



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

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

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5000 Forbes Avenue
Pittsburgh, PA 15213

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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 Consortium and Advisory Council
- Number and impact of deployments achieved through collaboration

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

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

What was accomplished under these goals?

Research

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

On October 5, 2021, the annual call for proposals was released for CMU researchers to propose projects for July 1, 2022 – June 30, 2023. Twenty-two proposals were received, totaling more than \$2 million in requests. Representatives from our Advisory Council and the UTC management team participated in the review of the proposals. Sixteen of the projects were selected based on the available funding. Mobility21 UTC management personnel worked with the PIs to ensure all US DOT & project requirements were met so the projects could start July 1, 2022.

During this reporting period, two UTC faculty meetings were held. The meetings are held to provide the faculty updates on the Mobility21 UTC, share information among the four UTC academic consortium partners, present research being conducted and discuss opportunities for collaboration.

On August 11, 2022, PennDOT Announced \$22 Million PennSTART Facility - PennDOT Secretary Yassmin Gramian announced the PennSTART facility, a state-of-the-art safety, training and research facility in collaboration with the Pennsylvania Turnpike Commission and the Regional Industrial Development Corporation of SW PA. Located in Mount Pleasant, this facility will provide real-world training for emergency responders, transportation technology companies, and research institutions while supporting the local economy. It will build on the growing technology and AV industries in the region, as well as support jobs and business development. Mobility21 UTC Director, Raj Rajkumar and Executive Director, Stan Caldwell have been deeply involved in the planning for this new facility and it is expected to be a research asset for UTC faculty for AV testing.

Additional accomplishments:

- *August 12, 2022 - Burcu Akinci Included in Pittsburgh Business Times 20 People to Know in Energy* - Mobility21 UTC researcher Burcu Akinci was highlighted in the Pittsburgh Business Times as 20 People to Know in Energy, highlighting her recent role leading the CMU Department of Civil and Environmental Engineering.
- *July 26, 2022 - Mobility21 UTC Research is Awarded the Philip and Marsha Dowd Fellowship* - Mobility21 UTC researcher and CMU College of Civil & Environmental Engineering Associate Professor Pingbo Tang was recently awarded the Philip and Marsha Dowd Fellowship, which is awarded to a faculty member in engineering to recognize educational contributions and to encourage the undertaking of an educational project.
- *July 20, 2022 - Professor Steve Smith Named President Elect of AAAI* - Mobility21 UTC researcher and CMU Robotics Institute Professor Steve Smith has been named President Elect for the Association for the Advancement of Artificial Intelligence, a nonprofit scientific society devoted to advancing the scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines. He will complete his term as President Elect and begin duties as President in 2024.
- *April 12, 2022 - Burcu Akinci Named Head of the Department of Civil & Environmental Engineering* - Mobility21 UTC researcher and Civil and Environmental Engineering's Burcu Akinci, Paul Christiano professor and leading researcher in the field of data-driven approaches to construction and infrastructure, has been named the next Head of the Department of Civil and Environmental Engineering at Carnegie Mellon University.
- *November 24, 2021 - UTC Researcher, Costa Samaras To Serve in White House Office of Science and Technology Policy*, as principal assistant director for energy and chief advisor for energy policy in OSTP's first-ever energy division.

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 193 deployment partners.

At Carnegie Mellon University Mobility21 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:

- *September 30, 2022 - University of Pennsylvania Student Earns Recognition for Best Student Paper* - PENN masters student Jasmine Siyu Wu received "The Ed McClure Award for Best Masters Student Paper" for her paper, "*Understanding Inequities in Access to Teen Driver Education.*" Jasmine's advisor is Mobility21 UTC researcher Megan Ryerson.
- *September 21, 2022 - Mobility21 Women in Transportation Fellow Participates in ITS World Congress - 2020 - 2022* Mobility21 Women in Transportation Fellow Maggie Harger recently participated the ITS World Congress, an international event that brings together world leaders, practitioners, policy makers, researchers, and private industry to advance and unite the intelligent transportation systems industry. This conference offered an opportunity to learn about current advances in intelligent transportation systems around the world, as well as strategies of implementation and policy considerations.
- *September 13, 2022 - Transportation Club Hosts First Meeting of Fall Semester* - Traffic21 Executive Director, Stan Caldwell presented to the CMU Transportation Club at their first general body meeting of the year about the University Transportation Center. The inaugural meeting had 30+ students in attendance from various backgrounds, including undergraduates, graduate students, and students in public policy, engineering, architecture and information systems management. The students were able to learn about the club, meet members of the board, and learn about how to get involved. 2020 - 2022 Women in Transportation Fellow, Maggie Harger serves as the chair for the club.
- *August 31, 2022 - RISS Scholar Tessa Guengerich's Evolution into the Transportation Sector* - In just a few years, a lot has changed for Tessa Guengerich. She graduated from college, got her first job, and landed a role in the automated vehicle industry. In both June 2018 & 2019, Mobility21 welcomed Tessa Guengerich to the CMU Robotics Institute Summer

Scholars (RISS) program. Tessa said she was excited to learn about things she wasn't exposed to before (computational statistics and machine learning) and was also excited to be surrounded by other students from around the world. In August 2019, Tessa was offered a job as a Robotics Engineer and began working for Carnegie Mellon University at the National Robotics Engineering Center. The job was a continuation and expansion of the project she assisted with while part of RISS. Looking to stretch and gain new skills, she joined ARGO AI, working as part of the Hardware Special Projects team. The job allows her to stay in Pittsburgh and continue to connect with her RISS mentor, Rachel Burcin. Tessa has also been able to give back, serving as a mentor to other RISS students.

- **August 22, 2022 - Robolaunch 2022 Reaches Over 13,000 Worldwide** –CMU's Robotics Institute hosts undergraduate student researchers from around the world annually through the Robotics Institute Summer Scholars (RISS) program. With its committed community of mentors and partners, the Robotics Institute helps launch these scholars into robotics graduate programs and industry with nearly 25 RISS alums receiving offers of admissions to the CMU computer science graduate programs. This summer, the scholars joined with the RISS community of alumni and friends of the program to design and create RoboLaunch, an outreach and broadening participation initiative. RoboLaunch offered a series of talks and conversations from diverse pioneers & RISS alumni exploring how robotics research/education can be fun. Thirteen sessions were held. RoboLaunch engaged over 13,000 individuals across the US and around the world.
- **August 16, 2022 - Hajra Shahab – Women In Transportation 2020 – 2022 Fellow, Graduates** - Hajra joined CMU's MSPPM-DA program in 2020 as a transportation fellow for Traffic21/Mobility21. Reflecting on her time as a student of Heinz College, she feels honored to have had the opportunity to become a part of the CMU community and be surrounded by some of the best minds under one roof. "Joining CMU as a Traffic21/Mobility21 fellow truly set the foundation of every milestone that I achieved in graduate school. With the help of this fellowship, I was not only able to explore opportunities on-campus within the space of transportation and mobility, but also assume leadership roles on multiple occasions and carry out multiple community-led initiatives for Pittsburgh community at large." Upon graduation, Hajra joined EBP-US as a Data Analyst-Transportation Economics focus and currently working with multiple DOTs, state agencies and other stakeholders to conduct mileage-based user fee socio-economic equity analysis, benefit-cost studies and cost optimization projects. She hopes her work continues to improve the state of transportation and mobility by making it sustainable, equitable and accessible for communities across the globe.
- **August 12, 2022 - How do Autonomous Vehicles See the World? – A Robolaunch Workshop** - Mobility21 sponsored 2021 RISS-student Rayna Hata was a co-leader for the Robolaunch workshop, "*How do Autonomous Vehicles See the World?*" Mobility21 partnered with the RI summer Scholar's program and Dr. Stephen Smith to help launch Rayna into robotics research. Now, Rayna is paying it forward by sharing and teaching what she has learned.
- **August 11, 2022 - RISS Robolaunch Hosts Special Seminar on STEM Outreach, Media & Robotics** – The Robotics Institute Summer Scholars (RISS) RoboLaunch program hosted a special seminar on STEM Outreach, Media & Robotics, "Can Hollywood Help Save Math Education?" with Dr. Michael Milford. The discussion focused on leveraging and partnering with media to drive exclusive STEM outreach.
- **August 5, 2022 - Mobility21 Faculty Mentor Summer 2022 RISS Scholars** - The Robotics Institute Summer Scholars program held their closing ceremony and provided an opportunity for the 2022 scholars to share their posters. Among the mentors who provided guidance to the summer scholars were Mobility21 UTC researchers Srinivasa Narasimhan, Christoph Mertz, and Steve Smith.
- **August 1, 2022 - CMU CEE Students Experience a 3D Experience of the Future Through Mega City 2070** - Mobility21 UTC researcher Pingbo Tang will allow CMU graduate students an opportunity to use his software pilot program, Mega City 2070, to experience a 3D model of a futuristic and interconnected built environment in the year 2070.
- **July 18, 2022 - Mobility21 Director & Researchers Present at Summer Engineering Experience** - Mobility21 Director Raj Rajkumar presented "*Connected and Autonomous Vehicles*" to a group of high school students who are attending this year's Summer Engineering Experience program. Other UTC researchers who presented included Christoph Mertz, who presented his "Bus on the Edge" project and Pingbo Tang, who provided students with an opportunity to engage in an advanced infrastructure lab activity with bridges, as well as an air traffic control presentation.
- **July 15, 2022 - What's New with Mobility21 Women in Transportation Fellow Maggie Harger** - Carnegie Mellon University incoming second year Master's student and Mobility21 Women in Transportation Fellow Maggie Harger landed a summer internship with the US Department of Transportation Volpe Center. Prior to starting her Master's degree, Maggie worked in the greater Seattle area to implement accessible and equitable public transportation projects as a mobility coordinator for the North King County region. She is interested in public transportation due to its ability to provide access to economic opportunities for people, as well as its positive impact on carbon emission reduction. This summer, Maggie will be assisting with a variety of projects for partners across the DOT. She looks forward to continuing her work this summer, as well as learning more skills related to policy implementation at a federal level.
- **June 6, 2022 - CMU Student Interns with SEPTA, Thanks to a CMU Transportation Club Visit Earlier this Year** - CMU rising Junior, Ken Huang, started his summer internship at Southeastern PA Transportation Authority (SEPTA). Growing up in San Francisco, Ken rode transit and liked that he could get to where he wanted to go without worrying about parking or being stuck in the city's traffic congestion. In 2020, Ken came to CMU to learn more about the technical side of transportation, enrolling in the school's civil engineering program. He quickly found the Transportation Club and this past year joined the leadership team. During the 2022 spring semester, he participated in a club visit to Philadelphia, where the students visited PENN and SEPTA. During the SEPTA tour, Ken asked lots of questions. The

SEPTA staff person suggested Ken apply to work at SEPTA. The other club leadership encouraged him to follow-up, which he did. And now he is working for SEPTA as an intern, assisting with engineering work for various infrastructure projects including bus loops/turn-arounds.

