Program Progress Performance Report
for University Transportation Centers

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

Federal Grant Number: DTRT-13-GUTC-26

Project Title: Technologies for Safe and Efficient Transportation (T-SET)
National University Transportation Center

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Submission Date: April 30, 2018
DUNS Number: 05-218-4116
EIN Number: 25-0969449
Recipient Organization: Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213

Recipient ID Number: 31572.x.1080311
Project Grant Period: 9/30/2013 – 8/31/2018
Reporting Period End Date: March 31, 2018
Report Term or Frequency: Semi-Annual

Signature: [Signature]
1. ACCOMPLISHMENTS: What was done? What was learned?

What are the major goals of the program?

Research, Development, Deployment - The T-SET UTC focuses on safety. Our research is specifically targeted at improving the safety of automotive drivers and passengers, bicyclists and pedestrians, and the safe usage of trucks and mass transit vehicles. The thrusts of the T-SET UTC are structured along 5 core areas: In-Vehicle Technologies, Infrastructure Technologies, Human-Vehicle Interactions, Mobility/Data Analytics and Policy.

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 - Education and workforce development are important complements of the T-SET UTC research program.

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

Technology Transfer - The UTC will fully use the resources and the experience of these university centers to promote enterprises arising from its research program. Faculty who already created startups in the past, serve as mentors to colleagues interested in this activity.

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 - Collaboration is the heart of the entire T-SET program. CMU and Penn seek to ensure our research and development program leads to deployment of technologies in the transportation systems serving our communities and state, providing pilot applications for global use. The CMU-Penn team will collaborate with related centers on the two campuses, state and local public partners, non-profit community partners and industry partners.

Metrics:
- Number and diversity of members of both the T-SET Consortium and Advisory Council, and by the Number and impact of deployments achieved through collaboration

What was accomplished under these goals?

Research, Development, Deployment
Below are examples of specific accomplishments in supporting our research, development and deployment goal in the past six months:
- Meeting regularly with the researchers, students, collaborating partners, and other interested parties.
Refinement and final successful roll-out of the on-line database system for tracking research projects, progress reports, publications, etc. This database was adopted by the UTC at Portland State University.

Conducted six T-SET UTC faculty meetings including a webinar-based system of linking faculty and students to ensure interaction of our consortium. A faculty member interactively presents their T-SET funded research at the beginning of each meeting.

Participated in the UTC and Council of University Transportation Centers (CUTC) Winter meetings and the CUTC Banquet during the annual Transportation Research Board meeting, which resulted in exchanging best management practices and discussion of UTC priorities. We also serve on the Executive Board of CUTC.

Some highlights of the research, development, and deployment accomplishments during the past six months:

- In January 2018, T-SET researcher Dr. Sean Qian, Assistant Professor in CMU’s CEE program, Yiming Gu, and Ph.D. student Guohui Zhang won the 2017 Greenshields Prize at the TRB Annual Conference for their paper, “Traffic State Estimation for Urban Road Networks Using a Link Queue Model.” The Greenshields prize, honoring Dr. Bruce D. Greenshields, is awarded to the best paper submitted through the TRB Annual Meeting paper submission process that bases sound theory on rigorous empirical analysis and has practical applications or implications.

- Through the Building an Accessible, Low-stress, Safe, and Sustainable Bicycle Infrastructure Network for the City of Pittsburgh project, researchers were able to develop a system of metrics to measure safety of bikes for each road segment in the City of Pittsburgh, namely a bikeability score. Those metrics include crash frequency, injuries, traffic volume, traffic speed, riding easiness, bus coverage, crime, etc. In addition, a GIS-based web application was developed to provide user interfaces to visualize and customize bikeability score for users and agencies (http://mac.heinz.cmu.edu/traffic/bike).

- The Crowdsourced Traffic Calming project has improved ability to quantify traffic flows (both spatial and temporal accuracies are improved by virtue of a dense sensor network) through its development of “TrafficDOT.” Researchers have deployed a test LP-WAN network in the City of Palo Alto, California and conducted extensive field strength studies in and around the target deployment area. They have demonstrated that the network is adequate for the intended deployment and that the propagation and coverage criteria set out at the beginning of the experiment are within the capabilities of the network.

- The researchers from the Autonomous Air Traffic Controller project developed Fly-by-Logic, a fully automated technique for controlling autonomous drones from temporal logic specifications, which guarantees continuous-time and -space correctness. This research will supply crucial evidence and safety benchmarks to administrative/regulatory bodies like USDOT and Federal Aviation Administration as society navigates its way in a driverless/pilotless world.

