



**A USDOT NATIONAL
UNIVERSITY TRANSPORTATION CENTER**

Carnegie Mellon University



THE OHIO STATE UNIVERSITY



Semi-Annual Progress Performance Report for University Transportation Centers

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Office of the Assistant Secretary for Research and Technology
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Improving Mobility of People and Goods

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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 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 Deployment Partner 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

- Thirty research projects were active during this report period.
- Three UTC faculty meetings were held. The meetings are held to provide updates on the UTC, share information among the four academic consortium partners, present research and education projects and discuss opportunities for collaboration.

Additional accomplishments:

- *February 13, 2023 - Mobility21 UTC Faculty Member Named as Fellow of the American Association for the Advancement of Science* - Mobility21 UTC researcher Burcu Akinci has been elected as fellow of the AAAS. Akinci was honored for her significant contributions to her field for data and model-drive infrastructure management through digital twins.

- *January 9, 2023 - Destenie Nock Joins Clean Energy Works Board* - Mobility21 UTC researcher Destenie Nock has been named to the Clean Energy Works Board.
- *January 6, 2023 - Rahul Mangharam Named Board Member of The Autoware Foundation* - University of Pennsylvania Mobility21 researcher Rahul Mangharam is kicking off 2023 as a new Board Member of The Autoware Foundation. The foundation is a non-profit organization supporting open-source projects enabling self-driving mobility.
- *December 16, 2022 - Rajkumar Appointed to PennSTART Operating Committee* - Mobility21 UTC Director Raj Rajkumar was appointed to the Pennsylvania Safety Transportation and Research Track (PennSTART) Operating Committee, which held its inaugural meeting today. Funding for the PennSTART facility in southwestern Pennsylvania was announced by PennDOT Secretary Yassmin Gramian in August 2022.
- *December 12, 2022 - Pingbo Tang Awarded Dowd Fellowship to Develop Simulations* - Mobility21 UTC researcher Pingbo Tang will be supported by the Dowd Fellowship to integrate data-driven simulation games into two existing courses and one new course for "learning operations by trying" experiences with various civil systems.
- *November 10, 2022 - Mobility21 UTC Researcher Destenie Nock Featured at COP27* - Researcher Destenie Nock was featured on the "Beyond the Models - From Improbable Scenarios to Resilient Systems" panel at COP27 to discuss how improved energy modeling can support a more feasible, reliable and equitable energy transition.
- *November 9, 2022 - Informs Awards 2022 First Place Award to Mobility21 UTC Researcher Peter Zhang* - Mobility21 UTC researcher Peter Zhang was awarded the 2022 First Place award in the INFORMS Junior Faculty Forum Paper Competition for his paper, "Adjustability in Linear Robust Optimization," co-authored with Ningji Wei of Texas Tech University.
- *November 2, 2022 - "Future of Work" Grant Awarded* - Mobility21 UTC researcher Lee Branstetter's project that investigates how artificial-augmented learning can help accelerate student learning in community college information technology courses has been awarded one of 14 "Future of Work" grants by the National Science Foundation.
- *October 27, 2022 - Mobility21 Advisory Council Member Named to Michigan Transportation Hall of Honor* - Mobility21 Advisory Council member Kirk Steudle, along with Greg Johnson, Sharmyn Elliott, and Sam Crowl were recently inducted into the 2022 Michigan Transportation Hall of Honor.
- *October 19, 2022 - Professor Destenie Nock Named Minority Issues Forum Paper Competition Finalist* - Mobility21 UTC researcher Destenie Nock was named a Minority Issues Forum Paper competition finalist for her paper, "Unveiling Hidden Poverty Using the Energy Equity Gap" in Nature Communications with Shuchen Cong, Lucy (Yueming) Qiu and Bo Xing.
- *October 6, 2022 - Mobility21 UTC Researcher Named Wimmer Faculty Fellow* - Mobility21 UTC researcher and CMU CEE Assistant Professor Katherine Flanigan has been named one of the 2022-23 Wimmer Faculty Fellows at the Eberly Center for Teaching Excellence and Education Innovation.

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 **196** deployment partners.

At Carnegie Mellon University Women in Transportation Fellows help lead, and the UTC supports, a university-wide graduate and undergraduate student transportation club. The UTC also actively engages student groups at its partner universities and colleges.

Highlighted Education Initiatives:

- *March 31, 2023 - Update from Mobility21 Sponsored RISS Student Rayna Hata* - Update from Mobility21 sponsored Robotics Institute Summer Scholar Student Rayna Hata: "My research with the RISS program and UTC researcher Stephen Smith of the Intelligent Coordination and Logistics Lab at CMU Robotics Institute. For the past two years, I have been researching methods of Blind Pedestrian Navigation on Urban Crosswalks using the PedPal app, first created by Dr. Smith and his team. At the end of RISS, I presented my research to other RISS peers and professors at the Robotics Institute, where I received thoughtful feedback and comments about my research and my presentation—every moment at RISS allowed me to grow as a researcher. My overall experience at RISS solidified my interest in attending graduate school and obtaining my PhD in robotics to further my education and research experience in assistive technology and human-computer interaction. I am excited to return to the Carnegie Mellon University Robotics Institute this fall as a PhD student."
- *March 24, 2023 - CMU Student Showcases Mobility21 Research* - Carnegie Mellon University doctoral student Lindsay Graff presented a poster on her Mobility21 project "*A MultiModal Network Modeling Framework to Evaluate Time-Dependent Accessibility Under Generalized Costs*" at the CMU Civil and Environmental Engineering Research Showcase.
- *March 23, 2023 - WTS Pittsburgh Chapter Hosts 6th Annual Scholarship Gala* - Mobility21 Program Manager Lisa Kay Schweyer and 2021-2023 Women in Transportation Fellow Maggie Harger participated in the 6th Annual WTS Pittsburgh Chapter Scholarship Gala. The event was an opportunity to network with current and future transportation industry professionals and leaders, and to celebrate the achievements of scholarship recipients.

- *March 22, 2023 - Destenie Nock and Her Student Participate in Scott Institute Energy Week* - Mobility21 researcher Destenie Nock and her PhD student Lily Hanig participated in CMU Energy Week activities, where Lily presented her work during the poster session.
- *March 17, 2023 - Transportation Club Hosts Career Panel* - Members of the CMU Transportation Club hosted four transportation professionals for their annual career panel event. Panelists represented the City of Pittsburgh, Department of Mobility & Infrastructure, WSP, Pittsburgh Regional Transit, and Hitachi Rail. The panelists shared their experiences in planning transit-oriented communities, conducting right-of-way development, managing sidewalks and curbs, and rail wayside engineering. Students asked questions of the panelists, as well as engaged in networking at the end of the event.
- *February 28, 2023 - Inclusive Stem Teaching Project CMU Discussions Led by Mobility21 & Robotics Institute Program Managers* - Lisa Kay Schweyer, Program Manager for Mobility21 UTC and Rachel Burcin, Global Programs Manager for the Robotics Institute, co-chaired an information session today about the Inclusive Stem Teaching Project and a companion discussion group for members of the Carnegie Mellon University community. Lisa Kay and Rachel will also be leading the CMU community discussion group, which will meet 3 times over the next 2 months.
- *February 17, 2023 - Transportation Club Hosts "Movie Night" On Campus* - The Transportation Club hosted movie night on the CMU campus to watch "The Terminal." The event provided 23 students a chance to network and share in the camaraderie of the club while enjoying popcorn and a (transportation themed) movie.
- *February 16, 2023 - Transportation Club Students Attend Hitachi Rail Open House* - Students from the CMU Transportation Club attended the Hitachi Rail Open House to learn about the career and development opportunities that Hitachi Rail offers. Students had the chance to speak with several of the Hitachi Rail top business leaders, toured the research labs, and participated in individualized sessions to learn more about their projects and available positions.
- *January 30, 2023 - Former Women in Transportation Fellow Addresses Transportation Issues to Create a More Equitable World* - Former Women in Transportation Fellow Ngani Ndimbie (2016-2018), a senior consultant at High Street, was featured in a CMU publication talking about her work to help improve transportation challenges for underinvested and underserved communities.
- *January 18, 2023 - CMU Student Hannah Morin Shares EV Knowledge* - Mobility21 UTC researcher Jeremy Michalek's PhD student Hannah Morin, who studies Engineering and Public Policy and Material Science and Engineering, was interviewed by a Hudson High School (Ohio) student for his paper on electric vehicles, and the California 2035 all EV rule.
- *January 16, 2023 - Mobility21 Women in Transportation Fellow Shares TRB Experience* - Mobility21 UTC Women in Transportation Fellow for 2021-2023, Maggie Harger attended the Transportation Research Board's 102nd Annual Meeting in Washington, DC. The meeting offered her the opportunity to learn about the latest developments in transportation research, policy, and innovative practices from across the world. Maggie reports some highlights of the event included remarks from U.S. Transportation Secretary Pete Buttigieg and U.S. Energy Secretary Jennifer M. Granholm on the state of transportation policy in America, specifically the new joint office between the US Department of Transportation and the US Department of Energy. Maggie and other students from CMU were able to meet fellow students involved in transportation at the University of Pennsylvania, as well as several CMU alumni who are now professionals in the field.
- *January 16, 2023 - Experience at TRB's Annual Meeting* - CMU student & transportation club member, Brian Hsu also attended the Transportation Research Board Annual Meeting in Washington, D.C. "...As a future roadway engineer, I was particularly excited to see the emphasis in roadway design on safety, complete streets, and human factors. I found the discussions about the AASHTO Green Book and how to effectively implement its guidelines to be very informative."
- *January 13, 2023 - TRB Graduate Research Award Program Recognizes CMU Student* - Carnegie Mellon University doctoral student Yanyu Wang was recognized at the 2023 TRB Annual Meeting for her 2021-2022 applied research on airport and related aviation system issues to help the public sector improve the quality, reliability, safety, and security of the U.S. civil aviation system in her paper, "Proactive Improvements of Standard Taxi Routes in Airports Based on Reinforcement Learning and Data-Driven Simulation." Her faculty mentor is Mobility21 UTC researcher Pingbo Tang.
- *January 13, 2023 - Hawaii autonomous race car team places third in driverless challenge* - "The University of Hawaii's autonomous race car team finished in third place at the Autonomous Challenge at CES (Consumer Electronics Show) on January 7 at the Las Vegas Motor Speedway. UH AI Racing Tech is a collaboration between UH Maui College, UH Manoa's College of Engineering, UC San Diego, Carnegie Mellon University and UC Berkeley."
- *January 7, 2023 - Mobility21 UTC Honors "Student of the Year" Lily Hanig at 32nd Annual USDOT Awards Ceremony* - Carnegie Mellon University student Lily Hanig was honored tonight as Mobility21 University Transportation Center's "Student of the Year" at the Council of University Transportation Center's annual awards event. Lily receiving her award from Dr. Firas Ibrahim, Director of the U.S. DOT's Office of Research, Development, and Technology, and Caesar Singh, Director, University Transportation Centers (UTC) Grants Program. Lily Hanig is a PhD student in Engineering and Public Policy at Carnegie Mellon University. Her research focuses on analyzing transportation system equity during 1) disruptive events (e.g., COVID-19 and climate change) and 2) energy transitions. Her current work assesses long-distance coverage of electric vehicles (EV) chargers along corridors in the US and future work will look at siting of EV chargers at the community level to optimize for equitable distribution and low emissions. Lily is excited to be working towards a more equitable and decarbonized transportation system during a period of disruption by new technologies in the field.
- *December 20, 2022 - Three University of Pennsylvania Students Win WTS Philadelphia Awards* - UTC researcher Megan Ryerson joined 3 students from the University of Pennsylvania, who were among the awardees at the WTS Philadelphia annual awards program. Nata Kovalova, a Master of City Planning Candidate received the Sylvia Alston Scholarship Award

Bingchu Chen, Graduate Candidate at Master of City Planning/Master of Urban Spatial Analytics received the Circle of Continuity Award Siyu (Jasmine) Wu, Master of City Planning Candidate received the Vision for Equity Award.