- **May 15, 2022 - Heinz College Students Present Final Capstone and Thesis Presentations** - Students in the Heinz College MISM and MSISPM programs presented their final capstone projects over the course of two days, some of which were supported by UTC faculty and included clients from the US Department of Transportation, PennDOT, and Honda.
- **May 15, 2022 - Women in Transportation Fellow Hajra Shahab Graduates and Awarded the Barbara Jenkins Service Award** – Mobility21 Women in Transportation Fellow 2020-2022 Hajra Shahab was the 2022 recipient of the Barbara Jenkins Service Award at the Heinz College graduation ceremony for the class of 2022. The award is given annually to a graduating student who has demonstrated service to the Heinz College community and made significant contributions to the quality of life for residents in the Pittsburgh region.
- **April 26, 2022 - CMU Engineering & Public Policy Course Focuses on Transit in the City of Pittsburgh** – CMU’s Spring 2022 Engineering and Public Policy Senior Project Course was focused on transit in the City of Pittsburgh and culminated with a poster session highlighting five group projects. Mobility21 researcher Destenie Nock was co-instructor of the course and UTC researchers Corey Harper and Stan Caldwell served as advisors and provided feedback throughout the course and at the poster session.
- **April 23, 2022 - Carnegie Mellon University’s Transportation Club Hosts Bike Ride** - Students affiliated with the CMU’s Transportation Club recently participated in a bike ride around downtown Pittsburgh. The event allowed students to network with one another, as well as learn about the active transportation network within the city. The tour followed parts of the Allegheny, Monongahela, and Ohio River, and allowed the students to see a unique side of downtown Pittsburgh.
- **April 22, 2022 - Pittsburgh Robotics Network Hosts The State of Our Autonomous Vehicle Industry** - Mobility21 Women in Transportation Fellow Hajra Shahab and Executive Director Stan Caldwell participated in "The State of Our Autonomous Vehicle Industry " event hosted by Pittsburgh Robotics Network. "Seeing industry leaders in the AV space coming together to discuss the future of this technology and the industry at large was an enriching experience."
- **April 14, 2022 - Professor Katherine Flanigan Introduces Sensing in CEE Project Course** - Mobility21 UTC researcher and CMU College of Civil & Environmental Engineering Professor Katherine Flanigan is providing students with hands-on experience to solve complex problems in engineering by introducing the topic of “sensing and computing to design, construct, operate, and maintain individual and interdependent infrastructure systems” in her course, *CEE Challenges: Design in a Changing World*.

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
4/15/2022	Justin Starr	CCAC	AI as a Skilled Trade	N/A
4/22/2022	Pennsylvania Department of Transportation	CMU with PennDOT	Moving Forward with STEM	https://youtu.be/olk_aRDa27g
9/9/2022	Megan Ryerson & Jasmine Siyu Wu	UPENN	Identifying Community-Level Disparities in Access to Drivers Education and Training: Toward a Definition of Driver Training Deserts	https://www.youtube.com/watch?v=tinxERFSuvU

Additional technology transfer activities:

- **September 29, 2022 - Smart Cities Connect Fall Conference Features Professor Sean Qian** - Mobility21 UTC researcher Sean Qian joined panelists at the Smart Cities Connect Fall Conference in Washington, DC to discuss "Safe Reliable Daily Travel Using Emerging Technology," which highlighted federal research investments that lead to the safe and reliable daily movement of people and goods on the highway system.
- **September 18, 2022 - Mobility21 Presents at ITS World Congress 2022** - Mobility21 Executive Director Stan Caldwell, Program Manager Lisa Kay Schwyer, and UTC researcher Steve Smith presented the "Managing AI in Transportation" session at the ITS World Congress 2022. The session covered an overview of technology and AI impacts in transportation today, AI in traffic control devices, and AI for safe, equitable, and efficient mobility of people and goods. In addition, later in the week, Stan moderated a session on Automated Vehicle Policy.

- *September 15, 2022 - Professor Destenie Nock Answers Three Questions with Peter Kerwin* - Mobility21 UTC researcher Professor Destenie Nock addressed questions surrounding her research in a recent interview where she discussed creating an energy equity metric that illustrates the socioeconomic divide in access to energy.
- *September 13, 2022 - Ray Gastil Joins Panel at ASTC Annual Conference 2022* - Mobility21 UTC researcher and Carnegie Mellon University Remaking Cities Institute Director Ray Gastil joined panelists from around the country at the recent Association of Science and Technology Centers (ASTC) Annual Conference in Pittsburgh, where they discussed programs that forge innovative connections between science centers, museums, and communities and urban planning: "Build (Your Community) Back Better, Discovering Your Museum Superpowers to Enhance Community and Urban Planning."
- *August 24, 2022 - CMU Presents Faculty Discussion on Technology as a Force for Good* - Mobility21 UTC researcher Gabriela Gongora-Svartman joined CMU faculty from Heinz College in a Faculty Dialogues presentation, "Technology as a Force for Good," to discuss how their and teaching in the growing field of public interest technology is creating a more prosperous, just and collaborative future for all.
- *August 23, 2022 - Ohio State University Discusses Vulnerable Road Users with The Bike Lane* - Mobility21 UTC researcher and The Ohio State University Professor Emeritus Umit Ozguner discussed vulnerable road users and automated vehicles in a recent issue of The Bike Lane Newsletter.
- *August 17, 2022 - UTC Researcher Discusses Green Energy in the Inflation Reduction Act* - Mobility21 UTC researcher Destenie Nock discussed the Inflation Reduction Act and the benefits of the bill for the energy sector with PBS during a recent discussion about green energy.
- *August 15, 2022 - Mobility21 UTC Researcher Provides Keynote at APTA Tech Conference* - Aaron Steinfeld, a Mobility21 researcher, presented the keynote at the 2022 APTAtech Conference. His talk, "*Artificial Intelligence and Robotics for Transit: A View from the Research Forefront*," provided attendees with information on how AI and robotics research are tackling complex transit needs and discussed recommendations for how to incorporate advanced technologies into practice. The presentation included content from his work with the Rehabilitation Engineering Research Center on Accessible Public Transportation (which Steinfeld co-directs), and the Mobility21 UTC.
- *August 15, 2022 - University of Pennsylvania's Megan Ryerson Lends Advice for Travel and the Middle Class* - Mobility21 UTC researcher Megan Ryerson from the University of Pennsylvania's Weitzman School of Design discussed travel and the middle class and how long travel will be sustainable with Penn Today. "We need an intercity transportation strategy focused on equitable access," she says.
- *August 14, 2022 - Mobility21 Program Manager Featured on Brewing Data Web/Podcast* - Mobility21 Program Manager, Lisa Kay Schweyer will be the featured guest on tomorrow's edition of Brewing Data. She will be discussing UTCs, transportation research, and transportation demand management. Brewing Data is a 30-minute interview style webcast, moderated by Robert Kohler @AirSage. The webinar was live streamed on LinkedIn and YouTube. The discussion was also converted into an audio-only podcast and transcribed into an article in AirSage Magazine.
- *August 10, 2022 - National Operations Center of Excellence Hosts Professor Sean Qian for Data & Decision Making for Operations Event* - Mobility21 UTC researcher Professor Sean Qian spoke at a recent webinar hosted by the National Operations Center of Excellence. His session was titled, "A Framework/Methodology to Support Data Fusion, Analysis, and Decision Making," which featured case studies on the use of data for planning and operations.
- *August 9, 2022 - Center for Executive Education in Technology Policy Visits NavLab* - The Center for Executive Education in Technology Policy, led by Mobility21 UTC researcher Jon Peha, taught a course that brought 14 participants from 12 countries to the CMU campus and a visit to NavLab, headed by Mobility21 UTC researcher Christoph Mertz.
- *August 9, 2022 - Mobility21 Research Featured at ITSPA Annual Meeting* - Stan Caldwell presented his Mobility21 research on emerging transportation technology and industry trends at the Intelligent Transportation Society of Pennsylvania's Annual Meeting at the Spooky Nook Sports Complex in Manheim, PA.
- *August 8, 2022 - APTA Workshop with Mobility21 Program Manager Focuses on Resilience Planning & Implementation* - Lisa Kay Schweyer, Program Manager for Mobility21 moderated a featured session on Resilience Planning and Implementation during APTA's Sustainability / Operations Planning and Scheduling Workshop. The discussion covered how "More and more agencies are working to develop resilient transit infrastructure."
- *August 3, 2022 - Mobility21 UTC researcher Viswanathan Discusses How Climate Tech Start-Ups Can Survive the Market* - Mobility21 UTC researcher Venkat Viswanathan discussed with GreenBiz how smaller climate tech startups can keep their company's value when the market situation fluctuates.
- *August 1, 2022 - Dr. Destenie Nock Explains Energy Justice in a Recent NSF-Funded Video* - Mobility21 UTC researcher Dr. Destenie Nock explains energy justice in a new video, funded by the National Science Foundation. The video covers three types of energy justice (distributional, procedural, and recognition). Reaching energy justice requires achieving equity in the distribution of costs and benefits, the social and economic participation in the energy system, as well as remediating social, economic, and health burdens on vulnerable groups which have been disproportionately harmed by the energy system.
- *July 15, 2022 - Mobility21 UTC Researchers Analyze Impact of Work Zones on Automotive Accidents* - Mobility21 UTC researchers Burcu Akinci and Sean Qian, along with CMU Ph.D. student Zhuoran Zhang, have created a work zone safety analysis model that proves the causal relationship between work zones and increased car crashes. "Causal models are crucial for improving road safety around work zones because they help us identify and analyze the various factors that impact risk in each scenario," said Akinci, head of the Department of Civil and Environmental Engineering.

