30
Learn on the Fly	AHFE Conference, July 2020, Virtual	Trade	2020-07-30
ELECTRICITY: An efficient multi-camera vehicle tracking system for intelligent city	Qian, Yijun, Lijun Yu, Wenhe Liu, and Alexander G. Hauptmann. "ELECTRICITY: An efficient multi-camera vehicle tracking system for intelligent city." In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops, pp. 588-589. 2020.	Peer Reviewed	2020-07-15
Learning Model Parameters for Real-Time Traffic Signal Optimization	Hu, H-C and S.F. Smith, "Learning Model Parameters for Real-Time Traffic Signal Optimization", Proceedings 30th International Conference on Automated Planning and Scheduling, July 2020.	Other	2020-07-07
Traffic Danger Recognition With Surveillance Cameras Without Training Data	Yu, Lijun, Qianyu Feng, Yijun Qian, Wenhe Liu, and Alexander G. Hauptmann. "Zero-VIRUS: Zero-shot vehicle route understanding system for intelligent transportation." In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops, pp. 594-595. 2020.	Peer Reviewed	2020-06-15
Mobility, Accessibility, and Connectivity: Assessments and Recommendations Concerning Rural Transportation Equity in Pennsylvania	Blair Chen, Erick Shiring, and Marcus Robinson of Heinz College and Ziyu Dai of the College of Engineering (students) *"Mobility, Accessibility, and Connectivity: Assessments and Recommendations Concerning Rural Transportation Equity in Pennsylvania."*	Other	2020-05-08
Are We There Yet? Myths and Realities of Connected and Automated Vehicles	Caldwell, Stan and Chris Hendrickson (2020) 'Are We There Yet? Myths and Realities of Connected and Automated Vehicles,' Carnegie Mellon University Traffic21 Institute, https://traffic21.heinz.cmu.edu/policy-briefs/	Other	2020-04-30
Are travelers substituting between transportation network companies (TNC) and public buses? A case study in Pittsburgh	Grahn, R., S. Qian, HS Matthews, C Hendrickson (2020) Are travelers substituting between transportation network companies (TNC) and public buses? A case study in Pittsburgh, Transportation, 1-29	Trade	2020-04-30
Smart Infrastructure for Future Urban Mobility	Smith, S.F., "Smart Infrastructure for Future Urban Mobility", AI Magazine, 41(1), Spring, 2020.	Trade	2020-04-30
The Need for Analysis and a Shared Vision for Intelligent Transportation Systems	Jon M. Peha, "The Need for Analysis and a Shared Vision for Intelligent Transportation Systems," Comments in the Matter of Use of the 5.850-5.925 GHz Band, Federal Communications Commission ET Docket No. 19-138, April 27, 2020.	Other	2020-04-27
Path Markup Language for Indoor Navigation	Yang Cai, Florian Alber and Sean Hackett, Path Markup Language for Indoor Navigation, Proceedings of ICCS 2020, LNCS, Springer	Trade	2020-03-29 *