- *December 19, 2022 - CMU Students Awarded 2022 Qualcomm Innovation Fellowship* - Wenhao Ding and Jiacheng Zhu, PhD students in CMU UTC researcher Ding Zhao's lab, proposed a new method, Learning to Collide, to identify risky scenarios leveraging the reinforcement learning technique. This method builds a framework where the autonomous system is a victim attacked by the scenario-generation algorithm. ... Ding and Zhu's proposal, 'Safety-Critical Scenarios Generation and Generalization for Autonomous Driving' was awarded the 2022 Qualcomm Innovation Fellowship.
- *December 16, 2022 - Heinz College Students Present Capstone Projects for Fall 2022* - CMU Heinz College Master of Information Systems Management program students engage in semester long "Capstone Projects" to apply coursework to real-world scenarios. This week, students shared the results of their semester long transportation research projects with the following clients: Torc, US Ignite, Chevron, 2 Green Edge, Blue Triton, Make It Home Safe and Honda.
- *December 13, 2022 - Heinz College MSPPM Students Present Capstone* - Heinz College Master of Science in Public Policy and Management students from Mobility21 Executive Director Stan Caldwell's Systems Synthesis course presented their final capstone presentation for their client, InnovatePGH, which focused on Smart Loading Zones and Curb Management.
- *December 13, 2022 - CMU Student's Work Impacting PRT's Zero Emissions Plan* - Mobility21 UTC Executive Director Stan Caldwell served as the faculty advisor to Carnegie Mellon University Energy, Science, Technology and Policy M.S. student Prathit Bhavin Dave, who completed an Applied Advanced Study project to refine the Pittsburgh Regional Transit's (PRT) Zero Emissions Bus rollout plan financial model and develop the user guide. PRT Chief Development Officer and project supervisor David Huffaker stated, "This guide provides a training tool for understanding a complex financial model that will allow us to evaluate various choices that we will inevitably need to make on our zero-emission journey."
- *December 12, 2022 - Park Clean Up Leads to Students' Developing New Tool for Transit Riders* - On October 29, after arriving to Phillips Park to help with a local clean-up effort, UTC Program Manager, Lisa Kay Schweyer was surprised to learn 3 Carnegie Mellon University students (Shirui Liang, Maria Manrique, Keziah Virdayanti) were also there to help. She joined the students while picking up litter and had a chance to share what she does at CMU, hear about their trip on the local bus to the park, and learn more about the students' interest in transportation and the project they had been thinking about for their Integrated Innovation Institute Design Methods class. Within a week, the students invited Lisa Kay to meet with the project team. From that conversation, and their own experience navigating transit systems, the group decided to work on a way to use technology to make the experience of first-time bus riders less stressful. The team conducted research, used various integrated innovation methods and conducted testing to propose their solution – an "AR Your Guide"! The solution is an augmented reality feature that can be integrated into existing transportation apps, providing users with an interactive guide that leads them to unfamiliar bus stops and instructs people new to bus transportation how to pay, track, and request stops.
- *December 7, 2022 - CCAC Students Are Giving Back to the Community* - In an effort to give back to the community, the students in the Ford ASSET Program at the Community College of Allegheny County assembled a kid-sized Bronco as part of the regional Free Care Fundraiser. Mobility21 faculty member Bob Koch, Chair for Community College of Allegheny County Skilled Trades Department and Automotive Ford ASSET program professor was on hand for the special delivery.
- *December 7, 2022 - Student Presentations on Intelligent Transportation Systems* - CMU's students in the Smart Cities: Growth with ITS class, instructed by Mobility21 Professor Sean Qian and co-instructed by Mobility21 Executive Director Stan Caldwell, hosted presentations from 10 groups of multidisciplinary master's students analyzing ITS technologies.
- *December 3, 2022 - CMU Transportation Club Hosts Networking Event* - Prior to final exam week at CMU, during what can be a busy time for many students, the CMU Transportation Club hosted a networking event for its members. Because the members of the transportation club come from a variety of academic backgrounds, they do not often have a chance to meet one another in class. This opportunity to meet fellow students and share about classes, job opportunities and other overlapping interests was beneficial to all. The club plans to host similar events before exam week in the spring semester.
- *November 12, 2022 - CMU Transportation Club Attends Transportation Camp "Unconference"* - Members of the CMU Transportation Club recently attended Transportation CampPGH, an "unconference" event organized by Mobilify Southwestern Pennsylvania and hosted on CMU's campus by Mobility21. Individuals from a variety of backgrounds were in attendance, from areas such as academia, the private sector, advocacy groups and the City of Pittsburgh. The themes chosen for discussion included street design, transit-oriented communities, and advocacy work. Additionally, Mobility21 Advisory Board member Vince Valdes, Executive Director and CEO of the Southwestern Pennsylvania Commission, and Beth Osborne, President of Transportation For America presented as keynote speakers.
- *November 10, 2022 - CMU Transportation Club Tours xBridge Innovation Center* - Members of the CMU Transportation Club took an exclusive behind the scenes tour of the xBridge Innovation Center at Pittsburgh International Airport. This technology center is a test bed for new tech that can benefit the airport, airline partners, and air travelers. Members of the transportation club were able to see a remote-controlled vehicle that may be ultimately utilized to move passengers around the airport, algae which can filter air throughout the interior, and a delivery robot which could help facilitate the movement of goods through security. The students were also able to learn more about construction of a new terminal at the airport.
- *October 24, 2022 - Carnegie Mellon's Career & Professional Development Center Presents First Autonomous Vehicle Focused Career Fair* - Facilitated by Mobility21, Carnegie Mellon's Career & Professional Development Center, in partnership with Heinz College Career Services, first autonomous vehicle focused career fair was held on CMU's campus in conjunction with the PA Automated Vehicle Summit.

- *October 7, 2022 - Penn Transportation Club Hosts First Guest Lecture of Fall Semester* - Members of the University of Pennsylvania's Penn Transportation Club hosted their first guest lecture of the Fall '22 semester, where city planner and Penn graduate Robert Ravelli spoke about the intersections of transportation and land use planning.
- *October 1, 2022 - Dignity in a Digital Age: Making Tech Work for All of Us* - Metro21 intern and Heinz College Masters Student Bobby Lincoln moderated a discussion with Congressman Ro Khanna and Congressman Conor Lamb on the future of technology. Representative Khanna discussed his new book, "Dignity in a Digital Age: Making Tech Work for All of Us," which offers a revolutionary roadmap to facing America's digital divide, offering greater economic prosperity to all. In Khanna's vision, "just as people can move to technology, technology can move to people...."
- During this reporting period, the motivation for traffic volume estimation using bus-based video and general data collection approach used in OSU researcher Mark McCord's project, *Determining Segment and Network Traffic Volumes* were presented in a required, undergraduate Civil Engineering with approximately 70 students. The traffic volume estimation using bus-based video and the empirical data collection and volume estimations served as the basis of a term project in one undergraduate/graduate Civil Engineering class consisting of 28 students.

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. The information and links are also sent to our US DOT Grants Manager for posting on the US DOT website.

Below are the SMCs held during this reporting period.

Date	Speaker(s)	University	Title	Video Recording Link
10/7/2022	Sarah Fox	CMU	Considerations on the future of Human-Automation Teaming in the Transit Workforce	https://youtu.be/iJM-d7JNiMw
11/4/2022	Justin Starr	CCAC	Student Applications of AI for Infrastructure Inspection	https://youtu.be/jtmJUvozsd0
12/2/2022	Umit Ozguner	OSU	Vulnerable Road Users Dominating the Shared Spaces with Vehicles	https://youtu.be/bSF4i2qbtK0
1/20/2023	Jeremy Michalek	CMU	Uber & Lyft in U.S. Cities: Findings and Recommendations	https://youtu.be/AMyh-npHB0
2/10/2023	Rahul Mangharam	UPENN	Tiny Machine Learning	https://youtu.be/mB4KC5f3atg
2/24/2023	Umit Ozguner and Bilal Hejase	OSU	Adapting a Learning-Based Driving Agent Using State-Action Interpretations	N/A
3/24/2023	Justin Starr	CCAC	Technician Interactions with Artificial Intelligence Systems	https://youtu.be/TI5Zk9KSrLI

Additional technology transfer activities:

- *March 2, 2023 - Fifth Annual Conference on Autonomous Vehicles and Public Transport* - Researcher Nik Martelaro participated in the Fifth Annual Conference on Autonomous Vehicles and Public Transport in San Francisco, CA, which was attended by a mix of individuals working in transit in both the public and private sectors. Nik spoke about his work on the intersection of autonomous vehicle driving technology and the future of bus transit labor, highlighting challenges to human-automation teaming and the potential impacts of automation on bus drivers.
- *December 7, 2022 - Transportation Engineering & Safety Conference Features Mobility21 UTC Researcher* - Mobility21 researcher Corey Harper was featured as a presenter on the "Smart City Systems, Sustainable Transportation, and the Importance of Resiliency in Our Infrastructure" panel, alongside other experts in the field at the Transportation Engineering & Safety Conference, hosted by Penn State University, to discuss how high-resolution rainfall data could improve safety and management of the transportation system during inclement weather events.