- *July 14, 2022 - **Mobility21 Researchers Publish Paper on Potential Hydropower Contribution to Mitigate Climate Risk and Build Resilience in Africa*** - Mobility21 UTC researcher Costa Samaras co-authored a paper with Ana Lucia Caceres, Paulina Jaramillo, Scott Matthews and Bart Nijssen titled "Potential hydropower contribution to mitigate climate risk and build resilience in Africa," which evaluates the potential synergies between hydropower, wind and solar.
- *July 5, 2022 - **IEEE Publishes University of Pennsylvania Paper on Autonomous Vehicle Racing*** - Mobility21 academic partner University of Pennsylvania Professor Rahul Mangharam and Johannes Betz, along with Hongrui Zheng, Alexander Liniger, Ugo Rosolia, Phillip Karle, Madhur Behl and Venkat Krovi co-authored a paper published by IEEE titled "Autonomous Vehicles on the Edge: A Survey on Autonomous Vehicle Racing," which represents the first holistic survey that covers the research in the field of autonomous racing.
- *July 1, 2022 - **Traffic21 Director Chris Hendrickson Writes Decarbonization Editorial for ASCE*** - Traffic21 Director and Mobility21 researcher Chris Hendrickson authored an editorial for the American Society of Civil Engineers in the Journal of Transportation Engineering, Part A: Systems titled "Deep Decarbonization and Transportation Engineering."
- *July 1, 2022 - **NEUAC Annual Conference Welcomes Dr. Destenie Nock*** - Mobility21 UTC researcher Dr. Destenie Nock was welcomed at the NEUAC Annual Conference in New Orleans, LA to give a talk on "Identifying Multiple Forms of Energy Poverty: Energy Burden and Energy Deficits" alongside co-speakers Luling Huang and Shuchen Cong to explain the concepts of energy burden and energy poverty and how they are influenced by the end user behavior.
- *June 22, 2022 - **Challenges in Machine Learning and Game Theory for Social Impact*** - Mobility21 UTC researcher Fei Fang presented "Challenges in Machine Learning and Game Theory for Social Impact" as part of the Robotics Institute Summer Scholars RoboLaunch, a Robotics Outreach Initiative.
- *June 21, 2022 - **29th International Symposium on Sustainable Systems & Technology*** - Mobility21 UTC researcher and Principal Assistant Director for Energy and Office of Science and Technology Policy and Chief Advisor for Energy Policy, Costa Samaras gave the opening keynote, Advancing a Clean Energy Revolution for All, at International Symposium on Sustainable Systems & Technology (ISSST 2022) in Pittsburgh, PA.
- *June 16, 2022 - **Dr. Destenie Nock Explains How to Identify Hidden Forms of Energy Poverty*** - Dr. Destenie Nock recently posted a video where she explains her research on identifying hidden forms of energy poverty.
- *June 16, 2022 - **Get on the Bus Team Meets to Move Forward with Phase 2*** - Mobility21 UTC researcher and CMU Robotics Institute Professors Steve Smith and Zak Rubenstein and Metro21 Executive Director Karen Lightman met with project team members from Allies for Children to discuss phase 2 of the "Get on the Bus" project to review data for route overview and to discuss next steps towards implementation.
- *June 15, 2022 - **AFL-CIO Constitutional Convention in Philadelphia*** - Mobility21 UTC researchers Nik Martelaro and Jodi Forlizzi along with CMU President Farnam Jahanian were part of a panel organized by the CMU Block Center for Technology and Policy at the AFL-CIO 's 29th Constitutional Convention, to discuss building workers' input on the future of technology in a groundbreaking new strategy.
- *June 3, 2022 - **International Conference on Transportation & Development Plenary Features Mobility21 Researcher*** - Traffic21 Director Chris Hendrickson was a featured speaker during a plenary session at the International Conference on Transportation & Development titled "Envisioning the Future of Cities and Transportation" along with Paula Hammond, Senior Vice President and National Transportation Market Leader of WSP USA and Dr. Hani Mahmassani, William A. Patterson Distinguished Chair in Transportation of Northwestern University.
- *June 2, 2022 - **Mobility21 Research Team Provides Final Update on Research Project*** - Mobility21 UTC researcher Peter Zhang, his students Yidi Miao and Hao, and Mobility21 Program Manager Lisa Kay Schweyer met with community partner Heritage Community Initiatives to provide a final update on the research project, "Demand learning and supply optimization for last-mile transportation in disadvantaged neighborhoods."
- *June 2, 2022 - **Robots Can Learn to Safely Navigate Warehouses*** - Mobility21 UTC researcher Ding Zhao, along with a team of CMU engineers and computer scientists, have been developing the warehouse robots of the future. "Warehouse robots need to be smart enough to deploy quickly and navigate safely in new dynamic environments."
- *June 2, 2022 - **Automated Road Transportation Symposium (ARTS) 2022 Focuses on Infrastructure, Policy and AVs*** - Mobility21 UTC Advisory Council member and chair of the TRB Vehicle-Highway Automation Committee, Jane Lappin, hosted the 2022 TRB Automated Road Transportation Symposium (ARTS). ARTS convenes global thought leaders from the industry, government and research communities to collaborate on the opportunities and challenges associated with automating road transportation. US Department of Transportation Deputy Assistant Secretary for Research and Technology Robert Hampshire gave the keynote, and 20 interactive "deep-dive" breakout sessions were held.
- *May 24, 2022 - **Pennsylvania Chambers of Commerce Join for Annual Meeting and Reception*** - Mobility21 Executive Director Stan Caldwell traveled to the state capital Harrisburg, PA, where he participated in the joint Pittsburgh and Philadelphia Chambers of Commerce Annual Meeting and Reception. Stan met with state legislators and state officials, along with deployment partners to provide updates on UTC impacts and accomplishments.
- *May 23, 2022 - **IEEE International Conference on Robotics and Automation (ICRA) 2022 Hosts Workshop on Autonomous Racing*** - Mobility21 UTC researchers Rahul Mangharam and Johannes Betz of the Mobility21 academic partner University of Pennsylvania hosted a Workshop on Opportunities and Challenges with Autonomous Racing, hosted by the IEEE International Conference on Robotics and Automation. The main objective of this workshop was to attract the interest of the robotics community on research challenges specific to high-speed autonomous racing.

- *May 20, 2022 - **Mobility21 Executive Director Discusses Research with Aviation Industry Professionals*** - Stan Caldwell provided a tour of CMU and industry automated vehicle research and development sites to officials from the Allegheny County Airport Authority and Spirit Airlines. Caldwell discussed his Mobility21 research on emerging transportation technology and industry trends, along with its economic impact on the Pittsburgh region.
- *April 26, 2022 - **Federal Transit Administration's Chief Innovation Officer Joins Remaking Cities by Design Dialogues*** - Mobility21 UTC researcher Ray Gastil of the Remaking Cities Institute at Carnegie Mellon University hosted Federal Transit Administration's Chief Innovation Officer Karina Ricks on Remaking Cities by Design Dialogues. Karina discussed new directions for local mobility and new insights since delivering her lecture on mobility justice with the Remaking Cities Institute in the fall of 2021.
- *April 22, 2022 - **2022 Pennsylvania Broadband Symposium*** - Vice Chancellor and Chief Information Officer at the University of Pittsburgh Mark D. Henderson kicked off the 2022 Pennsylvania Broadband Symposium by highlighting technology as the key to unlocking and participating in the economy. Metro21 Executive Director Karen Lightman moderated the panel "Access and Technologies," which featured: Nathan Flood, President & CEO, KINBER Sam Garfinkel, Executive Director, Meta Mesh Wireless Communities Lance Grable, Director, Office of Planning and Redevelopment, Beaver County Andy Stutzman, Project Director for Civic Technology, ExCITe Center, Drexel University.
- *April 19, 2022 - **SWPA Connected Initiative Launches Connectivity Roadmap*** - A briefing was held on Phase 1 Results of the Southwestern Pennsylvania Connected - Equitable Broadband Access Plan for local government officials and foundations who funded the plan. Mobility21 UTC researchers Jon Peha and Stan Caldwell presented, highlighting the CMU faculty and student contributions to the planning process.
- *April 7, 2022 - **Metro21 Lunch and Learn: Monitoring Infrastructure*** - Metro21 Executive Director Karen Lightman led a panel of experts to discuss challenges and solutions to current and future infrastructure monitoring. Panelists included: UTC faculty members Burcu Akinci, CMU Civil & Environmental Engineering Katherine Flanigan, CMU Civil & Environmental Engineering Sebastian Scherer, CMU Robotics Institute Benjamin Schmidt, Roadbotics, Inc. (UTC spinoff).

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:

- *September 26, 2022 - **ASCE International Conference on Transportation & Development Holds Advisory Committee Meeting*** - Chris Hendrickson, faculty director of Traffic21 Institute and Mobility21 UTC researcher, participated in the first meeting of the ASCE International Conference on Transportation and Development's Advisory Committee.
- *September 23, 2022 - **Traffic21 Director Participates in Global Clean Energy Action Forum*** - Traffic21 Director Chris Hendrickson participated the 2022 Global Clean Energy Action Forum, which featured a high-level plenary, topical roundtables with energy and science ministers from 31 countries, CEOs and experts, side events, and technology demonstrations.
- *August 4, 2022 - **Association of Commuter Transportation Holds 2022 International Conference*** - The Association of Commuter Transportation 2022 International Conference was held in Chicago. Mobility21 UTC Program Manager, Lisa Kay Schweyer, also a Board Member of ACT, engaged in conference sessions, served as a conference buddy to 3 first-time attendees, and participated the board meeting. Over 520 transportation professionals were in attendance for the event.
- *July 27, 2022 - **PA STIC Meeting Held in Harrisburg*** - PennDOT and Mobility21 Advisory Council member, Secretary Yassmin Gramian welcomed State Transportation Innovation Council members, including Mobility21 Executive Director Stan Caldwell, to celebrate the 10th anniversary of Pennsylvania's award winning STIC.
- *July 26 & 27, 2022 - **Traffic21 Faculty Director Participates in the National Research Council's meetings*** - Mobility21 researcher Chris Hendrickson participated in the National Research Council's workshop on *Pathways for a Just Transition* and the *Accelerating Deep Decarbonization in the US Committee* meeting in Washington DC.
- *June 17, 2022 - **Council of University Transportation Center's Annual Meeting*** - The Annual Council of University Transportation Center's summer meeting brought together the nation's leading transportation professionals from academia and industry along with U.S. DOT and other transportation agency officials. Raj Rajkumar, Director, Stan Caldwell, Executive Director and Lisa Kay Schweyer, Program Manager of Mobility21 participated in the meeting.
- *June 8, 2022 - **Association of Commuter Transportation Higher Education Council Convening*** - Lisa Kay Schweyer, Program Manager for Mobility21 UTC and Michelle Porter, the Director of CMU's Parking & Transportation Services participated in today's Association of Commuter Transportation Higher Education Council. The group works to address shared issues, encourage information sharing, expand awareness, advance future trends and technologies, and advance policies that support equitable access to all types of campus transportation and mobility programs.
- *June 3, 2022 - **MetroLab Hosts 2022 Annual Summit*** - MetroLab Network hosted the 2022 Annual Summit in Chicago, IL and featured Metro21 Executive Director Karen Lightman on three panels. The summit brought together leaders from across the country to discuss partnerships, mobility and data, and resilience.
- *June 2, 2022 - **University of Pennsylvania Researchers Submit Video for ITS World Congress 2022 Competition*** - Mobility21 academic partner University of Pennsylvania researchers Dr. Rahul Mangharam, Dr. Helen Loeb, along with students Xiatao Sun and Zhijie Qiao submitted "Drive Right: Simulator for Safe Autonomous Driving" for the ITS World Congress 2022 video competition. The 2022 video competition asks the question, "How do you envision disruptive

technologies will transform transportation and outcomes for generations leading to greener communities and more resilient systems, increased access and equity, and safer, smarter roads for all?"