FCC Likely to Move Forward on 5.9 GHz Rule Change	FCC Likely to Move Forward on 5.9 GHz Rule Change, Communications Daily, Howard Buskirk, March 10, 2020, Copyright 2020 Warren Communications News, Inc	Trade	2020-03-10 *
Anytime Computation and Control for Autonomous Systems	1. Y. V. Pant, H. Abbas, K. Mohta, R. A. Quaye, T. X. Nghiem, J. Devietti, R. Mangharam. "Anytime Computation and Control for Autonomous Systems", in IEEE Transactions on Control Systems Technology. 2020.	Peer Reviewed	2020-03-10 *
Technical Standards and Spectrum Sharing for Intelligent Transportation Systems	Jon M. Peha, "Technical Standards and Spectrum Sharing for Intelligent Transportation Systems," Comments in the Matter of Use of the 5.850-5.925 GHz Band, Federal Communications Commission ET Docket No. 19-138, March 7, 2020.	Other	2020-03-07 *
Technical Standards and Spectrum Sharing for Intelligent Transportation Systems	Jon M. Peha, "Technical Standards and Spectrum Sharing for Intelligent Transportation Systems," Comments in the Matter of Use of the 5.850-5.925 GHz Band, Federal Communications Commission ET Docket No. 19-138, March 7, 2020.	Other	2020-03-07 *
Argus: Efficient Activity Detection System for Extended Video Analysis	Liu, Wenhe, Guoliang Kang, Po-Yao Huang, Xiaojun Chang, Lijun Yu, Yijun Qian, Junwei Liang, Liangke Gui, Jing Wen, Peng Chen, and Alexander G. Hauptmann. "Argus: Efficient activity detection system for extended video analysis." In Proceedings of the IEEE Winter Conference on Applications of Computer Vision Workshops, pp. 126-133. 2020.	Peer Reviewed	2020-03-02 *
Adaptive feature aggregation for video object detection	Qian, Yijun, Lijun Yu, Wenhe Liu, Guoliang Kang, and Alexander G. Hauptmann. "Adaptive feature aggregation for video object detection." In Proceedings of the IEEE Winter Conference on Applications of Computer Vision Workshops, pp. 143-147. 2020.	Peer Reviewed	2020-03-02 *
Training-free monocular 3d event detection system for traffic surveillance	Yu, Lijun, Peng Chen, Wenhe Liu, Guoliang Kang, and Alexander G. Hauptmann. "Training-free monocular 3d event detection system for traffic surveillance." In 2019 IEEE International Conference on Big Data (Big Data), pp. 3838-3843. IEEE, 2019.	Peer Reviewed	2020-02-24 *
FADS: Framework for Autonomous Drone Safety	Y. V. Pant , M. Z. Li, R. A. Quaye, H. Abbas, M. Ryerson, R. Mangharam. "FADS: Framework for Autonomous Drone Safety". Transportation Review Board, Part A/B. 2019	Peer Reviewed	2020-02-20 *
A Social Force Based Pedestrian Motion Model Considering Multi-Pedestrian Interaction with a Vehicle	ACM Trans. Spatial Algorithms Syst. 6, 2, Article 11	Peer Reviewed	2020-02-03 *

not previously reported

*Other publications, conference papers and **presentations**:*

Title	Event	Event Type	Attendance	Date
"Embracing Technology Disruptions with Cautious Optimism in the COVID Era."	Inaugural Bus Technology Summit	Presentation	100	2020-09-22
Autonomous Vehicle Trends Since March 2020	Quarterly Meeting of the Transportation Management Association of Chester County	Presentation	75	2020-09-17
A Generative Simulation Platform for Multi-agent Systems with Incentives	3rd Workshop on Combining Physical and Data-Driven Knowledge in Ubiquitous Computing (Ubicomp-CPD 2020)	Presentation	40	2020-09-12
Emerging Wireless Technology and Competition	NSF Workshop on Wireless, Spectrum & Innovation	Presentation	100	2020-08-28
"Autonomous Vehicles: Why Now and Why Pittsburgh"	Webinar Hosted by the Pittsburgh Chapter of the Women's Transportation Seminar	Presentation	50	2020-08-13
How New Technologies are Impacting Transportation and Improving Infrastructure Durability	Transportation Infrastructure Durability Center at the University of Maine Annual Conference	Presentation	100	2020-08-12

Analysis of the Potential for Micromobility to Replace Short Car Trips in Urban Areas, And Impacts on Congestion	Civil and Environmental Engineering Summer Research Poster Session	Presentation	75	2020-07-24
Metaheuristic for School Bus Routing and Scheduling with Collaboration	CEE Summer Research Poster Session	Presentation	50	2020-07-24
Improving Spectrum Efficiency for 5G through Multi-Network Access	IEEE/IET International Symposium on Communication Systems, Networks and Digital Signal Processing.	Presentation	200	2020-07-22
"Possibilities for Deep Decarbonization of US Transportation Modes"	International Society for Industrial Ecology Conference ISIE Americas 2020	Presentation	90	2020-07-06
Zero-VIRUS: Zero-shot vehicle route understanding system for intelligent transportation	4th AI City Challenge at CVPR 2020	Presentation	300	2020-06-15
ELECTRICITY: An efficient multi-camera vehicle tracking system for intelligent city	4th AI City Challenge at CVPR 2020	Presentation	300	2020-06-15
"Changing Hunger: CMU Works with 412 Food Rescue and Allies for Children to Deliver School Lunches to Children due to COVID-19"	RETRC 2020 Spotlight	Presentation	85	2020-05-14
"Ready or Not, Here it Comes: How Disruptive Technologies coming out of the Pittsburgh region will impact our communities and what local governments can do to prepare for and utilize these innovations to deliver more efficient and smarter services to its residents."	Association for Pennsylvania Municipal Management (APMM) Annual Meeting	Presentation	200	2020-05-11
CMU GetGoing	AI and social good symposium	Presentation	30	2020-04-24
KEYNOTE: Spectrum Policy for Intelligent Transportation Systems	IEEE Wireless Telecommunications Systems	Presentation	200	2020-04-23