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 during the report period:

- *March 8, 2023 - ACT Celebrates International Women's Day with Panel* - Association of Commuter Transportation Board of Directors members Connie McGee, Jessica Alba, Roz Tucker, and Lisa Kay Schweyer (Mobility21 Program Manager) hosted an International Women's Day discussion. The conversation highlighted how empowering women includes promoting and enabling their equal and meaningful participation, as historically, women have been underrepresented in transportation.
- *February 18, 2023 - Southwestern Pennsylvania Commission Holds First Regional Broadband Summit* - Southwestern

Pennsylvania Commission hosted the first of its kind Regional Broadband & Connectivity Summit, bringing together regional stakeholders, industry and non-profit experts, and local, state and federal governments and agencies to address equitable and affordable access to high-speed broadband internet in southwestern Pennsylvania. Metro21 Executive Director Karen Lightman participated and provided her expertise on broadband.

- *February 13, 2023 - Mobility21 Program Manager Lisa Kay Schweyer Added to Cleveland Federal Reserve Bank's Community Advisory Council.*
- *February 9, 2023 - Mobility21 Program Manager Participates in ACT Winter Meeting - Lisa Kay Schweyer serves as a board member for the Association for Commuter Transportation. She participated in the winter board meeting and met with the new members of the ACT ImpACT Leadership cohort.*
- *February 7, 2023 - Metro21 Hosts National Science Foundation Workshop at Carnegie Mellon University Campus - Metro21: Smart Cities Institute, led by Executive Director Karen Lightman, hosted participants from across the country for an invite-only workshop funded by the National Science Foundation to discuss the need to address multiple societal challenges such as mobility and access, energy efficiency, and provision of ecosystem services.*
- *January 24, 2023 - Mobility21 UTC Researcher Hosts Digital Infrastructure & Services Workshop - Mobility21 UTC researcher and Director of the Mobility Data Analytics Center at Carnegie Mellon University Professor Sean Qian hosted the Digital Infrastructure & Services Workshop, with the goal of uniting University-Industry-Government to collaboratively address societal issues, particularly related to mobility, energy, wireless communications, and human activities. Participants in the workshop included CMU faculty, representatives from Honda, Fujitsu, and the City of Pittsburgh.*
- *January 8, 2023 - Council of University Transportation Centers Holds Annual Winter Meeting - The Council of University Transportation Center's (CUTC) winter meeting brought together the nation's leading transportation professionals from academia and industry along with US 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 13, 2022 - Mobility21 Program Manager Facilitates 1st Meeting of CUTC Peer Exchange Roundtable Group - Mobility21 Program Manager Lisa Kay Schweyer facilitated the 1st CUTC Peer Exchange Roundtable Group (which was established in response to feedback provided at the 2022 CUTC Summer Meeting, to share information and support university transportation research center administrative staff at CUTC member centers).*
- *October 24, 2022 - Metro21 Hosts 'Enabling the Implementation of Integrated and Scalable Smart Cities' Listening Session - Metro21: Smart Cities Institute Executive Director, Karen Lightman moderated a listening session with stakeholders from around the United States, including rural, urban and suburban perspectives, to better inform understanding of mobility/transportation challenges. NSF sponsored this listening session.*
- *October 13, 2022 - University of Florida 'Careers In Transportation Class' Includes Mobility21 Speakers - The University of Florida was awarded a grant from the Council of University Transportation Centers to encourage students to choose transportation as a profession. To do this, they developed a 1-credit course featuring speakers from academia, government, and the private/consulting sectors. At today's class both Stan Caldwell, Mobility21 Executive Director and Lisa Kay Schweyer, Program Manager shared their career journeys with the students.*

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 4,571 subscribers**. The readership represents individuals in industry, government, academia and community organizations **from 13 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. **610 articles were posted** in this reporting period.

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 team and a link to the final research report. During this report period, the following recaps were released:

- *Demand Learning & Supply Optimization for Last-Mile Transportation in Disadvantaged Neighborhoods, Peter Zhang*
- *Connected Vehicle Infrastructure for a Smart City, Ray Gastil*
- *Smart and Equitable Parks: Quantifying Returns on Investments, Katherine Flanigan*
- *Platooning for Improved Safety and Efficiency of Semi-Trucks (PISES-III), Venkat Viswanathan and Varun Shankar*
- *Equity and Transportation System Implications of Shared Autonomous Vehicle Deployment, Corey Harper*
- *Towards a Smart, Safe, and Sustainable Sidewalk: How Infrastructure Affects Users, Ding Zhao*
- *Bus on the Edge: Applications, Christoph Mertz*
- *Rethinking Connected Vehicles for Spectrum Scarcity, Jon Peha*
- *Ridehailing Service Equity in Normal and Rare Conditions, Jeremy Michalek, Daniel Armanios, and Destenie Nock*
- *Mixed Autonomy Era of Transportation: Resilience and Autonomous Fleet Management, Carlee Joe-Wong*

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

Raj Rajkumar reached out to the PI for the new national UTC for Mobility to offer assistance in transitioning and the continuation of the Annual National Mobility Summit.

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 **196** deployment and equity partners.

The list below 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
City of Philadelphia	Philadelphia, PA		X		X	
Hitachi Rail	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, <https://mobility21.cmu.edu/about/leadership/advisory-council>.

- **March 16, 2023 - Mobility21 Hosts Fourth Annual National Mobility Summit of USDOT UTCs** - Mobility21 hosted the Fourth Annual National Mobility Summit of US Department of Transportation University Transportation Centers in Washington D.C. The summit provided a unique opportunity for over 110 researchers, government, community, and industry representatives from across the country to discuss improving mobility for people and goods as well as highlighting UTC innovations and impacts.

The day began with a welcome from Mobility21 Director Raj Rajkumar and US Department of Transportation Director of UTC Grants Program Caesar Singh.

The day also included a keynote session, where **Alasdair Cain**, US DOT Director of Research, Development and Technology Coordination and several other senior leaders from the department discussed their programs and opportunities for collaborative transformational research. The keynote panelists included: **Maryam Allahyar**, Director, Research & Development, Office of Research, Development & Technology, Federal Railroad Administration; **Brian Cronin**, Director, Office of Safety and Operations R&D, Federal Highway Administration; **Tom Keane**, Associate Administrator, Federal Motor Carrier Safety Administration; **David Schneider**, Acting Deputy Associate Administrator, Office of Research, Demonstration, and Innovation, Federal Transit Administration; **Egan Smith**, Managing Director, Intelligent Transportation Systems Joint Program Office; and **Nanda Srinivasan**, Associate Administrator, Research and Program Development, National Highway Traffic Safety Administration.

In addition, there were three discussion panels which focused on the topics of environment and climate change, workforce development, and equity.

- ✓ **Environment/Climate Change** – UTC Innovations and Impacts: **Richard Ezike**, Program Communication Specialist, Joint Office of Energy and Transportation; Ralph Buehler, Professor and Chair at Virginia Tech School of Public and International Affairs (SPIA); **Genevieve Giuliano**, Distinguished Professor, USC Sol Price School of Public Policy, Pacific West Region UTC; **Stanley Young**, Research Scientist, National Renewable Energy Laboratory.
- ✓ **Workforce Development** – UTC Innovations and Impacts: **Tom O'Brien**, Executive Director, California State University, Long Beach College of Professional and Continuing Education Center for International Trade and Transportation; **Nick Geale**, Vice President for Workforce Policy, American Trucking Associations; **Sarah Fox**, Assistant Professor Human-Computer Interaction Institute, & Nik Martelaro, Assistant Professor Human-Computer Interaction Institute, Carnegie Mellon University; **Matt Colvin**, Chief of Staff, Transportation Trades Department, AFL-CIO; **Hilary Nixon**, Deputy Executive Director, Mineta Transportation Institute; Carita Ducre, Vice President for Workforce Development and Education Services, APTA.

- ✓ *Equity* – UTC Innovations and Impacts: **Arlando Teller**, Assistant Secretary for Tribal Affairs, USDOT; **David Kack**, Director, Western Transportation Institute and the Program Manager for Mobility and Public Transportation; **Carol Tyson**, Government Affairs Liaison, Disability Rights Education & Defense Fund; **Steven Polzin**, Deputy Director at the TOMNET UTC at Arizona State University, TOMNET; UTC **April Rai**, President & CEO, COMTO.

The day highlighted work from 15 UTC's around the country (representing 50+ educational institutions) and concluded with a research showcase where UTCs shared their ideas and created new collaborations.

- *November 16, 2022 - PennSTART Highlighted at STIC Meeting in Harrisburg* - Pennsylvania State Transportation Innovation Council (STIC) co-chair and Mobility21 Advisory Council Member Secretary Yassmin Gramian hosted the STIC quarterly meeting. Mobility21 Executive Director and founding STIC member Stan Caldwell participated in the meeting, where the PennSTART test track was highlighted.
- *November 15, 2022 - UTC Research Informs Pittsburgh's ITS Plan* - Mobility21 Executive Director Stan Caldwell participated in a workshop at the City of Pittsburgh Department of Mobility and Infrastructure to develop the concept of operations for the city's ITS Plan. Caldwell applied his experience from UTC research projects to help inform the plan.
- *November 3, 2022 - Traffic21/Mobility21 University Transportation Center Deployment Partner Consortium Symposium Held* - The Traffic21/Mobility21 University Transportation Center Deployment Partner Consortium Symposium kicked off with Mobility21 UTC Director, Raj Rajkumar, providing a welcome and an overview of updates on activities and plans at the Mobility21 National University Transportation Center.

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. Over 135 people attended the symposium and engaged in the day's events.

The Symposium's first panel focused on Driving the Economic Engine of the Region. The panel was moderated by **Karen Lightman**, Executive Director of Metro21 and featured: **Scott Andes**, Program Lead \$1 Billion Build Back Better Regional Competition, U.S. Economic Development Administration **Richard Ezike**, Program Communications Specialist, Joint Office of Energy and Transportation **Ellie Ezzell**, Economic Development Specialist, RIDC of Southwestern PA.

The event's keynote speaker was **Carl Andersen**, Technical Director, Operations Research and Development, FHWA, Turner Fairbank. He highlighted FHWA's existing programs and new initiatives.

The Symposium's second panel highlighted UTC Impacts from the Partners' Perspectives. The panel was moderated by **Stan Caldwell**, Executive Director, Mobility21 and featured: **Rajeev Chhajer**, Group Leader – Connected Technologies Research / Associate Director – 99P Labs, Honda R&D, **Kelly Maurer**, Director of Public Works, Cranberry Township **Ben Schmidt**, Global Chief Technology Officer, RoadBotics by Michelin.

The event wrapped up with the UTC Research/Education Showcase & Networking Reception, which featured 19 displays.