- **May 25, 2022 - Mobility21 Highlights the Work of Ding Zhao in U.S. DOT Video** - Mobility21 UTC produced a video to highlight projects by UTC researcher Ding Zhao for an upcoming U.S. Department of Transportation Forum on Cybersecurity. The video focuses on key projects funded by the Mobility21 UTC in which Ding Zhao focuses on trustworthiness, cybersecurity and privacy in transportation applications. Ph.D. student, Diana Gomez is also featured.
- **May 12, 2022 - The Future of Artificial Intelligence and the Workforce** - Carnegie Mellon University and CCAC hosted a panel discussion, "The Future of Artificial Intelligence and the Workforce," which included speakers: Mobility21 UTC partner and CCAC professor Dr. Justin Starr, Joel Reed of the Pittsburgh Robotics Network, Michael Sebetich of Argo AI, and CMU Prof. Mark Kamlet. The panel dispelled common misconceptions of AI and shared how to work symbiotically with AI.
- **April 27, 2022 - Association of Commuter Transportation Hosts 2022 Future of Commuting Summit** - Today, the Association of Commuter Transportation 2022 Future of Commuting Summit convened in Pittsburgh, featuring local leaders discussing Transforming the Steel City: Kim Lucas, Managing Director, Department of Mobility and Infrastructure, City of Pittsburgh David Huffaker, Chief Development Officer, Port Authority of Allegheny County Chris Watts, Vice President of District Development, Pittsburgh Downtown Partnership and Vincent Valdes, Executive Director – President & CEO, Southwestern Pennsylvania Commission & Mobility21 Advisory Council member. Mobility21 Program Manager, Lisa Kay Schweyer engaged the speakers as she moderated the session. Over 110 participants engaged in the day's events.
- **April 25, 2022 - Pittsburgh's Smart Loading Zones Launch Event** - Mobility21 Executive Director Stan Caldwell participated in the ribbon cutting of the City of Pittsburgh's new Smart Loading Zone Pilot Project, launched in cooperation with the Pittsburgh Parking Authority and Automotus. Mobility21 researcher Sean Qian is working through a Department of Energy grant to evaluate this pilot.
- **April 22, 2022 - Mobility21 Hosts PennDOT's 'Moving Forward with STEM' Discussion** - The Mobility21 UTC hosted the Pennsylvania Department of Transportation Secretary Yassmin Gramian and other leaders in the industry for PennDOT's 'Moving Forward with STEM' panel discussion. Mobility21 Executive Director, Stan Caldwell, opened the event welcoming the panelists and attendees on behalf of Carnegie Mellon University. He highlighted the university's history in STEM and the UTC's focus on workforce development. Hajra Shahab, the 2020 - 2022 Traffic21 Women in Transportation Fellow then introduced the panel and the moderator for the event: Matt Blackburn, Aurora; Rachel Burcin, Manager of Carnegie Mellon University Robotics Institute Global Programs; Robert Koch, Community College of Allegheny County Skilled Trades Department and Automotive Ford ASSET program professor; Audrey Russo, Pittsburgh Technology Council, PennDOT District 11 Executive Director Cheryl Moon-Sirianni (moderator). Panelists then shared their views on the importance of STEM, cultivating the next generation of transportation industry workers, and Pittsburgh's leading role in the transportation revolution (through higher education institutions and transportation-related technology companies). Additionally, the panel discussed ways to increase diversity and equity in STEM and the transportation workforce. Over 100 national industry leaders from departments of transportation, intermediate units, school districts, higher education institutions, transportation providers, community organizations, industry and students registered for the event.
- **April 18, 2022 - Waynesburg to assist CMU with transportation surveys** – "Representatives from Waynesburg University's Center for Entrepreneurial Leadership will be conducting surveys focused on transportation with residents throughout Greene County during the spring and summer as a part of Carnegie Mellon University's Rural County Mobility Platform project." The Carnegie Mellon team is led by Mobility21 researcher Sean Qian, includes Rick Stafford, Karen Lightman of Metro21, Chris Hendrickson and Costa Samaras.
- **April 4, 2022 - Mobility21 UTC Academic Partner Rahul Mangharam to Lead Autoware CoE** - Mobility21 UTC researcher, Rahul Mangharam from PENN will be leading the Autoware Center of Excellence, with the objective of bringing together industry and academia to advance Autonomous Driving technology based on Autoware Open-Source Software. "The Autoware CoE for autonomous driving was setup because we believe that all machines that move people and goods will have a significant element of autonomy. Our goal is to develop OpenAV software for OpenEV platforms."
- **April 1, 2022 - Mobility21 UTC Researchers Participate in NSBE 48th Annual Convention** - Mobility21 UTC researchers Dr. Destenie Nock and Dr. Corey Harper participated in the National Society of Black Engineers (NSBE) 48th Annual Convention in Anaheim, CA. NSBE is one of the largest student-governed organizations based in the United States.

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 4,459 subscribers**. The readership represents individuals in industry, government, academia and community organizations **from 17 countries**.

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

Before updates are sent out in either publication, they appear as individual updates/articles on the website, and are also posted through our Facebook and Twitter social media accounts. **622 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. On April 25, 2022 - we released the "Research Recap" for Srinivasa Narasimhan's project "Real-Time Traffic Analytics at Intersections."

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

Plans are underway for the next Advisory Council and Deployment Partner Consortium Symposium to be held in November 2022, in Pittsburgh, and the Annual National Mobility Summit to be held March 31, 2023, in Washington, DC.

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 **193** 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
The Philadelphia Office of Transportation, Infrastructure, and Sustainability	Philadelphia, PA		X		X	
Street Sense, Inc.	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. The Advisory Council listing can be found on our website.

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

Publications, conference papers, and presentations

Title	Citation	Type	Date
<i>Autonomous Vehicles on the Edge: A Survey on Autonomous Vehicle Racing</i>	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.	Peer Reviewed	2022-08-30
<i>Stress Testing Autonomous Racing Overtake Maneuvers with RRT</i>	S. Bak, J. Betz, A. Chawla, H. Zheng and R. Mangharam, "Stress Testing Autonomous Racing Overtake Maneuvers with RRT," 2022 IEEE Intelligent Vehicles Symposium (IV), 2022, pp. 806-812, doi: 10.1109/IV51971.2022.9827237.	Peer Reviewed	2022-08-30
<i>Combinatorial and Parametric Gradient-Free Optimization for Cyber-Physical System Design</i>	H. Zheng, J. Betz, A. Ramamurthy, H. Jin and R. Mangharam, "Combinatorial and Parametric Gradient-Free Optimization for Cyber-Physical System Design," 2022 IEEE Workshop on Design Automation for CPS and IoT (DESTION), 2022, pp. 34-41, doi: 10.1109/DESTION56136.2022.00012.	Peer Reviewed	2022-08-30
<i>Photorealism in Driving Simulators: Blending Generative Adversarial Image Synthesis with Rendering for Computer Graphics</i>	Ekim Yurtsever, Dongfang Yang, Ibrahim Koc, and Keith Redmill, "Photorealism in Driving Simulators: Blending Generative Adversarial Image Synthesis with Rendering". Accepted to <i>IEEE Trans on ITS</i> 7/20/2022.	Peer Reviewed	2022-07-27
<i>Sensory Fusion for Remote Multi-Body Temperature Monitoring</i>	Sean Hackett, Florian Alber, and Yang Cai, <i>Sensory Fusion for Remote Multi-Body Temperature Monitoring</i> , <i>Proceeding of AHFE conference</i> , 24-28, 2022.	Peer Reviewed	2022-07-26
<i>Extreme Reality (EXR) Telemetry Interfaces</i>	Yang Cai, <i>Extreme Reality (EXR) Telemetry Interfaces</i> , <i>Proceedings of AHFE conference</i> , July 24-28, 2022, in the book "Human Factors in Robots, Drones, and Unmanned Systems, AHFE, 2022	Peer Reviewed	2022-07-25
<i>The Real Deal: A Review of Challenges and Opportunities in</i>	Rex Chen, Fei Fang, & Norman Sadeh (2022) "The Real Deal: A Review of Challenges and Opportunities in Moving	Trade Publication	2022-07-25