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: 677
http://mobility21.cmu.edu/	The Carnegie Mellon University's Mobility21 National University Transportation Center website	New Posts: 677
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: 191
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: 41 Views: 2,665
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: 1,111 Following: 1,745

Note: *A new section was added to our Traffic21 Institute website to catalog policy papers, traffic21.heinz.cmu.edu/policy-briefs/. We have had many opportunities to refer people to this new resource and were told by one of the applicants for the Toyota AI Ventures & Toyota Research Institute call for innovation for smart city startups that this new resource was "extremely helpful."*

Technologies or techniques

- As part of project, *Taxi-for-all: Incentivized Taxi Actuation System for Balanced Area-wide Service*, Carlee Joe-

Wong and her team developed a software simulator for taxi drivers' reactions to incentives offered to them and a reinforcement learning framework to optimize these incentives. The simulator, includes modules that admit customized models for how taxi drivers react to the incentives given, e.g., some drivers may simply ignore the incentives, while others may attempt to optimize their driving destinations so as to maximize the incentives received. Researchers are working on releasing an open-source version of the simulator that would allow other researchers to use our work in their own research on incentivization in transportation networks.

- New functions were added to the GetGoing app, a technology in development as part of Maxine Eskenazi's *Accessible with GetGoing* project. One new function integrates information on sidewalk conditions and barriers which will assist when providing walking directions to travelers. The other allows the traveler to specific if they use a wheelchair or have a vision impairment so the directions can be tailored.

- Researchers Alex Hauptman and his team produced open source software and an AVI video file reader as part of the *Vehicle Trajectory and Gap Estimation for Conflict Prediction* project. The software, Pyturbo: A pipeline system for efficient execution, has had 11k downloads since July 2020 (https://pypi.org/project/py-turbo/). And AVI-R: A robust reader for AVI video files had 6.6k downloads since June 2020 (https://pypi.org/project/avi-r/).

- Venkat Viswanathan and his team have developed new methodologies to solve spatiotemporal dynamical systems using convolutional neural ODEs as part of project, *Platooning for Improved Safety and Efficiency of Semi-trucks*.

- In July in collaboration with the Department of Energy's Lawrence Berkley National Lab, Mobility21 UTC researcher Venkat Viswanathan led research on a new class of soft, solid electrolytes that can help to create safer, higher energy and longer lasting batteries. Read more here.

- Starting in September, Joe Bartels, is a postdoctoral researcher in the Robotics Institute at Carnegie Mellon University and a 2020 – 2021 Innovation Fellow. He completed his MS and PhD in Robotics at CMU and also holds a BS and MS in Mechanical Engineering from the University of Nebraska – Lincoln. During his graduate studies at CMU and in collaboration with others in the Illumination and Imaging Lab, Joe developed a new class of 3D imaging systems for use in automation and robotics. These imaging systems include a long-range outdoor depth camera and a fully programmable 3D light curtain sensor. These next-generation 3D sensors will equip automated systems with enhanced perception capabilities, such as high-resolution obstacle detection and adaptive mid-range sensing. As a Swartz Innovation Fellow Joe is working with Mobility21 and the Swartz Center for Entrepreneurship to commercialize this technology for smart cities, self-driving cars, and robotics.

Inventions, patent applications, and/or licenses - Nothing new to report during this reporting period.