- *November 2, 2022 - Mobility21 UTC Advisory Council Holds Annual Meeting for 2022* - Mobility21 UTC Director, Raj Rajkumar welcomed the group and provided an overview of updates of activities and plans. The remaining time was spent by council members sharing their thoughts on how to best transfer the knowledge generated through the UTC, the 2023 Mobility Summit, and new opportunities. Members participating in this meeting were: **Raymond T. Betler**, Chairman of LB Foster, Former President and CEO of Wabtec Corporation, **Robin Chase**, Co-founder Zipcar, Veniam, NUMo, **Ty Gourley**, Vice President of Hillman Family Foundations, **Charles L. Hammel III**, President and owner, PITT OHIO Express, **Jane Lappin**, Former Director, Public Policy & Government Affairs, Toyota Research Institute, **Ken McLeod**, Policy Director at The League of American Bicyclist, **Jim Misener**, Senior Director, Product Management and the Global V2X Ecosystem Lead for Qualcomm Technologies, Inc and former Executive Director of UC Berkley PATH, **Paul Skoutelas**, President and Chief Executive Officer of The American Public Transportation Association, **Kirk Steudle**, President, Steudle Executive Group, former Senior Vice President of the Econolite Transportation Systems Group and subsidiary CAVita, and former Director of Michigan Department of Transportation and **Vincent Valdes**, Executive Director, Southwestern Pennsylvania Commission.

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

Publications, conference papers, and presentations

Title	Type	Citation	Date
<i>MAVIPER: Learning Decision Tree Policies for Interpretable Multi-Agent Reinforcement Learning</i>	Peer Reviewed	Milani, Stephanie, Zhicheng Zhang, Nicholay Topin, Zheyuan Ryan Shi, Charles Kamhoua, Evangelos E. Papalexakis, and Fei Fang. "MAVIPER: Learning Decision Tree Policies for Interpretable Multi-Agent Reinforcement Learning." In <i>Machine Learning and Knowledge Discovery in Databases: European Conference, ECML PKDD 2022, Grenoble, France, September 19–23, 2022, Proceedings, Part IV</i> , pp. 251-266. Cham: Springer Nature Switzerland, 2023.	2023-03-17
<i>COVID-19 public transit precautions: Trade-offs between risk reduction and costs</i>	Peer Reviewed	Hanig, Lily, Corey D. Harper, and Destenie Nock. "COVID-19 public transit precautions: Trade-offs between risk reduction and costs." <i>Transportation Research Interdisciplinary Perspectives</i> 18 (2023): 100762.	2023-03-01
<i>Drive Right: Promoting Autonomous Vehicle Education Through an Integrated Simulation Platform</i>	Peer Reviewed	Qiao, Z., Loeb, H., Gurrila, V., Lebermann, M., Betz, J., & Mangharam, R. (2023). <i>Drive Right: Promoting Autonomous Vehicle Education Through an Integrated Simulation Platform</i> . arXiv preprint arXiv:2302.08613.	2023-02-16
<i>Robot Synesthesia: A Sound and Emotion Guided AI Painter</i>	Trade	Misra, Vihaan, Peter Schaldenbrand, and Jean Oh. "Robot Synesthesia: A Sound and Emotion Guided AI Painter." arXiv preprint arXiv:2302.04850 (2023).	2023-02-09
<i>COVID-19 public transit precautions: Trade-offs between risk reduction and costs</i>	Peer Reviewed	Hanig, L., Harper, C. D., & Nock, D. (2023). <i>COVID-19 public transit precautions: Trade-offs between risk reduction and costs</i> . <i>Transportation Research Interdisciplinary Perspectives</i> , 18, 100762.	2023-01-31
<i>What Stay-At-Home Orders Reveal About Dependence on Transportation Network Companies</i>	Peer Reviewed	393 Corey Harper 1/19/23 Hanig, Lily, Destenie Nock, and Corey D. Harper. "What Stay-At-Home Orders Reveal About Dependence on Transportation Network Companies." (2023).	2023-01-19
<i>What Stay-At-Home Orders Reveal About Dependence on Transportation Network Companies</i>	Peer Reviewed	Hanig, Lily, Destenie Nock, and Corey D. Harper. "What Stay-At-Home Orders Reveal About Dependence on Transportation Network Companies." (2023).	2023-01-19
<i>Tangible Extended Reality with Sensor Fusion a</i>	Other	<i>Tangible Extended Reality with Sensor Fusion at the Electronic Imaging conference in San Francisco, on January 15-19, 2023.</i>	2023-01-16
<i>Identifying Safety-Critical Heavy-duty Vehicles in Fleets with Complementary Vehicle Inspection Datasets through Cross-Database Clustering Analysis</i>	Peer Reviewed	Yuan, C., Shi, Y., Xiong, R., & Tang, P*, (under review) "Identifying Safety-Critical Heavy-duty Vehicles in Fleets with Complementary Vehicle Inspection Datasets through Cross-Database Clustering Analysis." <i>Transportation Research Record (TRR)</i> .	2023-01-09
<i>Identifying Safety-Critical Heavy-duty Vehicles in Fleets with Complementary Vehicle Inspection Datasets through Cross-Database Clustering Analysis</i>	Peer Reviewed	Yuan, C., Shi, Y., Xiong, R., & Tang, P*, (under review) "Identifying Safety-Critical Heavy-duty Vehicles in Fleets with Complementary Vehicle Inspection Datasets through Cross-Database Clustering Analysis." <i>Transportation Research Record (TRR)</i> .	2023-01-09
<i>Measuring time-dependent accessibility with emerging mobility options: a generic multi-modal network modeling framework</i>	Other	L.K. Graff, K.A. Flanigan and S. Qian (2023). "Measuring time-dependent accessibility with emerging mobility options: a generic multi-modal network modeling framework," <i>Transportation Research Board Annual Meeting, Washington, DC</i> .	2023-01-07
<i>Knowledge-driven Scene Priors for Semantic Audio-Visual Embodied Navigation</i>	Trade	Tatiya, Gyan, Jonathan Francis, Luca Bondi, Ingrid Navarro, Eric Nyberg, Jivko Sinapov, and Jean Oh. "Knowledge-driven Scene Priors for Semantic Audio-Visual Embodied Navigation." arXiv preprint arXiv:2212.11345 (2022).	2022-12-21
<i>Modems: Optimizing edge computing migrations for user mobility</i>	Peer Reviewed	Kim, Taejin, Sandesh Dhawaskar Sathyanarayana, Siqi Chen, Youngbin Im, Xiaoxi Zhang, Sangtae Ha, and Carlee Joe-Wong. "Modems: Optimizing edge computing migrations for user mobility." <i>IEEE Journal on Selected Areas in Communications</i> (2022).	2022-12-21
<i>Distribution-aware Goal Prediction and Conformant Model-based Planning for Safe</i>	Trade	Francis, Jonathan, Bingqing Chen, Weiran Yao, Eric Nyberg, and Jean Oh. "Distribution-aware Goal Prediction and Conformant Model-based Planning for Safe Autonomous Driving." arXiv preprint	2022-12-16

<i>Autonomous Driving</i>		<i>arXiv:2212.08729 (2022).</i>	
<i>MAGViT: Masked Generative Video Transformer</i>	<i>Trade</i>	Yu, Lijun, Yong Cheng, Kihyuk Sohn, José Lezama, Han Zhang, Huiwen Chang, Alexander G. Hauptmann et al. "MAGViT: Masked Generative Video Transformer." <i>arXiv preprint arXiv:2212.05199 (2022).</i>	2022-12-10
<i>iSimLoc: Visual Global Localization for Previously Unseen Environments with Simulated Images</i>	<i>Peer Reviewed</i>	Yin, Peng, Ivan Cisneros, Shiqi Zhao, Ji Zhang, Howie Choset, and Sebastian Scherer. "iSimLoc: Visual Global Localization for Previously Unseen Environments With Simulated Images." <i>IEEE Transactions on Robotics (2023).</i>	2022-12-01
<i>Challenges in Close-Proximity Safe and Seamless Operation of Manned and Unmanned Aircraft in Shared Airspace</i>	<i>Trade</i>	Patrikar, Jay, Joao Dantas, Sourish Ghosh, Parv Kapoor, Ian Higgins, Jasmine J. Aloor, Ingrid Navarro et al. "Challenges in Close-Proximity Safe and Seamless Operation of Manned and Unmanned Aircraft in Shared Airspace." <i>arXiv preprint arXiv:2211.06932 (2022).</i>	2022-11-13
<i>Multimodal object detection via probabilistic ensembling</i>	<i>Peer Reviewed</i>	Chen, Yi-Ting, Jinghao Shi, Zelin Ye, Christoph Mertz, Deva Ramanan, and Shu Kong. "Multimodal object detection via probabilistic ensembling." <i>In Computer Vision—ECCV 2022: 17th European Conference, Tel Aviv, Israel, October 23–27, 2022, Proceedings, Part IX, pp. 139–158. Cham: Springer Nature Switzerland, 2022.</i>	2022-11-06
<i>FAR planner: Fast, attemptable route planner using dynamic visibility update</i>	<i>Peer Reviewed</i>	Yang, Fan, Chao Cao, Hongbiao Zhu, Jean Oh, and Ji Zhang. "FAR planner: Fast, attemptable route planner using dynamic visibility update." <i>In 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp. 9–16. IEEE, 2022.</i>	2022-10-23
<i>Social-PatteRNN: Socially-Aware Trajectory Prediction Guided by Motion Patterns</i>	<i>Peer Reviewed</i>	Navarro, Ingrid, and Jean Oh. "Social-PatteRNN: Socially-Aware Trajectory Prediction Guided by Motion Patterns." <i>In 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp. 9859–9864. IEEE, 2022.</i>	2022-10-23
<i>Rca: Ride comfort-aware visual navigation via self-supervised learning</i>	<i>Peer Reviewed</i>	Yao, Xinjie, Ji Zhang, and Jean Oh. "Rca: Ride comfort-aware visual navigation via self-supervised learning." <i>In 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp. 7847–7852. IEEE, 2022.</i>	2022-10-23
<i>Curriculum Reinforcement Learning using Optimal Transport via Gradual Domain Adaptation</i>	<i>Trade</i>	Huang, Peide, Mengdi Xu, Jiacheng Zhu, Laixi Shi, Fei Fang, and Ding Zhao. "Curriculum Reinforcement Learning using Optimal Transport via Gradual Domain Adaptation." <i>arXiv preprint arXiv:2210.10195 (2022).</i>	2022-10-18
<i>Coalitional Fairness of Autonomous Vehicles at a T-Intersection</i>	<i>Peer Reviewed</i>	Gomez, Diana, Haohong Lin, Peide Huang, Corey Harper, and Ding Zhao. "Coalitional Fairness of Autonomous Vehicles at a T-Intersection." <i>In 2022 IEEE 25th International Conference on Intelligent Transportation Systems (ITSC), pp. 2536–2541. IEEE, 2022.</i>	2022-10-08
<i>Leveraging Structure from Motion to Localize Inaccessible Bus Stops</i>	<i>Trade</i>	Panigrahi, Indu, Tom Bu, and Christoph Mertz. "Leveraging Structure from Motion to Localize Inaccessible Bus Stops." <i>arXiv preprint arXiv:2210.03646 (2022).</i>	2022-10-07
<i>Stress Testing Autonomous Racing Overtake Maneuvers with RRT</i>	<i>Other</i>	Bak, Stanley, Johannes Betz, Abhinav Chawla, Hongrui Zheng, and Rahul Mangharam. "Stress Testing Autonomous Racing Overtake Maneuvers with RRT." <i>arXiv preprint arXiv:2110.01095 (2021).</i>	2022-10-03
<i>T2FPV: Constructing High-Fidelity First-Person View Datasets From Real-World Pedestrian Trajectories</i>	<i>Trade</i>	Stoler, Benjamin, Meghdeep Jana, Soonmin Hwang, and Jean Oh. "T2FPV: Constructing High-Fidelity First-Person View Datasets From Real-World Pedestrian Trajectories." <i>arXiv preprint arXiv:2209.11294 (2022).</i>	2022-09-22 *
<i>Privacy of Autonomous Vehicles: Risks, Protection Methods, and Future Directions</i>	<i>Trade</i>	Xie, Chulin, Zhong Cao, Yunhui Long, Diange Yang, Ding Zhao, and Bo Li. "Privacy of Autonomous Vehicles: Risks, Protection Methods, and Future Directions." <i>arXiv preprint arXiv:2209.04022 (2022).</i>	2022-09-08 *
<i>Estimating global demand for land-based transportation services using the shared socioeconomic pathways scenario framework</i>	<i>Peer Reviewed</i>	Nkiriki, Joan, Paulina Jaramillo, Nathan Williams, Alex Davis, and Daniel Erian Armanios. "Estimating global demand for land-based transportation services using the shared socioeconomic pathways scenario framework." <i>Environmental Research: Infrastructure and Sustainability 2, no. 3 (2022): 035009.</i>	2022-09-08 *
<i>Plan B: Design Methodology for Cyber-Physical Systems Robust to Timing Failures</i>	<i>Peer Reviewed</i>	Khayatian, Mohammad, Mohammadreza Mehrabian, Edward Andert, Reese Grimsley, Kyle Liang, Yi Hu, Ian McCormack et al. "Plan B: Design Methodology for Cyber-Physical Systems Robust to Timing Failures." <i>ACM Transactions on Cyber-Physical Systems (TCPS) 6, no. 3 (2022): 1–39.</i>	2022-09-07 *
<i>On the Generalizability of Motion Models for Road Users in Heterogeneous Shared Traffic Spaces</i>	<i>Peer Reviewed</i>	F. T. Johora, D. Yang, J. P. Müller and Ü. Özgüner, "On the Generalizability of Motion Models for Road Users in Heterogeneous Shared Traffic Spaces," in <i>IEEE Transactions on Intelligent Transportation Systems</i> , 2022, doi: 10.1109/TITS.2022.3192138.	2022-09-01 *
<i>Mixed-Autonomy Era of</i>	<i>Other</i>	Lin, I., Osman Yagan and Carlee Joe-Wong. "Mixed-Autonomy Era of	2022-08-31 *