<i>Moving Reinforcement Learning-Based Traffic Signal Control Systems Towards Reality</i>	<i>Reinforcement Learning-Based Traffic Signal Control Systems Towards Reality". 12th International Workshop on Agents in Traffic and Transportation (ATT '22, at IJCAI '22), CEUR Workshop Proceedings 3173: 14–31.</i>		
<i>Point Cloud Registration With Object-Centric Alignment</i>	<i>B. L. Žagar, E. Yurtsever, A. Peters, and A. C. Knoll, "Point Cloud Registration With Object-Centric Alignment", IEEE Access, 10(2022), pp. 76586-76595.</i>	<i>Peer Reviewed</i>	<i>2022-07-15</i>
<i>Predicting Pedestrian Crossing Intention with Feature Fusion and Spatio-temporal Attention</i>	<i>Dongfang Yang, Haolin Zhang, Ekim Yurtsever, Keith Redmill, and Umit Ozguner, "Predicting Pedestrian Crossing Intention with Feature Fusion and Spatio-Temporal Attention", IEEE Transactions on Intelligent Vehicles, 7:2(June 2022), pp. 221-230.</i>	<i>Peer Reviewed</i>	<i>2022-07-15</i>
<i>A New FCC Policy that Forces Consideration of the Harm Claim Threshold</i>	<i>Jon M. Peha, "A New FCC Policy that Forces Consideration of the Harm Claim Threshold," Comments in the Matter of Promoting Efficient Use of Spectrum through Improved Receiver Interference Immunity Performance, Federal Communications Commission ET Docket No. 22-137, June 27, 2022.</i>	<i>Other</i>	<i>2022-06-27</i>
<i>Predicting Pedestrian Crossing Intention With Feature Fusion and Spatio-Temporal Attention</i>	<i>D. Yang, H. Zhang, E. Yurtsever, K. A. Redmill and Ü. Özgüner, "Predicting Pedestrian Crossing Intention With Feature Fusion and Spatio-Temporal Attention," in IEEE Transactions on Intelligent Vehicles, vol. 7, no. 2, pp. 221-230, June 2022, doi: 10.1109/TIV.2022.3162719.</i>	<i>Peer Reviewed</i>	<i>2022-06-15</i>
<i>Integrating public transportation and shared autonomous mobility for equitable transit coverage: A cost-efficiency analysis</i>	<i>Whitmore, Allanté, Constantine Samaras, Chris T. Hendrickson, H. Scott Matthews, and Gabrielle Wong-Parodi. "Integrating public transportation and shared autonomous mobility for equitable transit coverage: A cost-efficiency analysis." Transportation Research Interdisciplinary Perspectives 14 (2022): 100571.</i>	<i>Peer Reviewed</i>	<i>2022-06-01</i>
<i>Integrating public transportation and shared autonomous mobility for equitable transit coverage: A cost-efficiency analysis</i>	<i>Whitmore, Allanté, Constantine Samaras, Chris T. Hendrickson, H. Scott Matthews, and Gabrielle Wong-Parodi. "Integrating public transportation and shared autonomous mobility for equitable transit coverage: A cost-efficiency analysis." Transportation Research Interdisciplinary Perspectives 14 (2022): 100571.</i>	<i>Peer Reviewed</i>	<i>2022-06-01</i>
<i>Net-societal and net-private benefits of some existing vehicle crash avoidance technologies</i>	<i>Khan, Abdullah, Corey D. Harper, Chris T. Hendrickson, and Constantine Samaras. "Net-societal and net-private benefits of some existing vehicle crash avoidance technologies." Accident Analysis & Prevention 125 (2019): 207-216.</i>	<i>Peer Reviewed</i>	<i>2022-05-02</i>
<i>Economic and Behavioral Dimensions of Urban Transport Policy</i>	<i>Gu, Vincent Xinyi, Tobias Schmidt, Octavio Mesner, and Corey Harper. "Economic and Behavioral Dimensions of Urban Transport Policy." In 2020 APPAM Fall Research Conference. APPAM, 2020.</i>	<i>Peer Reviewed</i>	<i>2022-05-02</i>
<i>Statistical inference of travelers' route choice preferences with system-level data</i>	<i>Guarda, Pablo, and Sean Qian. "Statistical inference of travelers' route choice preferences with system-level data." arXiv preprint arXiv:2204.10964 (2022).</i>	<i>Other</i>	<i>2022-04-23</i>
<i>Estimating probabilistic dynamic origin-destination demands using multi-day traffic data on computational graphs</i>	<i>Ma, Wei, and Sean Qian. "Estimating probabilistic dynamic origin-destination demands using multi-day traffic data on computational graphs." arXiv preprint arXiv:2204.09229 (2022).</i>	<i>Other</i>	<i>2022-04-20</i>
<i>Proton donors induce a differential transport effect for selectivity toward ammonia in lithium-mediated nitrogen reduction</i>	<i>Lazouski, Nikifar, Katherine J. Steinberg, Michal L. Gala, Dilip Krishnamurthy, Venkatasubramanian Viswanathan, and Karthish Manthiram. "Proton donors induce a differential transport effect for selectivity toward ammonia in lithium-mediated nitrogen reduction." ACS Catalysis 12 (2022): 5197-5208.</i>	<i>Peer Reviewed</i>	<i>2022-04-15</i>
<i>A finite-sampling, operational domain specific, and provably unbiased connected and automated vehicle safety metric</i>	<i>Weng, Bowen, Linda Capito, Ümit Özgüner, and Keith Redmill. "A finite-sampling, operational domain specific, and provably unbiased connected and automated vehicle safety metric." IEEE Transactions on Intelligent Transportation Systems (2022).</i>	<i>Peer Reviewed</i>	<i>2022-04-13</i>
<i>Drive Right: Autonomous Vehicle Education through an Integrated Simulation Platform</i>	<i>Zhijie Qiao, Helen Loeb, Venkata Gurrla, Matt Lebermann, Johannes Betz, Rahul Mangharam, "Drive Right: Autonomous Vehicle Education through an Integrated Simulation Platform", SAE International Journal of Connected and Automated Vehicles, Volume 5, Issue 12-05-04-0028</i>	<i>Peer Reviewed</i>	<i>2022-04-13</i>
<i>A finite-sampling, operational domain specific, and provably</i>	<i>Weng, Bowen, Linda Capito, Ümit Özgüner, and Keith Redmill. "A finite-sampling, operational domain specific, and provably</i>	<i>Peer Reviewed</i>	<i>2022-04-13</i>

<i>unbiased connected and automated vehicle safety metric</i>	<i>unbiased connected and automated vehicle safety metric." IEEE Transactions on Intelligent Transportation Systems (2022).</i>		
<i>Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities</i>	<i>Vadapat, Govindarajan, Stephen F. Smith, Zachary B. Rubinstein, and M. Bernardine Dias. "Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities." Public Roads 84, no. 4 (2021).</i>	<i>Peer Reviewed</i>	<i>2022-04-06</i>
<i>Super-linear Scaling Behavior for Electric Vehicle Chargers and Road Map to Addressing the Infrastructure Gap</i>	<i>Wadell, Alexius, Matthew Guttenberg, Christopher P. Kempes, and Venkatasubramanian Viswanathan. "Super-linear Scaling Behavior for Electric Vehicle Chargers and Road Map to Addressing the Infrastructure Gap." arXiv preprint arXiv:2204.03094 (2022).</i>	<i>Other</i>	<i>2022-04-06</i>
<i>Mixed Reality Driving Simulator as a Training Tool for Autonomous Vehicles</i>	<i>Loeb, H, Mangharam, R. Mixed Reality Driving Simulator as a Training Tool for Autonomous Vehicles, WCX World Congress, Detroit, April 5-7 2022.</i>	<i>Other</i>	<i>2022-04-05</i>
<i>Autonomous Road Vehicle Emergency Obstacle Avoidance Maneuver Framework at Highway Speeds</i>	<i>Lowe, Evan, and Levent Güvenc. "Autonomous Road Vehicle Emergency Obstacle Avoidance Maneuver Framework at Highway Speeds." arXiv preprint arXiv:2203.15166 (2022).</i>	<i>Other</i>	<i>3/29/2022 *</i>
<i>Predicting pedestrian crossing intention with feature fusion and spatio-temporal attention</i>	<i>Yang, Dongfang, Haolin Zhang, Ekim Yurtsever, Keith Redmill, and Umit Ozguner. "Predicting pedestrian crossing intention with feature fusion and spatio-temporal attention." IEEE Transactions on Intelligent Vehicles (2022).</i>	<i>Peer Reviewed</i>	<i>2022-03-28 *</i>
<i>Inferring the causal effect of work zones on crashes: Methodology and a case study</i>	<i>Zhang, Zhuoran, Burcu Akinci, and Sean Qian. "Inferring the causal effect of work zones on crashes: Methodology and a case study." Analytic Methods in Accident Research 33 (2022): 100203.</i>	<i>Peer Reviewed</i>	<i>2022-03-01 *</i>
<i>A Formal Safety Characterization of Advanced Driver Assist Systems in the Car-Following Regime with Scenario-Sampling</i>	<i>Weng, Bowen, Minghao Zhu, and Keith Redmill. "A Formal Safety Characterization of Advanced Driver Assist Systems in the Car-Following Regime with Scenario-Sampling." arXiv:2202.08935 (2022).</i>	<i>Other</i>	<i>2022-02-17 *</i>
<i>Dynamic Coupling Strategy for Interdependent Network Systems Against Cascading Failures</i>	<i>Lin, I., Carlee Joe-Wong, and Osman Yagan. "Dynamic Coupling Strategy for Interdependent Network Systems Against Cascading Failures." arXiv preprint arXiv:2203.01295 (2022). Submitted to the IEEE Transactions on Network Science and Engineering.</i>	<i>Peer Reviewed</i>	<i>2022-02-15 *</i>
<i>Autonomous vehicles on the edge: A survey on autonomous vehicle racing</i>	<i>Betz, Johannes, Hongrui Zheng, Alexander Liniger, Ugo Rosolia, Phillip Karle, Madhur Behl, Venkat Krovi, and Rahul Mangharam. "Autonomous vehicles on the edge: A survey on autonomous vehicle racing." arXiv:2202.07008 (2022).</i>	<i>Other</i>	<i>2022-02-14 *</i>
<i>Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities</i>	<i>Vadapat, Govindarajan, Stephen F. Smith, Zachary B. Rubinstein, and M. Bernardine Dias. "Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities." Public Roads 84, no. 4 (2021).</i>	<i>Peer Reviewed</i>	<i>2022-02-09 *</i>
<i>Integration of Automated Vehicle Sensing with Adaptive Signal Control for Enhanced Mobility</i>	<i>Smith, Stephen F., and Allen Hawkes. "Integration of Automated Vehicle Sensing with Adaptive Signal Control for Enhanced Mobility." (2021).</i>	<i>Other</i>	<i>2022-02-09 *</i>
<i>Congestion and environmental impacts of short car trip replacement with micromobility modes</i>	<i>Fan, Zhufeng, and Corey D. Harper. "Congestion and environmental impacts of short car trip replacement with micromobility modes." Transportation Research Part D: Transport and environment 103 (2022): 103173.</i>	<i>Peer Reviewed</i>	<i>2022-02-01 *</i>
<i>AI and essential labor: representing the invisible work of integration</i>	<i>Spektor, Franchesca, Estefania Rodriguez, Samantha Shorey, and Sarah Fox. "AI and essential labor: representing the invisible work of integration." XRDS: Crossroads, The ACM Magazine for Students 28, no. 2 (2022): 16-19.</i>	<i>Other</i>	<i>2022-01-10 *</i>
<i>TRM: Temporal Relocation Module for Video Recognition</i>	<i>Qian, Yijun, Guoliang Kang, Lijun Yu, Wenhe Liu, and Alexander G. Hauptmann. "TRM: Temporal Relocation Module for Video Recognition." In Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision, pp. 151-160. 2022.</i>	<i>Peer Reviewed</i>	<i>2022-01-03 *</i>
<i>A novel map-matching algorithm for relating work zones and crashes</i>	<i>Zhang, Zhuoran, Burcu Akinci, and Sean Qian. "A novel map-matching algorithm for relating work zones and crashes." In Construction Research Congress 2022, pp. 366-375. 2022.</i>	<i>Peer Reviewed</i>	<i>2022-01-01 *</i>
<i>Autonomous Road Vehicle Path Planning and Tracking Control</i>	<i>Guvenc, Levent, Bilin Aksun-Guvenc, Sheng Zhu, and Sukru Yaren Gelbal. Autonomous Road Vehicle Path Planning and Tracking Control. John Wiley & Sons, 2021.</i>	<i>Peer Reviewed</i>	<i>2021-12-21 *</i>