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**	**Previous Reporting Period**	**This Reporting Period**	**Annual Total**
Output #1	Annual Number of Journal Publications	35	11	27	38
Output #2	Annual Number of Research Pilot Deployments	10	14	5	19

Please see "Section #3 Publications" for examples of publications.
Some examples of these research pilot deployments include:

- Rahul Mangharam worked with SAE to use the principles taught in his F1Tenth Course (https://f1tenth.org/learn.html) at the University of Pennsylvania to create a broader course now offered by SAE.
- On August 26, 2020 the Tribune-Review article highlighted the deployment that happened as part of the *Utilizing School Bus Routes to Deliver Meals to Families in Need* project. The article states: "Penn Hills School District officials have a plan to ensure students stay fed this coming school year no matter if they come to class or learn online… Hines commended the food service department for its efforts to ensure no student goes hungry during the covid-19 pandemic. … Hines also said the summer/spring food distribution was successful due to partnerships with nonprofits Second Chance, Allies for Children, United Way and Carnegie Mellon University."
  - *Note– this project was named MetroLab Network's Innovation of the Month for September 2020.*

- The two Smart Mobility Challenge projects, "Data-driven mobility service design: a case study for Moon Township" and "Smart Multi-modal Transportation Solution for North Huntingdon Township in Response to Roadway Construction Projects on Route-30" are developing real-world practices. For Moon Township, finding ways to improve the efficiency and reduce the cost for micro-transit services, and ultimately improve the holistic transportation systems by using efficient micro-transit service to complement regular public transit would provide a fundamental knowledge to understand human behavior from analyzing real-world ridership data, and optimally design micro-transit services. For municipalities like North Huntingdon, the results could be used to evaluate policies and management strategies related to large roadway construction projects. In both cases, the tools developed will be open sourced and shared in the public domain.

> **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**	**Previous Reporting Period**	**Current Reporting Period**	**Annual Total**
Outcome #1	Annual Number of Media Stories Referencing UTC Research, Faculty, or Spinoff	**80**	64	40	104
Outcome #2	Annual Number of 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)*	**50**	60	44	104

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

- September 28, 2020 – "Some industry experts are even more bullish. Hui Zhang, managing director in Germany of NIO, a Chinese electric carmaker with global ambitions, said he thought parity could be achieved in 2023. Venkat Viswanathan, an associate professor at Carnegie Mellon University who closely follows the industry, is more cautious. But he said: 'We are already on a very accelerated timeline. If you asked anyone in 2010 whether we would have price parity by 2025, they would have said that was impossible.'" Source: New York Times.

- September 18, 2020 – "Advances in batteries may help accelerate the widespread adoption of air taxis, with a shift from lithium-ion to a lighter battery made from pure lithium metal on the horizon. Venkat Viswanathan, associate professor of mechanical engineering at Carnegie Mellon University, is developing such a battery in partnership with the US government's Department of Energy and a battery maker. He says that the battery will be more energy efficient, up to 30 per cent lighter than standard lithium-ion batteries, and enable air taxis to travel longer on one charge." Source: Financial Times.

- July 24, 2020 – "But do cars with advanced safety systems really make everything safer? Most studies suggest they do. For example, the crash involvement rate for vehicles with blind-spot monitoring was 14% lower than the same models without the equipment, according to a study by the Insurance Institute for Highway Safety. … Corey Harper, a researcher at Carnegie Mellon University, says his analysis suggests the combination of vehicle crash avoidance technologies reduces crash frequency by about 3.5%." Source: Forbes.

- July 2020 - Mobility21 Director Raj Rajkumar was interviewed by *Business Insider* to discuss his thoughts on Tesla's groundbreaking Autopilot feature and how it compares with competing technologies. Read here.

- July 22, 2020 – "Now, researchers at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), in collaboration with Carnegie Mellon University, have reported in the journal Nature Materials a new class of soft, solid electrolytes — made from both polymers and ceramics — that suppress

dendrites in that early nucleation stage, before they can propagate and cause the battery to fail." Source: Science Daily.

- July 20, 2020 – "Pei Zhang, associate research professor of electrical and computer engineering at Carnegie Mellon University, turned to taxis as a mobile sensing platform. Why? A fleet of taxis has a long operational time, a large spatial coverage, and great potential for data collection…" Source: Tech Xplore.