<i>Transportation: Resilience & Autonomous Fleet Management</i>		<i>Transportation: Resilience & Autonomous Fleet Management. Technical Report, Carnegie Mellon University.</i>	
<i>Autonomous Vehicles on the Edge: A Survey on Autonomous Vehicle Racing</i>	Peer Reviewed	J. Betz et al., "Autonomous Vehicles on the Edge: A Survey on Autonomous Vehicle Racing," in <i>IEEE Open Journal of Intelligent Transportation Systems</i> , vol. 3, pp. 458-488, 2022, doi: 10.1109/OJITS.2022.3181510.	2022-08-30 *
<i>Stress Testing Autonomous Racing Overtake Maneuvers with RRT</i>	Peer Reviewed	S. Bak, J. Betz, A. Chawla, H. Zheng and R. Mangharam, "Stress Testing Autonomous Racing Overtake Maneuvers with RRT," 2022 <i>IEEE Intelligent Vehicles Symposium (IV)</i> , 2022, pp. 806-812, doi: 10.1109/IV51971.2022.9827237.	2022-08-30 *
<i>Combinatorial and Parametric Gradient-Free Optimization for Cyber-Physical System Design</i>	Peer Reviewed	H. Zheng, J. Betz, A. Ramamurthy, H. Jin and R. Mangharam, "Combinatorial and Parametric Gradient-Free Optimization for Cyber-Physical System Design," 2022 <i>IEEE Workshop on Design Automation for CPS and IoT (DESTION)</i> , 2022, pp. 34-41, doi: 10.1109/DESTION56136.2022.00012.	2022-08-30 *
<i>Publication</i>	Trade	Brittany Eastman, <i>Legal Issues Facing Automated Vehicles, Facial Recognition, and Privacy Rights</i> , SAE International, 2022.	2022-07-29 *

* Not previously reported.

Other publications, conference papers and presentations:

Title	Event	Type	Attended	Date
Rehab Robotics Workshop	GRASP Lab Robotics	Academic	10	2023-03-17
1,2,3 Metadrive	Fourth Annual Mobility 21 Summit	Professional	100	2023-03-16
Metadrive 1 2 3	Virtual Reality and Healthcare Symposium	Professional	75	2023-03-03
A multimodal network modeling framework to evaluate time-dependent accessibility under generalized travel costs	CMU Advanced Infrastructure Systems Seminar	Academic	50	2022-11-04
Determining Traffic Volumes Using Video Imagery Obtained from Transit Buses in Regular Service: Research, Education, and Outreach	Mobility21 Deployment Partner Consortium Symposium	Professional	120	2022-11-03
Spectrum Sharing for C-V2X and Wi-Fi	Traffic21/Mobility21 Deployment Partner Consortium	Academic	130	2022-11-03
BusEdge: Spatio-Temporal Analytics for City Scale Understanding	Mobility21 Consortium Meeting	Academic	100	2022-11-03
BHH Theorem Through a Big Data Lens: TSP/VRP Approximation for Assessing Urban Transportation Efficiency	INFORMS Annual Meeting	Academic	30	2022-10-18
Demand learning and supply optimization for last mile transportation in low-income neighborhood	INFORMS Annual Meeting	Academic	30	2022-10-17
Last mile transportation efficiency as social services	INFORMS Annual Conference	Academic	25	2022-10-16
Adjustability in Robust Linear Optimization	INFORMS Annual Meeting	Academic	50	2022-10-16

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://www.cmu.edu/traffic21/	The Carnegie Mellon University's Traffic21 Institute website, which includes the archived previous UTC T-SET site	New Posts: 610
http://mobility21.cmu.edu/	The Carnegie Mellon University's Mobility21 National University Transportation Center website	New Posts: 610
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: 251
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: 106 Views: 408
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: 1,201 Following: 1,732

Technologies or techniques

- *January 23, 2023* - Ohio State researchers developing app for pedestrian safety – “After working with the City of Marysville and observing data from one of their smart intersections, these professors, including Professor Levent Guvenc, PhD who teaches mechanical and aerospace engineering, noted pedestrians’ movements can be quick and unpredictable, and they are often hard to see...From those capabilities, Doctor Guvenc and his team at the Ohio State University’s College of Engineering created an app for pedestrians and drivers to keep everyone on the road safe.”
- *October 7, 2022* - Using AI and robots to speed up optimization of new battery development – “A team of researchers at Carnegie Mellon University has developed a new approach to speeding up the process of creating ever more optimized batteries. In their paper published in the journal Nature Communications, the group describes how they paired a unique type of robot with an AI learning system to create ever more useful non-aqueous liquid electrolytes.”
- Researcher Mel Siegel has demonstrated the training game at UPMC STAT MedEvac Communication Center and made a Youtube video about our Mobile Incident Command Dashboard (MIC-D): <https://youtu.be/5cHkxSea4DY> as part of his project, *Digital Twin for Emergency Traffic Management*.

Inventions, patent applications, and/or licenses

There is one new invention/patent application to report this period.

Docket	Title	Inventors
2023-118 *	A Mathematical Programming Approach to Optimal Classification Forests	Victor Blanco Izquierdo; Alberto Japon Saez *; Justo Puerto Albandoz; Peter Zhang

* The provisional patent application was filed 11/18/22. The invention and patent have both been reported in iEdison (IRN 0247601-22-0064).

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
Output #1	Annual Number of Journal Publications	35	26
Output #2	Annual Number of Research Pilot Deployments	10	5

Please see “Section #3 Publications” for publications.

Some examples of the research pilot deployments include:

- *November 8, 2022* - All routes lead to cleaner air – “One of the longest running smart transport projects is in Pittsburgh, Pennsylvania, USA. In July 2012, the Robotics Institute at Carnegie Mellon University deployed its adaptive traffic signal technology, Surtrac in nine traffic junction sites in the East Liberty area of the city. The AI/robotic system treats traffic control at these junctions as a single machine scheduling issue...Stephen F Smith, research professor and director of the Intelligent Coordination and Logistics Lab, The Robotics Institute, Carnegie Mellon University explained: “At the beginning of each planning cycle, a given intersection perceives the approaching (or already queued) traffic from its local sensors and builds a prediction of when it expects each approaching vehicle to arrive at the intersection. Then, in real-time it constructs a ‘signal timing plan’ (a schedule of ‘green’ times for each intersection phase) that moves all of the sensed traffic through the intersection in a way that minimizes cumulative wait time.”
- Researcher Sean Qian developed mobility service model aims to simulate routing shuttles for rider pick-ups and drop-offs leveraging the real-world data (e.g., rider demand, travel time, and mainline bus schedule). The model has been implemented to simulate traffic and public transit in Columbus region as part of his project, *A modeling framework to quantify impacts of mobility services on multimodal transportation systems: Methodology and a case study in Columbus, OH*.
- As part of *the Bus on the Edge: Passengers* project, researcher Christoph Mertz has been able to equip a second bus with the bus-edge system. This new system has two additional cameras inside the bus with which will be able to observe the passenger behavior through an entire trip.