<i>Options for Improving the Safety of DUKW Type Amphibious Vessels</i>	<i>Options for Improving the Safety of DUKW Type Amphibious Vessels National Academies of Sciences, Engineering, and Medicine. 2021. Options for Improving the Safety of DUKW Type Amphibious Vessels. Washington, DC: The National Academies Press. https://doi.org/10.17226/26447.</i>	Peer Reviewed	2021-12-20 *
<i>Accelerating Decarbonization of the U.S. Energy System</i>	<i>National Academies of Sciences, Engineering, and Medicine. (2021). Accelerating Decarbonization of the U.S. Energy System, National Academies Press. https://doi.org/10.17226/25932.</i>	Peer Reviewed	2021-12-15 *
<i>An Online Evolving Method For a Safe and Fast Automated Vehicle Control System</i>	<i>Han, Teawon, Subramanya P. Nageshroa, Dimitar Filev, Keith Redmill, and Ümit Özgüner. "An Online Evolving Method For a Safe and Fast Automated Vehicle Control System." IEEE Transactions on Systems, Man, and Cybernetics: Systems (2021).</i>	Peer Reviewed	2021-12-08 *
<i>A Formal Characterization of Black-Box System Safety Performance with Scenario Sampling</i>	<i>Weng, Bowen, Linda Capito, Umit Ozguner, and Keith Redmill. "A Formal Characterization of Black-Box System Safety Performance with Scenario Sampling." IEEE Robotics and Automation Letters 7, no. 1 (2021): 199-206.</i>	Peer Reviewed	2021-11-12 *
<i>Vehicle automation emergency scenario: using a driving simulator to assess the impact of hand and foot placement on reaction time</i>	<i>Loeb, H. S., Vo-Phamhi, E., Seacrist, T., Maheshwari, J., & Yang, C. (2021). Vehicle automation emergency scenario: using a driving simulator to assess the impact of hand and foot placement on reaction time (No. 2021-01-0861).</i>	Trade Publication	2021-11-03 *
<i>Safe Intersection Crossing for Pedestrians With Disabilities</i>	<i>Smith, Stephen F., and Zachary B. Rubinstein. Safe Intersection Crossing for Pedestrians With Disabilities. No. Mobility21 Project# 40459.14. 1080376. Mobility21, Carnegie Mellon University, 2021.</i>	Other	2021-11-01 *
<i>Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities</i>	<i>Vadakpat, G., Smith, S. F., Rubinstein, Z. B., & Dias, M. B. (2021). Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities. Public Roads, 84(4).</i>	Trade Publication	2021-10-14 *
<i>Driver Warning Technologies and Partial Vehicle Automation: Save Lives and Money</i>	<i>Caldwell, S., Harper, C., Hendrickson, C., and Samaras, S. (2021). Driver Warning Technologies and Partial Vehicle Automation: Save Lives and Money. https://www.cmu.edu/traffic21/pdfs/2021---traffic21_policymaker_guide---driver-warning-technologies-and-partial-vehicle-automation.pdf</i>	Trade Publication	2021-10-08 *

* Not previously reported.

Other publications, conference papers and presentations:

Title	Event	Type	Attended	Date
Enhancing Robustness for Interdependent Network Systems with Dynamic Coupling Strategy	Workshop on the Economics of Fog, Edge, and Cloud Computing	Academic	15	2022-09-23
large-scale multi-class network modeling and simulation	meeting with Honda	Professional	5	2022-09-20
A modeling framework to quantify impacts of mobility services	CMU-Honda workshop	Professional	6	2022-09-20
Managing AI in Transportation	ITS World Congress 2022	Professional	80	2022-09-11
TSMO 1 system simulation with ramp metering	Meeting with MDOT	Professional	10	2022-08-12
Transportation Technology Trends from the Smart Transportation Dispatch	ITS Pennsylvania Annual Meeting	Professional	200	2022-08-09
Data Visualization and Analysis of Vehicle Component Level for Heavy Trucks and Trailers	Summer Research Symposium of the Department of Civil and Environmental Engineering	Academic	100	2022-07-29
Adjustability in Robust Linear Optimization	International Conference on Continuous Optimization 2022	Academic	40	2022-07-25
The Real Deal: A Review of Challenges and Opportunities in Moving Reinforcement Learning-Based Traffic Signal Control Systems Towards Reality	12th International Workshop on Agents in Traffic and Transportation	Academic	30	2022-07-25
Dynamic O-D estimation	Meeting with FHWA Turner Fairbanks Research Center	Professional	3	2022-07-11
Large-scale multi-class network modeling and simulation	meeting with Fujitsu	Professional	6	2022-06-20
Engagements with Carnegie Mellon	AFL-CIO 2022 Convention	Professional	40	2022-06-14
Towards Data-Driven and Continuous Safety Inspection of Commercial Trucks and Trailers	PITA Industry Board Meeting	Professional	40	2022-06-02
Autonomous Food Delivery Impacts on Traffic and Sustainability	Institute of Industrial and Systems Engineers Conference	Academic	40	2022-05-24

Congestion and environmental impacts of short car trip replacement with micromobility modes	Institute of Industrial and Systems Engineers	Academic	1000	2022-05-23
Large-scale multi-class network modeling and simulation	Meeting with Honda	Professional	5	2022-05-10
Demand learning and supply optimization for last mile transportation in low-income neighborhood	Production and Operations Management Annual Conference 2022	Academic	30	2022-04-21

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	New Posts: 622
http://mobility21.cmu.edu/	The Carnegie Mellon University's Mobility21 National University Transportation Center website	New Posts: 622
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: 240
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: 98 Views: 891
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: 1,200 Following: 1,729

Technologies or techniques

- A new data set has been curated and documented, as part of UTC project Image Processing Approaches to Traffic Situation Understanding, Risk Assessment, and Safety led by researcher Keith Redmill. The project code for Hybrid DRL-based Automated Driving is open source and available at: <https://github.com/Ekim-Yurtsever/Hybrid-DeepRL-Automated-Driving>.
- As part of UTC project, Training Drivers to Automated Vehicles led by Helen Loeb, the research team moved the driving simulation experience to an actual car. IMU sensors were affixed to the steering wheel and pedals so as to provide wireless input to the simulation. Preliminary results are satisfactory in the sense that we did not observe much latency. Once the car simulator get further developed, they anticipate the development of a second clinical study, this time in the vehicle.
- A new community website was published as part of the F1/10 Autonomous Racing Course and Competition project, <https://f1tenth.org/>.
- A new website was launched for Pingbo Tang's UTC project Deterioration Digital Twins of Commercial Trucks and Trailers for Targeted Inspection and Maintenance, <https://sites.google.com/andrew.cmu.edu/trsafety/home>.

Inventions, patent applications, and/or licenses

There are no new inventions, patent applications, and/or licenses to report this period.

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

	Research Performance Measure	Annual Target	Previous Reporting Period	Current Reporting Period	Annual Total
Output #1	Annual Number of Journal Publications	35	24	54	78
Output #2	Annual Number of Research Pilot Deployments	10	4	7	11

Please see "Section #3 Publications" for publications.

Some examples of the research pilot deployments include:

- **September 6, 2022** – As part of UTC project "**Smart Glasses for Improving Mobility of Low-Vision People**" the PI, Yang Cai was at Allegheny General Hospital with collaborator Dr. Paul Freeman to test the Artificial Reality (AR) glasses for low-vision patients. One patient was 100 years old. Her vision improved from 20/80 to 20/30 with the AR glass. A young man improved his vision from 20/80 to 20/25 and he was able to walk around with the glasses on.
- **August 23, 2022** - **Pittsburgh tests program to provide free transportation for lower-income residents** – "Pittsburgh is launching a pilot program that will provide 50 city residents with free access to public transportation and other alternate

means of transportation for one year. Officials said the initiative would help alleviate the financial burden of transportation... The 50 residents who take part in the pilot will be recruited by the city’s Department of Mobility and Infrastructure, Carnegie Mellon University and the Manchester Citizens Corporation.”

- **June 8, 2022 - Professor Katherine Flanigan Installs Sensors for Smart Parks Project** - Mobility21 UTC researcher Professor Katherine Flanigan recently worked with the City of Pittsburgh, the Pittsburgh Parks Conservancy, and Metro21 to install sensors throughout Mellon Park as part of her Smart & Equitable Parks project to assist city officials and planners in quantifying data-driven returns on potential investments to parks and mobility services.
- **May 16, 2022 - Signals along ‘Smart Spines’ optimize traffic flow** - “By revamping close to 150 city intersections with adaptive signaling technology, Pittsburgh plans to improve traffic flow and decrease idling times for city buses. The initiative will incorporate technology from Rapid Flow Technologies’ Scalable Urban Traffic Control program (Surtrac), an artificially intelligent adaptive signal control system first deployed in 2012, into eight high-priority traffic corridors, or “Smart Spines,” throughout Pittsburgh.”

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

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

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

	Research Performance Measure	Annual Target	Previous Reporting Period	Current Reporting Period	Annual Total
Outcome #1	Annual Number of Media Stories Referencing UTC Research, Faculty, or Spinoff	80	45	45	90
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	41	81	122

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

- **September 27, 2022 - To break an impasse in connected vehicle tech, transportation leaders call for a federal policy framework** – “Because experts worry there will not be enough spectrum for vehicle-to-everything communications in the long term, the FCC needs to do a complete analysis of the transportation industry’s spectrum requirements, said Jon Peha, an engineering professor and expert on information networks at Carnegie Mellon University who previously served as the FCC’s chief technologist.”
- **September 16, 2022 - Why Smart Cities are About More Than Just Tech** – “From optimizing school bus routes using machine learning to testing new ways to gather data on air quality, Metro21: Smart Cities Institute at Carnegie Mellon University in Pittsburgh has worked on a wide range of projects over the years. The organization’s aim is to look for ways that cutting-edge technology can benefit cities and their residents. Karen Lightman joined Metro21 in 2017 and is now executive director.”
- **September 9, 2022 - Oakland’s First Sidewalk Poetry Contest Celebrates Its History and Future** - “The sidewalks of Oakland (Pittsburgh) have undergone a revamping, with lines of poetry scattered across the neighborhood reflecting on the beloved history and heart of Oakland. Lisa Kay Schweyer, a contest winner and a program manager for the Mobility21 at Carnegie Mellon University, wrote her poem about some of the overlooked but important Oakland features.”
- **September 2, 2022 - The space race for our cellphones** – “SpaceX CEO Elon Musk and T-Mobile CEO Mike Sievert late last week announced plans to start delivering service through SpaceX’s Starlink by the end of next year in the United States... The partnership would effectively enable cellphones to do what satellite phones can do, Jon Peha, former FCC chief technologist and professor of engineering and public policy at Carnegie Mellon University, tells Axios.”
- **August 23, 2022 - People are now testing Tesla’s ‘full self-driving’ on real kids** - “Cupani filmed the test of “full self-driving” in a parking lot. His son stood near the end of an aisle holding a smartphone to film the test... Detecting smaller objects like young children quickly and accurately will generally be more difficult than sensing large objects and adults for a computer vision system like what Tesla vehicles rely on, according to Raj Rajkumar, a Carnegie Mellon University professor who researches autonomous vehicles.”
- **August 17, 2022 - Traveling this summer? It’s never too soon to start planning your ground transportation.** – “Getting around on vacation is getting harder than ever. With another car rental shortage forecast for this summer, you might find yourself stranded at your hotel or vacation rental. But there are new ways to solve your ground transportation problems... Stan Caldwell... says new “mobility as service” platforms are offering travelers more options for getting around.”
- **August 16, 2022 - Former Volkswagen and Sony plant in Mount Pleasant will become training site for emergency response crews and state road workers** – “The test facility, known as Pennsylvania Safety, Transportation and Research Track, will use 80 to 100 acres of land at the former Volkswagen and Sony plant, state and local officials announced

Thursday. The facility, which could cost as much as \$20 million, will be a free training site for emergency response crews and state road workers, and lease time to private companies developing self-driving vehicles and other transportation products... Academic institutions such as Carnegie Mellon University, which is a leader in self-driving technology, also will be able to use PennSTART.”