- June 17, 2020 – "Pittsburgh officials asked researchers at CMU's Remaking Cities Institute to observe the installations in 2010; Quick was a research associate on the project. The new LEDs were centered mainly in the city's business districts, commercial areas, and major roadways. Five years later, Quick's team conducted another study on streetlighting. They found that all the LED lights they tested produced significant glare problems." Source: The Verge.

- May 28, 2020 – "Stan Caldwell, a traffic researcher and chief of Carnegie Mellon University's Traffic21 Institute, said most Americans are likely staying at or near home this weekend and in the months ahead, noting that airplanes, trains and buses are operating well below normal levels following a plunge in demand early in the spring. ... 'Vehicle travel will be the travel of choice for summer vacation and starting this weekend,' Caldwell said. 'My prediction is that there will be more regional travel by vehicle, but less overall travel in general.'" Source: Washington Post.

- April 14, 2020 – "The coronavirus pandemic forced students and researchers at Carnegie Mellon University in March to abruptly stop testing an adaptive learning software tool that uses artificial intelligence to expand tutors' ability to deliver personalized education. But researchers said the tool could help students get back up to speed on their learning when in-person instruction resumes. The software, which was being tested in the Pittsburgh Public School District before the coronavirus outbreak began closing universities, relies on AI to identify students' learning successes and challenges, giving educators a clear picture of how to personalize their education plans, said Lee Branstetter, professor of economics and public policy at Carnegie Mellon University." Source: Ed Scoop.

- April 1, 2020 – "…Transportation and housing are as intertwined as strands of DNA. But in California, legislation that would have made it easier to build clustered, multiunit housing near transit lines has failed to pass the state's Senate two years in a row. If you make it illegal to build dense cities, it's hard to cut carbon. 'Housing policy is climate policy,' says Constantine Samaras, a climate and energy researcher at Carnegie Mellon University. *'City policy is climate policy.'*" Source: Wired.

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):

- September 10, 2020 - Mobility21 UTC academic partner, the Ohio State University's Center for Automotive Research (CAR)'s EcoCAR team successfully completed year 2 of the EcoCAR Mobility Challenge despite obstacles during the COVID-19 pandemic. *"Year 2 was supposed to focus on the vehicle build. When COVID-19 caused us to go completely remote and leave the garage we turned our focus on the final competition deliverables which were written reports or video presentations," said Kristina Kuwabara, co-engineering manager and CSMS lead for the Ohio State EcoCAR team.* Read more here.

- August 3-5, 2020 - Nearly 600 transportation demand management (TDM) professionals gathered earlier this week for the International Association for Commuter Transportation's (ACT) annual conference. Lisa Kay Schweyer, Mobility21 UTC Program Manager and ACT Board member led a discussion group on TDM research, encouraging ACT members to connect with their local UTC and provided an update on the organization's Diversity, Equity and Inclusion task force activities.

- May 18, 2020 - Mobility21 UTC Researcher and CMU Professor Costa Samaras was interviewed as part of a transportation episode of Michael E. Webber's *Power Trip: The Story of Energy* documentary. Watch here.

- April 8, 2020 - CMU Mobility21 UTC researcher and CEE's Sean Qian studied the relationship between Uber and public transportation, demonstrating variance between time of day and location. His work was described in the following article published in CMU's Civil & Environmental Engineering News Spring 2020 newsletter…"*In our modern world, it's easy to get across town. With companies such as Uber and Lyft, known as transportation network companies (TNC), passengers have plenty of options on how they will travel. Both TNCs and public transportation leaders rely on data to influence their policies, so Associate Professor Sean Qian set out to study the relationship between TNCs and public transportation in Pittsburgh. In a recently*

published paper in the journal Transportation, Qian's Mobility Data Analytics Center focused on whether consumers were substituting public transit with TNCs, making last-minute decisions to choose a TNC over public transportation based on fares."

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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?