Education and Workforce Development

Our 2017 Women in Transportation Fellowship was awarded to Sarah Cho (Heinz College masters student) and our first Diversity in Transportation Fellowship was awarded to Allante Whitmore (CMU College of Engineering PhD student). These fellows have been working closely with center T-SET staff to support technology transfer, collaboration, education and workforce programs and gain exposure to our national network.

In the Carnegie Mellon University Heinz College’s March issue of the Future of Work Publication, UTC Executive Director Stan Caldwell shares five ways that autonomous vehicles will disrupt policy and current industry practices. Five Automated Vehicle Policy Disruptions was part of a series of articles on cutting-edge work done by Heinz College faculty and students surrounding the intersection of society and technology.

The CMU Transportation Club is supported by T-SET and its Women in Transportation Fellows. The club has met six times, with an average attendance of 20 students during the past reporting period. The Transportation Club exposes CMU students from colleges across the campus to transportation related classes and research
opportunities, educates students about employment opportunities in the transportation industry, and provides opportunities to meet industry leaders through programming events, conferences, and networking.

At the 2018 Transportation Research Board Annual Meeting, the first ever ‘War Games’ was held to bring together all types of transportation professionals and develop and understanding of potential trends and scenarios arising as new technologies come to market. CMU’s UTC was represented by T-SET research assistant Amanda Johnson who participated on the Pennsylvania Department of Transportation team, along with nine others teams from across the country.

On January 6, 2018, T-SET UTC student, Max Li of the University of Pennsylvania, won the U.S. DOT’s Outstanding Student of the Year Awards. He was recognized for his achievements and accomplishments in the field of transportation at the Council of University Transportation Centers Banquet during the annual meeting of the Transportation Research Board and presented a scholarship award.

On December 1, 2017, T-SET UTC hosted its second Smart Mobility Connection meeting on “Enhancing Mobility for People with Disabilities,” featuring UTC researchers Dr. Aaron Steinfeld and Dr. Stephen Smith. Researchers discussed their work in making transit more universal for all users, including individuals with disabilities, and demonstrated the powerful impacts of CMU transportation technologies. The Smart Mobility Connection is a new UTC seminar series intended to bring together faculty and students across multiple colleges of CMU to collaborate on transportation research.

On November 30, 2017, a record of three standout PennPlanning students won Women’s Transportation Seminar (WTS) awards at this year’s Awards Banquet. The three University of Pennsylvania Transportation Planning students Olivia Moyabed, Carrie Sauer, and Rachel Finfer – were honored for their dedication to accessible transportation, Vision Zero, safe mobility, and for helping students at the collegiate and high school level connect with transportation.

T-SET sponsored, and Stan Caldwell judged, the CMU Tepper School of Business Tech Innovation Challenge from November 17 – 18, 2017. This year’s challenge was on “The Future of Transportation Technology” and demonstrated a great opportunity to engage business students from across the nation in transportation issues. Although CMU’s team did not win the competition, our T-SET partner’s Wharton School of Business at Penn received first prize.

The Intelligent Transportation Society of America hosted the ITS World Congress 2017 in Montréal from October 29 to November 2. Stan Caldwell, T-SET Executive, participated in a panel discussion on the Smart Belt Coalition, a multi-state connected and automated vehicle test bed. Several CMU students and faculty also participated: Adam Mistick, MS candidate for Information Security Policy and management, presented his research on Cybersecurity Vulnerabilities in Autonomous Vehicle Development, CMU-Silicon Valley Professor Dr. Bob Iannucci, presented three papers related to Smart Cities and was joined by CMU students Samarth Mathur and Ashotosh Tadkase, both MS candidates for Environmental and Civil Engineering. Dr. Iannucci and his students’ papers grew from a UTC T-SET funded project.

On October 23, 2017, T-SET hosted the Secretary of the Pennsylvania Department of Transportation, Leslie S. Richards, joined by T-SET Deputy Executive Director Courtney Ehrlichman for the Women in Transportation & Government panel discussion. They shared with students personal stories on how they found themselves in a leadership role in transportation, the barriers they overcame, and how others could get into the field. The discussion was moderated by Melanie Harrington, President and CEO of Vibrant Pittsburgh.

T-SET research assistant Amanda Johnson, and Women in Intelligent Transportation Fellow Ngani Ndimbie were joined by PennDOT Secretary Leslie S. Richards for a CMU Heinz College and PennDOT coordinated
Facebook Live interview. Both Heinz students discussed with the Secretary their internships at PennDOT over the summer, and the importance of increasing diversity in government. Amanda and Ngani are both in their second year at Heinz studying Public Policy and Management.