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 28, 2023 - Hydrogen hub, carbon projects face internal, external hurdles** – “The head of the public-private partnership that is shepherding Pennsylvania’s application for a potential hydrogen hub centered around the Pittsburgh region said success isn’t just about winning funding but a real pathway to decarbonization...Destenie Nock, assistant professor of civil and environmental engineering, said the focus should be on a wider scope of industrial development than a single plant to make the biggest impact and to provide a voice consistently throughout the process and not just at certain points.”
- **March 6, 2023 - High levels of chemicals could pose long-term risks at Ohio train derailment site, researchers say** – “It’s not elevated to the point where it’s necessarily like an immediate ‘evacuate the building’ health concern,” said Dr. Albert Presto, an associate research professor of mechanical engineering at Carnegie Mellon’s Wilton E. Scott Institute for Energy Innovation, who is working on the university’s chemical monitoring effort in East Palestine. ‘But, you know, we don’t know necessarily what the long-term risk is or how long that concentration that causes that risk will persist.’” With a \$28.8 million investment grant award that came from a combination of federal, city and state funding, the Steel City is welcoming the SmartSpines project, which will use advanced transportation technologies to modernize traffic signals. The goal is to improve “safety, efficiency, system performance, and infrastructure return on investment.” Raj Rajkumar, a professor of computer engineering at Carnegie Mellon University, doubts that Tesla can fix all of the problems cited by NHTSA with a software update. The automaker, he says, relies only on cameras and artificial intelligence to make driving decisions, a system that will make mistakes. ‘Cameras can miss a lot of things,’ Rajkumar said. ‘These are not straightforward issues to fix. If they could have fixed it, they would have fixed it a long time back.’”
- **February 17, 2023 - Electric Vehicles Are A Status Symbol Now** - “‘You’re talking about renters who may not have the option to install charging infrastructure,’ Jeremy Michalek, a professor at Carnegie Mellon University and the director of its Vehicle Electrification Group, told me. ‘And even if they have charging infrastructure this year, renters tend to move, and they don’t know whether they’ll have that access next year. Even a lot of homeowners don’t have off-street parking, and relying entirely on public charging infrastructure is a whole different ball game.’”
- **February 14, 2023 - The Inconvenient Truth About Electric Vehicles** – “For those who can plug in at home, everyday driving gets better—no more service-station pit stops to top off the dinosaur car. If you can’t charge at home or at work, car ownership may get more annoying. As Michalek noted, fast-charging stations aren’t meant to be treated like gas stations.”
- **February 13, 2023 - Tesla’s Pickup Truck Is Coming Soon. Maybe.** – “More than three years after Elon Musk stunned the auto industry with an electric pickup truck that looked more like a stealth fighter than a way to haul two-by-fours and drywall, Tesla said last month that it would begin building the vehicle by the end of 2023...’Tesla thinks they can solve any problem and don’t have to learn from anyone else,’ said Raj Rajkumar, a professor of engineering at Carnegie Mellon University, ‘and then they get stuck in a corner.’”
- **January 16, 2023 - Destination unknown? Pittsburgh’s autonomous vehicle industry seeks a new course after a disastrous season.** - “‘We’re definitely in a colder period now,’ said John Dolan, a systems engineer and professor at the CMU Argo AI Center for Autonomous Vehicle Research. ‘A bit of an autonomous driving winter perhaps, as we’ve seen with some of these recent closures. I just don’t know how it’s going to go in the future.’”
- **January 13, 2023 - Electric planes sound like a fantasy but they may be the future for short-haul in Australia** – “In January Carnegie Mellon University’s Prof Venkat Viswanathan wrote an article for Nature on the future of batteries in aviation which has become a call-to-arms for engineers in the industry. Viswanathan and his coauthors concluded that it was possible to make significant gains in battery chemistry for use in aviation by 2030 – but only if everything went right along the way. And even then, they would still not be capable of powering the largest passenger aircraft.”
- **January 13, 2023 - What Happens to the Future of Electric Cars if Tesla Dies?** – “‘I give Elon Musk a lot of credit. He almost single-handedly made electric vehicles glamorous and sexy,’ Raganathan “Raj” Rajkumar, a professor of electrical and computer engineering and autonomous vehicle researcher at Carnegie Mellon University, told The Daily Beast. ‘People

associated them with the person who was transforming the automotive industry and doing the right thing for the planet.”

- *January 6, 2023 - We asked 17 smart people to predict the future of transportation in 2023* – “Raj Rajkumar, professor of electrical and computer engineering at Carnegie Mellon University, ‘There will be an ongoing retrenchment of the AV industry. Expect more layoffs in the large AV companies and at least one more high-profile flameout like Argo AI. Emphasis will dramatically shift from full autonomy and robotaxis to ADAS++ and high automation features. I, for one, am very bullish on the viability and appeal of advanced autonomy (as opposed to full autonomy, which will still take time).” .
- *December 20, 2022 - 25 years of autonomous vehicles: The challenge towards Level 5* – “The source of the many groundbreaking developments in autonomous vehicles (AVs) today came in the 1990s. Inspired by the futuristic image of self-driving cars of the sci-fi genre, the 90s witnessed several developments in autonomous driving: 1995: Carnegie Mellon University completed the first US coast-to-coast autonomous driving of 4,500 km.”
- *December 12, 2022 - Pittsburgh startup says its tech will let electric vehicles go the distance without recharging* – “Range anxiety remains one of the greatest obstacles to the broader adoption of electric vehicles, but local startup CorePower Magnetics is developing electrical components that could eliminate the problem....Based on a decade of research at Carnegie Mellon University, CorePower’s technology has attracted \$7.5 million in investment, including a \$5 million grant from the U.S. Department of Energy, according to the startup. It is working with agricultural equipment maker John Deere and power management company Eaton Corporation to expand its production...”
- *December 7, 2022 - How Uber and Lyft are transforming U.S. cities* – “Over the last decade, the meteoric rise of ridesourcing services like Uber and Lyft have transformed the urban landscape, affecting travel patterns, car ownership, and congestion, and more broadly, the economy, the environment, and equity. The ways in which Uber and Lyft are redefining mobility is the focus of a new policy brief series, ‘Uber and Lyft in U.S. Cities: Findings and Recommendations from Carnegie Mellon University Research on Transportation Network Companies (TNCs).”
- *November 18, 2022 - Nagoya startup offers unique tactic to sell driverless tech* – “In the field of self-driving cars, Japanese companies are being left in the dust of their U.S. rivals, including Waymo LLC of Google operator Alphabet Inc. and General Motors affiliate GM Cruise Holdings. However, a Nagoya University startup is throwing its hat in the ring using a unique strategy...Shinpei Kato, chief technical officer of the company who studied autonomous driving at Carnegie Mellon University in the United States, founded the Nagoya-based company.”
- *November 1, 2022 - Self-driving car company’s sudden shutdown is a ‘shock’* – “A promising autonomous vehicle company that had raised billions of dollars has suddenly folded. Argo AI, headquartered in Pittsburgh, had been considered an up-and-coming startup. News of its shutdown came as its main backers, Ford and Volkswagen, decided to no longer invest. ‘The shutdown of Argo AI was a big shock to the Pittsburgh community, especially because they were kind of seen as a Cinderella story for autonomous vehicle companies, growing up with homegrown talent and getting on the national stage, being based here in Pittsburgh,’ said Stan Caldwell, Executive Director of Traffic21, a traffic research institute with Carnegie Mellon University.”
- *October 25, 2022 - Your Car’s Driving Assistance Tech Isn’t Meant to Be Used Alone—Here’s Why* – “A new study finds that drivers using driver assistance features often treat their vehicles as fully self-driving. These applications still require the human to keep their eyes on the road and hands ready to take over the wheel, just as we have been doing with traditional cruise control for decades,’ Stan Caldwell, a professor of transportation and public policy at Carnegie Mellon University told Lifewire in an email interview... ‘Vehicles that you can buy currently can have levels 1 and 2 automation and include applications such as automated lane keeping, adaptive cruise control, and automated emergency braking.”
- *October 14, 2022 - Carnegie Mellon University’s Robotics Institute is moving into new space* – “Currently located within Newell – Simon Hall at 5000 Forbes Ave. along CMU’s Oakland campus, the RI is setting its sights on leasing additional space in a former Barnes & Noble location on Murray Avenue in Squirrel Hill. This will be an expansion to the institute’s current footprint, which is also scattered across other buildings on CMU’s campus...CMU professors Jean Oh, head of the Bot Intelligence Group; Zac Manchester, who runs the Robotic Exploration Lab; and Sebastian Scherer, the AirLab leader, will use the space for their respective research teams that conduct robotics-based work relating to aerial autonomy, collaboration and exploration, among others.”
- *October 14, 2022 - Tesla will remove more vehicle sensors amid Autopilot scrutiny* – “Tesla Inc said on Tuesday it will remove ultrasonic sensors from its vehicles starting this month, as it moves ahead with using only cameras in its safety and driver-assistant features...The transition will temporarily limit automated parking features, but not affect crash safety ratings, Tesla noted. ‘It remains to be seen whether this will be ‘two steps forward and one step backward’ or the other way around,’ said Raj Rajkumar, a professor of electrical and computer engineering at Carnegie Mellon University.”
- *October 11, 2022 - The Long Road to Driverless Trucks* – “Eventually, the industry will also embrace electric trucks powered by battery rather than fossil fuel, and this will raise still more questions for autonomous trucking. Where and how will the batteries get recharged? Won’t this prevent self-driving trucks from running 24 hours a day, as the industry has promised? ‘There are so many issues that in reality are far more complex than they might seem on paper,’ said Steve Viscelli, an economic and political sociologist at the University of Pennsylvania who specializes in trucking.”
- *October 11, 2022 - Drones could make last-mile package deliveries greener* – “Using drones for the last mile of package deliveries uses less energy and creates fewer emissions than conventional means, a new study shows...To address this issue, researchers looked at what they refer to as ‘an increase in the demand for last-mile delivery while trying to reduce the environmental impacts of the transportation sector.’ Many companies are exploring using autonomous vehicles to perform last-mile delivery, says Thiago Rodrigues, a [CMU] PhD candidate.”