- *August 12, 2022 - Drones carrying parcels found to use much less energy per parcel than diesel trucks* – “A team of researchers at Carnegie Mellon University has found that drones carrying parcels use much less energy per parcel than diesel delivery trucks. In their paper published in the journal *Patterns*, the group described their tests of drones carrying packages and how they compared with trucks.”
- *July 15, 2022 - Tesla’s high-profile Autopilot executive departs* – “Andrej Karpathy, a high-profile Tesla executive who played a key role in developing the electric car maker’s artificial intelligence and driver assistant technology, said on Wednesday he is leaving the company... “I would imagine that there will be an internal promotion to fill Karpathy’s position. It would not be easy to get somebody externally with Karpathy’s experience and knowledge,” said Raj Rajkumar, professor of electrical and computer engineering at Carnegie Mellon University.”
- *July 5, 2022 - Tesla closes an office as layoff hits Autopilot jobs, including hourly ones* - Tesla (TSLA.O) has shuttered its office in San Mateo, California and laid off roughly 200 employees working on its Autopilot driver-assistant system there, one of the people told Reuters, in a move seen as accelerating cost-cutting... ‘Tesla clearly is in a major cost-cutting mode,’ said Raj Rajkumar, professor of electrical and computer engineering at Carnegie Mellon University.”
- *July 5, 2022 - 4 ways communities can implement smart streetlights, traffic sensors, and other technology, according to leaders in cities with successful smart city projects* – “But, starting small, such as deploying smart streetlights on a couple of blocks before expanding citywide, allows cities to experiment and test solutions to see what works best, Karen Lightman, executive director of the Metro21: Smart Cities Institute at Carnegie Mellon University, said. Otherwise, city leaders may risk wasting money on technology that isn’t the right fit. Cities also need to gather a small amount of data before they can know how to best use smart technology, Lightman added.”
- *June 28, 2022 - Pennsylvania Study Looks at Work Zone Crashes, Risk Factors* – “New research from the Carnegie Mellon University’s College of Engineering, in partnership with PennDOT], found that work zones more than 1.8 miles long could increase crash risks; and that road work scheduled for night hours do not increase crash risks. ‘So far, we cannot say what mitigation efforts can lead to the safest work zones; this will be our next step. But this provides insights on under what conditions a work zone can lead to more crashes, and when a work zone does not,’ said Sean Qian, professor of civil and environmental engineering and director of the Mobility Data Analytics Center.”
- *June 24, 2022 - Self-driving cars crash, too, but figuring out what it means requires much better data* - “What NHTSA provided was a ‘fruit bowl’ of data with a lot of caveats, making it difficult for the public and experts alike to understand what is being reported. Independent analysis of the data is key to identifying any safety gaps and potential remedies.’ But given the wide disparity between each company’s abilities to obtain and verify crash reports, the data is likely to remain unstandardized for quite some time. ‘Standardization would be premature,’ said Raj Rajkumar, a professor of computer and electrical engineering at Carnegie Mellon University.”
- *June 21, 2022 - Data likely shows Teslas on Autopilot crash more than rivals* - In a June 2021 order, NHTSA told more than 100 automakers and automated vehicle tech companies to report serious crashes within one day of learning about them and to disclose less-serious crashes by the 15th day of the following month... Raj Rajkumar, an electrical and computer engineering professor at Carnegie Mellon University who studies automated vehicles, said he wouldn’t be surprised if Tesla was found to have had a high number of crashes involving its driver-assist systems.”
- *June 17, 2022 - To convince more drivers to go electric, the Biden administration wants chargers that work for all EVs* – “On Thursday, the administration proposed rules that would, among other things, mean that any charging station built with federal money must accommodate any electric car... That infrastructure has improved a lot. But there are still real barriers, especially for anyone who doesn’t have a driveway, said Jeremy Michalek at Carnegie Mellon University. That was him when he first got an electric car.”
- *June 15, 2022 - All signs point to a ‘growing appetite’ for digital twins: report* – “There is a ‘growing appetite’ for digital twin technology across all major sectors, including smart cities, according to the report, particularly as organizations seek to digitize and improve their operations. The growing pressure among cities and corporations to decrease emissions is also accelerating the pace of such digital innovation, it states... Karen Lightman, executive director of the Metro21: Smart Cities Institute at Carnegie Mellon University, also cautioned city leaders against falling for the technology’s “hype,” particularly as the definition of a digital twin can vary widely.
- *June 13, 2022 - How Much Better Are Electric Cars for the Environment?* – “Jeremy Michalek, a professor with Carnegie Mellon University, who directs the Vehicle Electrification Group, told Newsweek that electric vehicles in the United States tend to have lower carbon footprints on average than gasoline or diesel cars, although there are exceptions.”
- *June 13, 2022 - Teslas Are Braking for No Reason, But That’s Not Autopilot’s Only Problem* – “But as Raj Rajkumar, an electrical and computer engineering professor at Carnegie Mellon University who studies automated vehicles, told CBS News: ‘It’s very easy to bypass the steering pressure thing. It’s been going on since 2014. We have been discussing this for a long time now.’”
- *June 6, 2022 - Autonomous transit — From the moon to your red light* – “By now, everyone in Pittsburgh has most likely witnessed autonomous vehicle testing on our local streets... According to Venture Beat, in 2019, five

manufacturers tested 55 different autonomous vehicle models in Pittsburgh alone...CMU's Traffic21 Institute and Rapid Flow Technologies spent several years developing and deploying the Surtrac adaptive traffic signal control system, the market's most advanced adaptive traffic signal system."

- *May 30, 2022 - Try these ride-hailing tips on your next trip* – “Most of my ride-hailing experiences have been uneventful — except for one recent trip to the airport. On a rainy afternoon, I failed to connect with my driver, which precipitated a soggy 20-minute delay. That got me thinking: Maybe I could benefit from some advice... ‘The best strategy today is to have access to many services and to use each one when it best fits your trip needs,’ says Stan Caldwell, executive director of Carnegie Mellon University’s Traffic21 Institute, which focuses on transportation issues.”
- *May 25, 2022 - Going Nowhere Fast? Smart Traffic Lights Can Help Ease Gridlock* - Smith, a faculty member at CMU’s Robotics Institute who studies the use of artificial intelligence to coordinate large systems in transportation, manufacturing and other fields, developed traffic signals equipped with individual computers and software with AI capabilities, which can use cameras, radar or inductive loop detectors in the pavement to spot approaching vehicles and adjust their timing...”
- *May 20, 2022 - Will we see self-driving buses on the new bus rapid transit being built in Pittsburgh?* – “Just moments into an interview with Vincent Valdes, executive director of Southwestern Pennsylvania Commission (the group that decides how to spend federal transportation dollars, locally) Valdes brought up the idea of autonomous buses along the BRT route... Stan Caldwell does a lot of research on technology trends in automated vehicles with his Traffic 21 Institute initiative. He works at Carnegie Mellon University and invited Channel 11 to the Navlab, where they’ve been doing research on this type of technology since the 80s.”
- *May 2, 2022 - Electric vs. Gas Cars: What Are the Hidden Environmental Costs of EVs?* – “Extreme heat and cold have negative effects on the efficiency of electric vehicles. EVs in more extreme climate areas in the U.S. can use up to 15% more energy on average, according to Carnegie Mellon University’s Department of Engineering and Technology.”
- *April 29, 2022 - Allegheny, Indiana, Fayette lead 10-county region in number of slow internet connections* – “The Southwestern Pennsylvania Commission, Allies for Children, and the Metro21 and Traffic21 initiatives at CMU, collaborated to form Southwest Pennsylvania Connected, a group to advise applicants for funding from the 2021 Infrastructure Investment and Jobs Act. Through the law, some \$65 billion will be available to broadband installation and expansion projects in the U.S., with priority given to areas with slow speeds and high poverty recipients without access.”
- *April 27, 2022 - Pittsburgh Technology Council starts apprenticeship program to increase diversity in STEM industry* - “There’s no reason this apprenticeship program can’t work for tech jobs,” said Ms. Russo, who described the program Friday as part of a presentation by Carnegie Mellon University and the Pennsylvania Department of Transportation to encourage women and minorities to pursue careers in science, technology, engineering and math.”
- *April 26, 2022 - As Some Americans Celebrate End Of Travel Mask Mandates, Most Say ‘Not So Fast’* – “Yet despite vocal proponents of the new rule, several polls suggest a majority of the public isn’t ready for masks to come off... ‘I believe air travel will continue to increase as we move from a pandemic to endemic posture,’ said Stan Caldwell, associate professor of transportation and public policy at Carnegie Mellon University’s Heinz College.”
- *April 26, 2022 - Full US transition to electric vehicles still decades away* - “The Biden administration is moving the U.S. toward an all-electric vehicle future, though making it a reality may still be decades away... Stan Caldwell, executive director of the Traffic21 Institute at Carnegie Mellon University, said more consumers will move to cleaner vehicles as more options come to the market.”
- *April 15, 2022 - The future of open city streets could start with smarter traffic lights* – “In 2009, the billionaire industrialist Henry Hillman decided his hometown of Pittsburgh could do better. Its traffic congestion problems weren’t as bad as those of most large US cities, but Hillman had the means to do something about them. His foundation donated to CMU with a writ to work on solutions—a prompt that eventually led to Traffic21, an institute charged with devising novel transportation tech and using the city as a lab to test it... Traffic21’s executive director, Stan Caldwell, began searching for where to start. Civil engineers consistently pointed to the proliferation of traffic cameras: The tools offered lots of data about how folks moved around, but the people sitting in control rooms didn’t have the training to manage or interpret it.”
- *April 13, 2022 - The Last Big Obstacle to Electric Cars Is All in Your Mind* – “The roughly half of Americans who park in their own driveways or garages can plug in their cars when they get home each night and drive to work the next morning on a full charge... ‘In places like Manhattan, I know what a pain it is to find a parking spot,’ Jeremy Michalek, a mechanical engineering professor and co-founder of the Vehicle Electrification Group at Carnegie Mellon University, told The Daily Beast.
- *April 12, 2022 - Electric Vehicle Experts Talks Affordability, Minority Communities and More on ‘Auto Trends’* – “In a two-part radio conversation, Auto Trends with JeffCars.com, a syndicated multicultural automotive radio program, talks with two leading EV experts for its first-ever, high-charged discussion concerning the current state of the EV market. Dr. Jeremy Michalek, who is a professor of mechanical engineering and public policy at Carnegie Mellon University, joins the show with extensive knowledge of the EV market. Michalek, who is one of the foremost EV authorities in academia, is also a co-founder of Carnegie’s Vehicle Electrification Group.”
- *April 11, 2022 - How Cities Are Using Digital Twins Like a SimCity for Policymakers* – “Digital twins could also better demonstrate to the public how data drives policy decisions, but it’s tricky, says Ray Gastil, director of the Remaking Cities Institute at Carnegie Mellon University. ‘The amount of data you need to create a visualization [of an

entire city] that looks realistic enough for people to identify with is extraordinarily high,' he says.”