Throughout the reporting period, T-SET hosted many faculty seminars. These seminars reach our UTC campus communities, government and community partners as well as the public at large. Two examples of these seminars are listed below:

- March 30, 2018 - UTC researcher Venkat Viswanathan spoke to UTC students and faculty about the safety and security of electric vehicles in his presentation, “Analyzing and Defending Cyberattacks on Electric, Hybrid, and AV Battery Systems.” Venkat’s discussion included the ways hackers could control your self-driving car, cracking Tesla’s wall of silence on the Model 3 battery, and the challenges of electric driving range and battery degradation.

- February 16, 2018 - Traffic21’s Chris Hendrickson and T-SET UTC researcher Sean Qian, discussed safety research in transportation, and the Mobility Data Analytic Center’s Bikeability Score Platform.

In addition, the work of our researchers impacts education and workforce development. A couple of examples of those efforts are highlighted below:

- The Building of an Accessible, Low-stress, Safe, and Sustainable, Bicycle Infrastructure Network for the City of Pittsburgh project has trained two undergraduate students and one doctoral students for the interdisciplinary research on computer science, data analytics and engineering. Those students are now interested in pursuing transportation-related careers.

- Through the Bystander Interactions with Failing Vehicle Autonomy, a MS Human Computer Interaction Institute student has been doing an independent study (Spring 2018 semester) with the PIs on communication methods between pedestrians and AVs. A set of designed interactions are currently being prepared for a field study later in the semester.

Technology Transfer
Below are some highlights of T-SET UTC technology transfer activities during the reporting period:

- March 6th, 2018, One of T-SET’s Women in Intelligent Transportation’s Fellows, Ngani Ndimbie, spoke on a panel titled “Complete Streets in the Age of Automated Vehicles” at the National Bike Summit in Washington, D.C. Ndimbie was joined by representatives from BikePGH and Local Motors.


- T-SET UTC’s Chris Hendrickson was recognized for his role in the Transportation Research Board’s Future Interstate Study. Hendrickson is one of fourteen committee members - experts in transportation research, planning, and policy, who will play an integral role in revisioning our interstate system. Over the course of 30 months, members will hear from key stakeholder groups and compile a comprehensive final report. He is also a member of the TRB Research and Technology Coordinating Committee which met in December to review the FHWA research program.

- October 13, 2017, Professor R. Jayakrishnan from the University of California-Irvine presented his research on collaborative consumption in transportation as the first 2017-2018 T-SET Distinguished speaker. Professor Jayakrishnan’s presentation “User-Driven Service Order Adjustment for Efficiency in Collaborative Consumption of Transportation Supply,” suggested that a paradigm-shift in transportation, initiated by more peer-to-peer communication, presents a new opportunity for users to
consume with more complete information and greater satisfaction. The Distinguished Speaker series is made possible by CMU’s Traffic21, Mobility21, and T-SET UTC.

- **Traffic21 Director Chris Hendrickson** presented as a distinguished speaker at a transportation seminar held by the Transportation Research Institute at the University of Michigan in Ann Arbor. Hendrickson presented CMU’s research efforts in ‘transformational transportation technologies’ supported by Traffic21 and related University Transportation Centers. His presentation is available here.

- The researchers from the Sharing Connected Vehicle Infrastructure for Safety Applications, Smart City and Internet Access project was the keynote speaker at a conference in Harrisburg PA for senior municipal officials, where they spoke for an hour about emerging wireless technology, and how this technology can help meet community needs such as transportation. The PI also spoke on this topic at an IEEE conference, and the Ph.D. student on this project spoke at two research conferences.

- **Stan Caldwell** serves on the Executive Board of the Council of University Transportation Centers where we work to collaborate with fellow UTC. During this past reporting period, Stan Caldwell was a featured speaker at the Oklahoma Transportation Research Day hosted by the University of Oklahoma on October 17th. Caldwell also presented safety research in two session of the December 2017 Penn State Transportation and Safety and Engineering Conference in State College, PA.

  Chris Hendrickson was the keynote speaker at the Florida Automated Vehicle Summit hosted by the University of South Florida on November 14th, November 3, 2017. Also Professor Hendrickson spoke at the USDOT UTC Center for Connected Multimodal Mobility’s (C2M2) Fall Conference in Clemson, South Carolina to share knowledge between both UTCs. C2M2 is a consortium of higher education and research institutions in South Carolina working toward the vision to create a globally recognized multimodal mobility innovation center for moving people and goods, specializing in connected and autonomous vehicle research.