- August 7, 2020 – UTC PI John Peha's paper, Leading the Way: A National Task Force on Connected Vehicles was published by the Day One Project (Day One is an initiative of the nonpartisan Federation of American Scientists) as one of the 100 best policy ideas related to science and technology that should be enacted during the next Administration. Read <u>here</u>.

- During the past year, representatives of the General Accounting Office visited with Umit Ozunger and Keith Redmill of the Ohio State University to learn more about their work on the Effect of Pedestrian and Crowds on Vehicle Motion and Traffic Flow. This visit was one of several made by the GAO to learn more from experts on this topic. The resulting GAO publication "*PEDESTRIAN SAFETY: NHTSA Needs to Decide Whether to Include Pedestrian Safety Tests in Its New Car Assessment Program,*" published in April can be found <u>here</u>.

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?

- As a result of his work including his most recent UTC project, *Data-driven mobility service design: a case study for Moon Township,* UTC PI Sean Qian decided to spin off a new company. This project allowed the team to develop and model an innovative strategy for integrating RIDEACTA FMLM service and UBER with existing fixed route transit. It was determined that this innovative model and tool developed in the research has great commercialization potential and can be easily replicated in other regions nationally. The new company is **TraffiQure**.

- On August 19, 2020, Rapid Flow Technologies, a Mobility21 UTC spin-off company, has been named as a semi-finalist in the Toyota Mobility Foundation City Architecture for Tomorrow Challenge. During the application period, over 90 global teams submitted their ideas for review, which was then narrowed to only 16 semi-finalist teams. Each semi-finalist team receives up to a $5,000 grant each to develop Proofs of Concept of their solutions.

- On June 19, 2020, Roadbotics, a Mobility21 spin-off company, has been named a "World Economic Forum 2020 Technology Pioneer." *The Technology Pioneers of 2020 bring together 100 early to growth-stage companies from around the world that are pioneering new technologies and innovations, ranging from the use of artificial intelligence to diagnose cancers and quantum computing systems, to carbon capture and removing technologies, cell-grown meat production and use of microbiome to track goods.*

What is the impact on the body of scientific knowledge?

July 2020 – Three Mobility21 PI's, Aaron Steinfeld, Stan Caldwell, Steve Smith contributed as volunteer expert stakeholders for the US Department of Transportation, *Identifying Real-World Transportation Applications Using Artificial Intelligence (AI), Real-World AI Scenarios in Transportation for Possible Deployment Final Report* (Publication Number: <u>FHWA-JPO-20-810</u>).

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. 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 to do that.

During this reporting period, CCAC engaged different individuals and groups discussing the various opportunities within "Intelligent Transportation Systems", "Advanced Driver Assist Systems" (ADAS) and "Connected &

Autonomous Vehicles." Some of these discussions are with high school faculty, helping them modify their curriculum to include ADAS and connected and autonomous vehicles. They covered the theory and hands-on training for automotive technicians in CCAC courses that included; ADAS specific training and information to repair these systems.

CCAC staff developed and experimental course, ATE-252 "Explorations in Transportation Innovation" in the spring of 2020 which enrolled 12 students. The idea of this course was to combine different disciplines into one exploratory transportation course. The course included students from the automotive program, data analytics program and the mechatronics program. The students would interact across disciplines with a common transportation theme. At the end of the course students would present a transportation project in one of those areas. Unfortunately due to COVID-19, the face to face labs had to be converted to virtual learning and the course primarily took on a data analytic theme.

CCAC and the automotive program in general educated over 250 automotive students with some ADAS information, and graduated 31 with associate degrees. Our outreach events exposed over 25 different groups to "Transportation & Transportation Related Careers and Information:"

- ✓ 15 different high school automotive programs in Career and Technical Education
- ✓ Outreach events with the Petroleum Retailers and Automotive Repair Association
- ✓ Additional meetings to inform PA State Perkins administration and staff to support increased funding for career and technical schools who train students in ITS career opportunities

And throughout the reporting period, Bob has participated in the ITS Professional Capacity Building program meetings that focus on ITS training in community colleges. During one session Turner Fairbanks engineers discussed their plans to deploy Connected Vehicle Education (CAVe) in a box for education and training purposes. CCAC plans on using this simulator, once developed, in their transportation training courses.