- *October 10, 2022 - ‘Pittsburgh knows how to make things’: Global manufacturing summit takes stage in Downtown* – “It was the Global Manufacturing and Industrialization Summit, the latest major international conference to take over (part of) the David L. Lawrence Convention Center. When Pittsburgh was first announced as the location of GMIS’s inaugural America edition, everyone from Gov. Tom Wolf to the Pennsylvania Department of Community and Economic Development issued statements about the honor... Bryan Salesky, CEO of Pittsburgh-based autonomous vehicle company Argo AI, spoke with Carnegie Mellon University professor Martial Herbert about another buzzword that had been on previous panelists’ lips: automation. ‘... And that has meant tighter collaboration between academic institutions and industry, which he described as a ‘complete transformation.’”
- *October 4, 2022 - When Will AVs Actually Start to Smooth Traffic Flows?* – “Autonomous vehicles have the ability to make traffic move smoother. But first, they need to be more widely deployed. And that means creating the right regulations for the right cars. At least 20 percent of the vehicles on the roadways will need to be autonomous in order to realize the traffic operational gains that come with connected vehicles, according to new research from Carnegie Mellon University. ‘One of the goals of our work was to quantify the amount of AVs [autonomous vehicles] under which we would begin to realize these traffic and congestion benefits; surprisingly, we found that only 20 percent are needed,’ said Carlee Joe-Wong, one of the authors of the report, *Mixed-Autonomy Era of Transportation: Resilience and Autonomous Fleet Management*. ‘And that 50-ish percent AVs was sufficient for realizing most of the gains.’”
- *October 4, 2022 - Why activists are calling on Carnegie Mellon University and the City of Pittsburgh to ban facial recognition tech* – “Ethical concerns about artificial intelligence are why local groups such as Partnership to Advance Responsible Technology exists, and why CMU’s own Block Center for Technology and Society launched the Responsible AI initiative in April... ‘In Bill Peduto’s chapter [as mayor] he saw CMU and Pittsburgh as a laboratory’ Fan said at the rally, ‘one where university research and technology helped cops and militaries enact surveillance, fear and violence to build their shiny vision of smart city Pittsburgh.’”

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 7, 2023 - USDOT RD&T UTC Video Forums* – CMU researcher Ding Zhao and his student Diana Gomez were featured in a video, and participated live during the [UTC Video Forum - Cybersecurity and Transportation](#).
- *February 13, 2023 - Traffic21 Director Presents to National Academy of Medicine* - Traffic21 faculty director and Mobility21 researcher Chris Hendrickson participated in a National Academy of Medicine roadmap panel on transportation, mobility and urban transformation with his presentation titled, “*Grand Challenge on Climate Change, Human Health and Equity: Transportation.*”
- *February 2, 2023 - UTC Presentation at PA House Emerging Tech Caucus Event* - Members of the Pennsylvania House of Representatives Emerging Technologies Caucus, chaired by Rep. Napoleon Nelson from Montgomery County, met at the headquarters of Aurora in Pittsburgh. The legislators saw autonomous trucks and participated in a panel discussion featuring Matt Blackburn, Senior Manager, Government Relations, Aurora and Eileen Steffan, VP of Academic Affairs, Pittsburgh Technical College who discussed their innovative AV workforce education initiative and Stan Caldwell, Executive Director of Mobility21 who presented his UTC research on emerging transportation technology trends.
- *January 24, 2023 - Congressmen Reschenthaler’s Staff Visits with Mobility21 UTC* - Nate Nevala, District Chief of Staff for Congressman Guy Reschenthaler, visited CMU campus and met with Stan Caldwell, Executive Director of Mobility21 UTC. Together they toured NavLab and learned how Christoph Mertz commercialized his UTC research. Mr. Nevala also met with HCII Professors Sarah Fox and Nik Martelaro to discuss their UTC research on labor and bus automation and the policy brief they published.
- *January 17, 2023 - Stan Caldwell Attends Gubernatorial Inauguration* - Mobility21 Executive Director Stan Caldwell and CMU President Farnam Jahanian, who served on the Governor's Transition Team, traveled to Harrisburg for the Inauguration Ceremony for Pennsylvania Governor Josh Shapiro and Lieutenant Governor Austin Davis.
- *January 12, 2023 - Pittsburgh Regional Alliance Welcomes Pohang City Delegation to Pittsburgh* - The Pittsburgh Regional Alliance hosted The Pohang City Delegation, led by Mayor of Pohang City, Kang-deok Lee. The main purpose of the visit was to establish partnerships between the City of Pohang and Pittsburgh, to discuss, explore, and collaborate around open innovation to drive future technologies, and extend regional collaboration opportunities (to the Asian market via Pohang City and to the North American market via Pittsburgh.) Mobility21 Executive Director Stan Caldwell presented on research, education and technology transfer activities of the UTC and Metro21: Smart Cities Institute.
- *January 12, 2023 - University of Pennsylvania at 2023 TRB Annual Meeting* - Mobility21 UTC academic partner University of Pennsylvania researchers and students participated in lectern and poster sessions throughout the 2023 TRB Annual Meeting: Poster Sessions: Investigating the Recovery of For-Hire-Vehicle, Taxi, and AirTrain at Two New York City Airports During the COVID-19 Pandemic - **Xiaoxia Dong, Erick Guerra, Megan Ryerson**; and Mobility Disparities in Access to Early Licensure for Teens: Toward a Definition of Driving Training Deserts - **Megan Ryerson, Jasmine Siyu Wu, Xiaoxia Dong**. Lectern Sessions: Is Automobile Congestion a Useful Measure of Transportation Performance? An Oxford-Style Debate - **Megan Ryerson**; and Barriers and Facilitators to Participant Recruitment in Clinical Trials Involving Young Drivers and Their Parents - **Thandwa Mdluli, Nicole Frager, Andrew Weiss, Catherine McDonald**.

- *January 12, 2023 - Ohio State University Showcases Work at Poster Session during 2023 TRB Annual Meeting* - **Mark McCord, Rabi Misalani, and Harsh Shah** from Mobility21 UTC academic partner The Ohio State University showcased their project, "Vehicle Miles Traveled Monitoring of an Urban Network Using Bus-Based Video Imagery: Empirical Evaluation and Comparison with Location-Based Service Data Derived Estimates" during a poster session.
- *January 12, 2023 - Carnegie Mellon Engages at 2023 TRB Annual Meeting* - Carnegie Mellon University and Mobility21 UTC researchers, staff and students took part in several lectern and poster sessions during the 2023 TRB Annual Meeting including: Poster Sessions: Estimating Dynamic Origin-Destination Demand for a Multimodal Transportation Network: A Computational Graph-Based Approach - **Sean Qian and Qiling Zou**; Assessing the Impact of Communication Delay on Speed Harmonization of Connected and Automated Vehicles: Application of Markov Decision Switching to Field Experimental Data - **Zulqarnain Khattak**; Identifying Safety-Critical, Heavy-Duty Vehicles in Fleets with Complementary Vehicle Inspection Data Sets Through Cross-Database Clustering Analysis - **Pingbo Tang, Chenyu Yuan, Ying Shi, Ruoxin Xiong**; COVID-19 Public Transit Precautions: Trade-Offs Between Risk Reduction and Costs - **Lily Hanig, Corey Harper, Destenie Nock**; Calibrating Bridge Element-Level Condition Ratings Through Weighted Inspection Behavior Analysis - **Pengkun Liu, Ying Shi, Ruoxin Xiong, Pingbo Tang**; Energy Consumption and Greenhouse Gas Emissions of Autonomous Ground Delivery Vehicles - **Thiago Rodrigues, Jeremy Michalek, Constantine Samaras**; Should Ridesourcing Services Pool More Rides? - **Matthew Bruchon, Connor Forsythe, Jeremy Michalek**; Smart Curbspace: Estimating the Potential for Optimized Delivery Vehicle Parking Assignment to Reduce Double Parking, Congestion, and Energy Consumption - **Aaron Burns, Jeremy Michalek, Constantine Samaras**; Does Congestion Pricing for Uber and Lyft Work?: Effects of Chicago's Downtown Zone Surcharge - **Matthew Bruchon, Connor Forsythe, Charlotte Andreasen, Kate Whitefoot, Jeremy Michalek**; What's Driving Electric Vehicle Adoption?: Evaluating Changes in U.S. Consumer Preferences and Vehicle Technology - **Connor Forsythe, Kate Whitefoot, Jeremy Michalek**. Lectern Sessions: Taking a Multimodal Approach to Equitable Bikeshare Station Siting - **Zhufeng Fan, Corey Harper**; Tools for Assessing Transportation Demand Management Strategies - **Lisa Kay Schweyer**; Bridge Management Models for Load Ratings and Repair Methods - **Pingbo Tang**; Using Automatic Passenger Counting-Automatic Vehicle Location Data to Improve Transit Reliability and Accessibility Analysis - **Daryn Lee, Sean Qian** A Two-Stage Multi-task Learning Model for Proactive Non-recurrent Traffic Prediction - **Sean Qian**; Air Pollution, Greenhouse Gas, and Traffic Externality Benefits and Costs of Fully Electrifying Ridesourcing Services - **Jeremy Michalek**; Ridesharing the Wealth: Effects of Uber and Lyft on Jobs, Wages, and Economic Growth - **Adam Koling, Daniel Armanios, Jeremy Michalek, Connor Forsythe, Akshaya Jha**; How Clean Does the U.S. Electricity Grid Need to Be to Ensure Electric Vehicles Reduce Greenhouse Gas Emissions? - **Jeremy Michalek**; Exploring the Congestion, Emissions, and Energy Implications of Switching from In-Person to Online Grocery Shopping - **Carlos Mateo Samudio Lezcano, Corey Harper, Destenie Nock, Gregory Lowry, Jeremy Michalek**; and Will Pickup Truck Owners Go Electric? - **Connor Forsythe, Kate Whitefoot, Jeremy Michalek**.
- *January 6, 2023 - Metro21 Executive Director Participates in CES2023* - At the 2023 Consumer Electronics Show Metro21 Executive Director Karen Lightman served as a panelist discussing "Smart Infrastructure: Building the Future," and how planners are using sensors, data, analytics, and adaptability to create technological systems that will improve lives of citizens.
- *December 8, 2022 - Mobility21 Researcher Participates in Pitt's Elected Officials Retreat* - Stan Caldwell applied his research while participating in a session on "Shoring Up the PA Plan for Broadband to Support Economic Opportunity and for Pennsylvanians" at the annual University of Pittsburgh Institute of Politics Annual Elected Officials Retreat.
- *December 6, 2022 - NextG Alliance Report Gets Insight from Professor Jon Peha* - Mobility21 UTC researcher and Carnegie Mellon University Professor Jon Peha was one of the contributors to the NextG Alliance Academic Workshop Report on "An examination of three key issues: Smart Agriculture, Connected Vehicles and Spectrum Access."
- *December 1, 2022 - Mobility21 Director Speaks at CMU Event for Congressman Mike Doyle* - Mobility21 Director Raj Rajkumar thanked retiring U.S. Congressman Mike Doyle for his support of the Mobility21 University Transportation Center during a Carnegie Mellon University wide special event honoring the retiring Congressman for his service.
- *November 22, 2022 - University of Pennsylvania President Learns About F1Tenth Autonomous Racing* - University of Pennsylvania President Liz Magill joined students from the F1Tenth Autonomous Racing team, led by Mobility21 UTC researcher Rahul Mangharam, to learn about their work to build safety-critical systems.
- *November 22, 2022 - Researcher Fei Fang and her student Rex Chen, as part of their project, Alleviating Traffic Congestion: Developing and Evaluating Novel Multi-Agent Reinforcement Learning Traffic Light Coordination Techniques* travelled to Strongsville, Ohio and had an in-depth discussion with city engineers in the Strongsville municipality to understand their current practice.
- *November 16, 2022 - UTC Rural Efforts Highlighted at ARC Meeting in Washington, DC* - Mobility21 Executive Director Stan Caldwell joined Andrew Weinert from MIT/Lincoln Labs on a "New Technologies" panel during the Appalachian Regional Commission's Network Appalachia meeting in Washington, DC. Caldwell, in photo with ARC Federal Co-Chair Gayle Manchin, highlighted UTC research, workforce development and technology transfer efforts targeting disadvantaged communities in Appalachia.
- *November 16, 2022 - Mobility21 Part of 'Robot Invasion' at Pittsburgh Convention Center* - Mobility21 was part of the inaugural Robotics Discovery Day, hosted by the Pittsburgh Robotics Network. CCAC sponsored a booth where Justin Starr provided demos of a Cobot and an autonomous mobility scooter. Also, Carnegie Mellon University's Rachel Burcin

of the RISS program and Tim Heffernan of PA Rural Robotics participated in the event.