- **April 4, 2022 - IDC names 17 winners for its 2022 North America Smart City Awards** – Included in the list of Transportation Infrastructure winners was City of Pittsburgh and Move PGH.

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

- **September 12, 2022 - U.S. DOT Inspector General Eric Soskin Tours CMU’s UTC** - While visiting Pittsburgh for a conference, US DOT Inspector General Eric J. Soskin and staff members Anthony Wysocki and Audre Azuloas visited Carnegie Mellon University's Mobility21 National University Transportation Center (UTC) to learn more about the UTC program and see first-hand examples of research, education and technology transfer initiatives including spin off companies. The Inspector General met with UTC faculty, students and staff, toured the Nav Lab, and got to check out a connected and automated vehicle.
- **September 1, 2022 - National Safety Council Discusses Worker Safety** - CMU Heinz College Dean Ramayya Krishnan participated in a Congressional Roundtable with Senator Bob Casey, leaders from the National Safety Council, and thought leaders from unions and the private sector, to discuss Mobility21’s research on transportation worker safety.
- **August 18, 2022 - Traffic21 Welcomes German Embassy’s Head of Transportation and Digital Infrastructure** - Dr. Joachim Eichhorn, Head of Transportation and Digital Infrastructure Section of the German Embassy visited the CMU campus and met with Stan Caldwell to learn about Traffic21 and the Mobility21 UTC efforts and discuss potential areas of collaboration with German universities and companies.
- **June 15, 2022 - Mobility21 Hosts Delegation of Urban Planners and Policymakers from Germany** - Mobility21 UTC researchers Dr. Destenie Nock and Dr. Corey Harper presented their research to a delegation of urban planners and policymakers from Germany with the Heinrich-Boell Foundation. They discussed automated vehicles, public transit ridership during COVID, and other topics to provide data to the delegation to shape the sustainable, inclusive and democratic transformation of our societies and economies.
- **June 3, 2022 - Mobility21 Meets with Representatives from Bosch-Germany** - Mobility21 Director Raj Rajkumar met with representatives Thomas Matschke and Hans-Georg Horst from Bosch-Germany who visited CMU campus and discussed UTC research and opportunities for collaboration. This was supported by CMU’s Carnegie Bosch Institute.
- **May 4, 2022 - UTC Researchers Participate in AFL-CIO Workshop at CMU** - The CMU Block Center for Technology and Society hosted a workshop on campus with the AFL-CIO Technology Institute and the AFL-CIO Industrial Unions Council to discuss impacts of manufacturing technology on the workforce. Mobility21 Director Raj Rajkumar presented on "*Perspectives on Alternative Pathways for the Development of Autonomous Vehicles and the Convergence of Connectivity, Electrification and Autonomy*" and other UTC researchers participated including, Nik Martelaro, Sarah Fox and Stan Caldwell. Mobility21 Advisory Council Member and Director of the AFL-CIO Technology Institute, Amanda Ballantyne also participated.
- **May 4, 2022 - Mobility21 UTC Researcher Appointed to IJIA Study on Impacts of AVs** - As part of the Infrastructure, Investment and Jobs Act, Congress directed the Federal Highway Administration to conduct a study of the impacts of Automated Driving Systems (ADS) in consultation with a defined expert panel. Mobility21 Executive Director Stan Caldwell was appointed to this panel as a representative from academia and participated in the initial panel discussion today focused on ADS impacts on the roadway infrastructure.
- **May 1, 2022 - Stan Caldwell Appointed to the 100 Questions Initiative on Urban Mobility and Transportation** - The GovLab, along with CAF - Development Bank of Latin America, the Transformative Urban Mobility Initiative, and the New Urban Mobility Alliance will collaborate in identifying priorities for the field by creating and sourcing a curated community of “bilinguals” from around the world. Mobility21 Executive Director Stan Caldwell was selected as one of the bilinguals, participated in the first panel discussion and formulated questions related to his UTC research.
- **April 6, 2022 - Mobility21 Highlighted to Visiting Delegation from Dortmund** - A delegation from the City of Dortmund, Germany visited Pittsburgh and CMU, hosted by the Scott Energy Institute, to learn about our work with technology in energy, transportation, food systems, etc. Stan Caldwell presented an overview of Mobility21, and UTC researchers Don Carter and Ray Gastil presented their research associated with the Remaking Cities Institute.

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?

- **May 27, 2022 - Traffic21 Researchers Publish Policy Brief** - Mobility21 researchers Nik Martelaro and Sarah Fox from the Carnegie Mellon University Human-Computer Interaction Institute led a team of researchers in publishing the Traffic21 policy brief, "How to Make Sense of Bus Transit Automation: Considerations for policy makers on the future of human-automation teaming in the transit workforce."

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?

- “East Liberty-based RoadBotics has been acquired by French tire manufacturing giant Michelin. The 2016-founded Carnegie Mellon University spinout specializes in using artificial intelligence to map the status and condition of a region’s infrastructure through visual and other data inputs. Its signature AI platform RoadWay has provided over 250 governments across the world with new assessment and management capabilities for their roads, per the company.”

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). Dr. Starr and Mr. Koch worked collaboratively on several outreach activities, including events that leveraged the connected vehicle sensors lab, although renovation work on the West Hills Center impacted the physical space available. In the last reporting period, CCAC shared that our Velodyne lidar units made for valuable outreach activities – this has been formalized into a demonstration kit that Mr. Koch has been able to take on the road for outreach activities at a number of CTCs and high schools. Dr. Starr also worked to build collaborations with several German *berufskollegs* (technical schools), exploring ways in which students are engaged in apprenticeship programs, and connecting EV technician curricula with mechatronics and industrial maintenance technician programs.

CCAC hosted its Advanced Manufacturing Advisory Board meeting, where the college announced its shift to a Business and Industry Leadership Team (BILT) model for advanced manufacturing curricula, including many aspects of automotive technologies. The BILT system replaces a traditional advisory board with an industry led group that identifies Knowledge, Skills and Abilities required in new hires and guides the college in structuring appropriate curricula.

CCAC began working on its component of the Student Spaceflight Experiments Program (SSEP), where teams of students are designing microgravity experiments. A competitive selection process will result in one experiment being flown into space on a SpaceX mission next Spring, with astronauts conducting a student-designed experimental process. Four teams of CCAC students working with Dr. Starr have selected topics related to transportation, including supply chain and logistics for their experimental design, and are connecting their projects to their technician studies. Finalists will be selected in November.

Dr. Starr and R. Koch continue to attend the ITS PCB working groups and have received the lite version of the CAVe-in-a-Box design – which took into account many of the comments provided by CCAC in our evaluation of the initial revision of the device. This lite version has a dramatically reduced setup time and has been piloted in several mechatronics classroom activities. It effectively enables an instructor to get up and running quickly and integrate a demo into a lesson.

September 2022:

- Hosted visiting representatives from Germany to tour the West Hills Center, participate in Automotive and Mechatronics training courses, and speak to American apprentices about their experience in the educational system.
- Dr. Starr met with the Pennsylvania Water Education Association to discuss programs that could leverage drones and autonomous vehicles for wastewater or hydraulic infrastructure inspection.

August 2022:

- Kicked off its participation in the Student Spaceflight Experiments program. More than 150 students will be designing experiments for potential use on a SpaceX mission, and four teams, comprising 16 students are designing projects in the field of supply chain, logistics and transportation.
- Dr. Starr met with representatives of a manufacturer of large permanent magnet motors to discuss creating technician training programs to service these devices as used in automotive technology and industrial applications.
- Met with City of St. Mary’s, PA to discuss providing curriculum to support transportation education programs in rural locations that do not have a community college.

July 2022:

- Hosted the Verizon STEM program at the West Hills Center where approximately 150 students were exposed to mechatronics and automotive technology programs through a series of hands-on demonstrations.
- Attended the NC3 Leadership Conference in Kenosha, WI where we shared updates on our programs and learned more about new curricular partnerships being offered by Snap-On, Starrett, FESTO, and other industry leaders in intelligent transportation.

June 2022:

- Met with Hans-Böckler Berufskolleg, Robert-Bosch Berufskolleg, and Franz-Jurgens Berufskolleg to explore curriculum sharing, regional exchanges and ways to strengthen German-American collaboration at the vocational level.
- Met with Veka AG to learn more about company needs for supply chain and logistics training and collaborations with the German IHK and DHK to develop apprenticeship training programs in these fields.

May 2022:

- Visited the FESTO Didactic Manufacturing Facility in Mason, OH to outline CCAC's plans for the New Workforce Development Building and ways to integrate high-level supply chain concepts into new equipment.
- Dr. Starr visited two farms that are exploring electrification to learn more about the needs that onsite technicians, manufacturing representatives and electrical contractors have when shifting to electrified tractors and other farm equipment.
- Held an AI in the Workforce Panel discussion in collaboration with CMU on May 12, 2022. More than 120 representatives from Pittsburgh organizations attended to discuss ways in which AI can impact the future of work – with a major emphasis on transportation and robotics.
- Hosted a skilled trades fair at CCAC on May 18 for all students interested in the skilled trades, including mechatronics, automotive technology and logistics/supply chain. 120+ students saw the connected vehicle sensor demonstration.
- Attended the NW Pennsylvania High Priority Occupations business meeting where CCAC provided information about how its programs can meet the needs of transportation-related careers in rural areas outside Allegheny County.

April 2022:

- Dr. Starr met with representatives from a maker of agricultural equipment to discuss the need for creating curriculum for EVs targeted at rural areas, with a particular focus on charging station infrastructure.
- Student Capstone projects for the mobility scooter design program were presented and completed.
- Attended the Hiring in 2022 Roundtable Event, where CCAC shared data on automotive and transportation-related training programs.
- Attended the ITS PCB Program Job Market Study Meeting Series.

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

	Research Performance Measure	Annual Target	Previous Reporting Period	Current Reporting Period	Annual Total
Impact #1	Annual Number of Instances of Technology Adoption or Commercialization	3	3	3	6
Impact #2	Annual Number of Instances of Research Changing Behavior, Practices, Decision Making, Policies (Including Regulatory Policies), or Social Actions	3	4	3	7

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