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	Current Reporting Period	Annual Total
Impact #1	Annual Number of Instances of Technology Adoption or Commercialization	3	1	2	3
Impact #2	Annual Number of Instances of Research Changing Behavior, Practices, Decision Making, Policies (Including Regulatory Policies), or Social Actions	3	3	10	13

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

- August 26, 2020 - Mobility21 UTC researcher Scott Matthews, along with student Prithvi Acharya and Paul Fischbeck of Engineering and Public Policy have worked to create a new method to identify over-emitting vehicles. *"Across the U.S., there has been some criticism of the cost and efficacy of emissions inspection and maintenance (I/M) programs administered at the state and county level. In response, Engineering and Public Policy (EPP) Ph.D. student Prithvi Acharya and his advisor, Civil and Environmental Engineering Scott Matthews, teamed up with EPP's Paul Fischbeck. They have created a new method for identifying over-emitting vehicles using remote data transmission and machine learning that would be both less expensive and more effective than current I/M programs...."*

- July 3, 2020 – *"The [City of Pittsburgh] Department of Public Works usually uses 917 tons of salt per inch, but utilizing new technology and a different salt mixture last winter, the department used 376 tons per inch, the city says. The city says it costs about $88 per ton of salt. In previous years, dealing with this year's snowfall would have cost $1.75 million, but instead it cost $718,000…The technology is already paying for itself and will only lead to more savings year after year."* These recommendations were the result of UTC PI Steve Smith's research project, *Optimizing Snow Plowing Operations in Urban Road Networks*. Read More.

- May 27, 2020 - "The Association for Commuter Transportation (ACT) has developed a resource guide to help inform employers, commuters, and communities on how we can all get back to the workplace safely and efficiently. Prepared by a task force of transportation demand management (TDM) professionals representing service providers, employers, and government agencies, this handbook provides tips for managing many of the most common commute options during the current pandemic." Mobility21 UTC Program Manager Lisa Kay Schweyer assisted with the development of this guide as an active participant on this task force. Access the report here.

- May 18, 2020 - Metro21 Executive Director Karen Lightman was asked to work with the City of Pittsburgh Department of Mobility Infrastructure, as well as business owners, mobility leaders, technologists, and transportation officials to provide a report on the use of streets and mobility to aid the community during the COVID-19 pandemic. Access full report here.

- Upon recommendation of researcher Sean Qian and Metro21 Executive Director, "The City of Pittsburgh Department of Innovation and Performance is set to join two data-sharing agreements, at no cost to the City, that will improve planning and analysis related to mobility, transportation and public works." Read more here.

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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

The full impact of COVID-19 will not be fully known for some time. Earlier in the year, we surveyed our researchers for what they anticipated the impact would be on their research programs and their contingency plans to address any impacts. The list of the 22 responses was sent to our UTC Grants Manager.

At the time, we expected all research to continue and we worked with all researchers to assist their pivoting to remote work and mitigate impacts on their research. We spent our July 2020 UTC Faculty meeting discussing the progress researchers have made, gauging need for assistance and discussing further contingency plans for the Fall Semester. In most cases, timelines were delayed due to lab certifications and reopenings and hiring students/staff. However, most researchers felt they would be able to maintain their overall research project timelines.

One researcher, Maxine Eskanzi shared her experience: *"The goal of the last period of work was to collect as much data from real users as possible and then to use to personalize the system. Since the advent of the Covid19 pandemic, people, especially seniors, have not been traveling. Instead of data collection and personalization…we began work on precise instructions to hospitals (as described above) and giving information about the best path to take to a given destination for people who have low vision and/or use a wheelchair."*

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.

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7. SPECIAL REPORTING REQUIREMENTS

Submission status of Final Research Reports: During this report period, nine reports have been submitted to the repositories as indicated in the Grants Deliverables and Reporting Requirements - *Submission of Final Research Reports.*

Also per direction of our Grants Manager, we are reporting that CMU student, Prithvi Sudha Acharya attended the "Data for Policy" conference (originally to be held in London but was held virtually September 14 – 18, 2020. Prithvi had submitted a workshop and paper proposal, which was originally accepted but due to the switch to online was made into a discussion session for participants.