- *October 21, 2022 - Mobility21 Program Manager attends Tribal Colleges and Universities and University Transportation Center Summit* - The First Americans Land-Grant Consortium held its 18th Annual Conference, kicked off by a pre-conference event Tribal Colleges and Universities and University Transportation Center Summit. Mobility21 UTC Program Manager Lisa Kay Schweyer, participated in the summit and presented an overview of the UTC's work.
- *October 17, 2022 - National Association of Development Organizations Hold Annual Conference In Pittsburgh* – NADO's Conference's plenary session featured Rachel Burcin, Global Programs Manager for the CMU Robotics Institute, Tim Heffernan, Director of the PA Rural Robotics Program, Gina Masciola of WQED, and Lisa Kay Schweyer, Mobility21 Program Manager speaking on the 'Rust Belt to Smart Belt: Autonomy, Economic Development, & STEM Education Models for Inclusion, Change and Vibrant Communities.' Over 430 people were in attendance.
- *October 11, 2022 - UTC Research Presented at Mobility Summit* - Stan Caldwell from Mobility21 National UTC and Eric Donnell from Penn State's CIAMTIS Regional UTC participated in a research panel for a Mobility Summit in Harrisburg, PA hosted by the 82 Alliance, in partnership with PennDOT, to ensure Pennsylvania remains an economically competitive region that prioritizes people before vehicles.
- *October 1, 2022 - Metro21 Joins Panel for Sustainable Cities Innovation: Balancing Financial Priorities and Well-Being Webinar* - Metro21 Executive Director Karen Lightman joined speakers from the public and private sector to discuss strategies for the decarbonization of cities, with a focus on how technology can be used to create future sustainable cities that do not compromise on wellbeing in today's volatile economic environment.

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?

- *January 12, 2023 - University of Pennsylvania Adds New Course in Machine Learning* - Mobility21 academic partner and UTC researcher Rahul Mangharam is offering a new hands-on first course in machine learning at the University of Pennsylvania, ESE3600 TinyML - Tiny Machine Learning.
- *November 4, 2022 - Gov. Wolf signs legislation permitting driverless vehicles on public roads into law* – “With the stroke of Gov. Tom Wolf's pen, House Bill 2398 has now become law following months of negotiations and the bulk of it will take effect in July 2023. Late last month, the bi-partisan bill passed the House with a vote of 119-79 in favor after making its way through the Senate with a vote of 29-20 in favor...The bill's adoption is the result of work from a coalition of advocates, including Pittsburgh-based AV companies, research firms, universities and PennDOT.”
- Researcher Pingbo Tang reports that as a result of his work on project, *Deterioration Digital Twins of Commercial Trucks and Trailers for Targeted Inspection and Maintenance*, the two industry partners have used the research algorithms to help improve their software and hardware systems designs and development:
 - CompuSpecations used our algorithms to identify input errors in their vehicle inspection database to reduce the number of errors in the inspection reports. They also used the vehicle fleet inspection planning dashboard prototype to design its software interface.
 - Clarience Technology used the research results to identify critical sensors in their product series that could have the best potential for deployment to heavy-duty trucks. Specifically, they found that they should spend more time on refining their tire, brake, and lighting sensors to form a telematics system that can capture correlated faults of these three components and improve the reliability of the vehicle diagnosis of inspectors and truck drivers.

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?

- *November 29, 2022 - Peoples Energy Analytics Aims to Modernize the Energy Industry* - Mobility21 UTC researcher Destenie Nock, alongside her PhD student Shuchen Cong, have announced the launch of their new CMU spin-out company, Peoples Energy Analytics. The company focuses on energy poverty and data analysis, with a mission of modernizing the way the energy industry supports their customers by using a combination of smart meter energy usage analysis, surveys, and engineering models to achieve this goal.
- *October 14, 2022 - Miovision Acquires SCS Spinout Rapid Flow Technologies* - Rapid Flow Technologies, a traffic technology company co-founded by School of Computer Science Professor and Mobility21 UTC researcher Stephen Smith and former PhD student Gregory Barlow, has been acquired by Miovision, a Canadian company with a similar mission to the Carnegie Mellon University spinout.

What is the impact on the body of scientific knowledge?

Outside of the previously listed peer-review publications and listed inventions, patent applications, and/or licenses in Section 3, nothing new to report this reporting period.

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 (CCAC). Justin Starr and Bob Koch were both profiled by Futurum Careers to highlight how effective the collaboration between Mechatronics and Automotive Technology students. Justin Starr continued working on advancing his work with AI as a Skilled Trade, and presented on student work in infrastructure inspection at the Water Environment Federation Technology (WEFTEC) conference as well as the OMAG conference in Oklahoma. Bob Koch hosted a successful Odyssey Day event at CCAC and worked to help those in need, including an event featured on KDKA TV's "A Waiting Child." Justin Starr and Bob Koch both promoted Mobility21 programs at KDKA TV's STEAM Fest at the Pittsburgh Zoo, as well.

Finally, CCAC was pleased to sponsor several student teams in the Student Spaceflight Experiments Competition – an event in which CCAC students designed experiments to be performed on the International Space Station. Several student groups designed transportation-related experiments involving supply chain and logistics, and presented these experiments at the Moonshot Museum. The winning student group will see their experiment sent to the International Space Station in December 2023, where astronauts will perform their experimental protocol and send results back to Earth for analysis.

CCAC demonstrated the Smart Mobility Scooter at the ARM Institute's fall meeting and the Pittsburgh Robotics Network's Roboburgh Expo. One of our adjunct faculty members, Christopher Quick, has been leading classes of students in the development of the autonomous scooter, and the scooter is now functional and being tested at the West Hills Center.

Justin Starr and Bob Koch continue to attend the ITS PCB working groups and recently gave feedback to the CAVE-in-a-Box design team on our pilot of the "lite" version of the device that was used in class. We continue to use CAVE-in-a-Box in several mechatronics courses as part of an example of connective infrastructure and the needs of technicians.

March 2023:

- Presented about Mobility21 related programs to the County Industry Working Group, chaired by Allegheny County Controller Corey O'Connor.
- Hosted a demonstration of indoor drone inspection programs for mechatronics students at CCAC, as well as a culvert inspection under PA-228 in Cranberry Township for engineers attending the PA Water Environment Association Stormwater Summit.
- Hosted KDKA TV's "A Waiting Child" to provide an automotive experience for Travis, a boy featured on the program.

February 2023:

- Participated in the Water & Wastewater Equipment, Treatment & Transport Show and met with several engineering firms to discuss challenges in water and wastewater pipeline inspections and bridge / culvert inspections.
- Assisted Integrity Environment and the City of Fishers in performing the first drone inspection of a buried stormwater line in the State of Indiana.
- Ran two lab sessions using the US DOT CAVE-In-a-Box Lite Demonstration unit for mechatronics students working on connected infrastructure.

January 2023:

- Completed second trial with apprenticeship students and ChatGPT output to validate real-world use cases and begin writing up issues with trust and AI systems.
- Performed two lab activities with different groups of apprenticeship students in the Connected Vehicle Sensor labs, using both lidar and stereocameras.
- Conducted a miniature racing session with the Virtual Racing League to explore updates to the DonkeyGym software platform as well as several hardware racing kits.

December 2022:

- Participated in ITS PCB Working Groups #2 & #3 meetings.
- Conducted initial workshops with technicians and ChatGPT for common workplace applications.
- Met with Community College of Beaver County to discuss collaboration between skilled trades and technology programs, including transportation subspecialties.

November 2022:

- CCAC Exhibited at the Pittsburgh Robotics Network's Discovery Day at the David L. Lawrence Convention Center.
- CCAC demonstrated our updated Smart Mobility Scooter at the ARM Institute's annual meeting on 11/15-16.
- CCAC held the virtual skilled trades fair the week of Thanksgiving to present on automotive and mechatronics programs to more than 50 students in high schools and Certified Technical Colleges.

- CCAC students participated in SSEP presented their experimental plans to a panel of space industry judges at the Moonshot Museum. More than 150 students participated in the experimental design process.

October 2022:

- CCAC held its annual Odyssey Day event on October 1. Over 100 attendees explore topics relating to alternative energy, clean natural gas, and the future of transportation.
- Justin Starr worked with John Deere to collaborate on ways in which EV Charging service programs could require modifications for use in rural, agricultural locations, including a discussion of potential field service by trained technicians.
- Justin Starr was a guest on NPR’s *The Confluence* on WESA-FM to promote the Student Spaceflight Experiments Program.
- Justin Starr presented student work using AI to detect infrastructure failures in water and wastewater lines at WEFTEC.
- Justin Starr and Bob Koch represented CCAC mechatronics and automotive programs at KDKA TV’s STEAM Fest at the Pittsburgh Zoo. Presented to more than 300 visiting K12 students.
- Justin Starr presented additional examples of student work on AI & infrastructure defect recognition to showcase technician training programs at the OMAG Sewer Expo.

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	4
Impact #2	Annual Number of Instances of Research Changing Behavior, Practices, Decision Making, Policies (Including Regulatory Policies), or Social Actions	3	2

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* - Nothing to report.
- *Changes that have a significant impact on expenditures* - Nothing to report.
- *Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards* - Nothing to report.
- *Change of primary performance site location from that originally proposed* - Nothing to report.

7. SPECIAL REPORTING REQUIREMENTS

Submission of Final Research Reports: Four final research reports have been submitted to the repositories as required in the Grants Deliverables and Reporting Requirements.