- **T-SET faculty member Steve Smith** presented his research at the October 2017 UTC Transportation Innovation Series at DOT Headquarters in Washington, DC and the video is available on the US DOT website.

- **T-SET Director Raj Rajkumar** presented his UTC research to the national Academy of Engineering Annual Meeting October 9, 2017 in Washington, DC. Professor Rajkumar also presented his automated vehicle research, and provided autonomous vehicle rides, to the National Safety Council Board of Directors on a January 30th visit to CMU.

As part of the sponsored research projects, technology transfer is also happening. Some examples:

- The Sharing Connected Vehicle Infrastructure for Safety Applications, Smart City and Internet Access project PI presented for the first time at the IEEE Vehicular Technology Conference in June 2017. He shared that the research shows federal, state and local governments could save on the order of 20% of the estimated $4 billion cost of deploying the roadside infrastructure that is required under the plan proposed by the U.S. Department of Transportation by working with commercial actors in entirely new ways. His work to date has also shown that there are benefits to sharing some (but not all) of the spectrum allocation for intelligent transportation systems (ITS) with unlicensed devices, and that those who want better performance for ITS might do better by asking for more ITS spectrum that is shared rather than asking that the ITS spectrum that they have not be shared. He has presented his work to date to FCC staff, and will continue to do so as the research continues.
• A journal paper will be submitted within the next month, documenting the theoretical and experimental results of damage diagnosis algorithms in the vehicle-bridge system as part of the Infrastructure Monitoring for Gradual Damage Detection Form an Inservice Light Rail Vehicle project.

• The Non-Intrusive Driver Distraction Monitoring Using Vehicle Vibration Sensing project team has two PhD students involved in the research. The developed hardware has been used as a data acquisition platform in graduate level project courses at CMU to promote student interest in safe transportation systems. The technology was demoed and the demo abstract was published at the 2017 Cyber-Physical Systems Week held in Pittsburgh. The work is presented through multiple invited seminars at Stanford, CalTech, Princeton, Georgia Tech, Univ. of Houston, etc. to promote collaboration and expansion of the work. In addition, the technology has been demoed to companies, such as Intel, Google to promote industry collaborations and potential commercialization.

• The Autonomous Air Traffic Controller project will be releasing a free and open-sourced “toolchain” in the next few months.

• October 6, 2017, T-SET UTC researcher Zhen (Sean) Qian presented “Statistical Interference of Probabilistic Origin-Destination Demand Using Day-to-Day Traffic Data” at the University of Pittsburgh’s Swanson engineering seminar series. Qian’s research involves developing a novel theoretical framework for estimating the mean and variance matrix of O-D demand considering the day-to-day variation induced by travelers’ independent route choices.

Collaboration
At the core of our efforts, is collaboration. Below are some examples of how that collaboration takes place:

January 4, 2018 – At the University of Pittsburgh, T-SET featured a poster and display in the Western PA Mobility Showcase. This was a new event created by the City of Pittsburgh’s Mobility and Infrastructure Department, and featured over 20 exhibits and was open to elected officials, policy makers and the general public.

The Crowdsourced Traffic Calming project in wide scale, outdoor sensing has crossed many other disciplines other than Traffic Calming. Through new relationships with USGS and Contra Costa County Transport Authority, T-SET researchers have begun considering fusing data across disciplines for previously disjointed efforts. Since the additional cost of a transducer on the hardware platform is low, the researchers can imagine building devices that can sense many quantities other than those originally designed for. One such application is environmental sensing cross impact with traffic sensing. With environmental sensing and modeling, researchers open the possibility of predicting natural events that may impact traffic safety, such as floods and landslides, to enable early warnings. Conversely, researchers can monitor the impact of traffic and road management changes on the environment itself. On societal aspects, partners in government have begun to think widely of using technology to improve the lives of their citizens. The proposed work on sensing for traffic calming has sparked city officials to look for better ways to gather data and be more scientific in proving their suggested course of actions both to city council and affected communities. On a wider scale, the work has been influential in engaging cities to think about the Smart City and what other services that can be provide to their citizens.

The researchers from the Autonomous Air Traffic Controller project are now in collaborative research talks with NASA Langley on the design of some multi-mission drones.

How have the results been disseminated?

T-SET faculty and staff actively present research results at conferences and events with examples above in the
Technology Transfer section.

Stories about T-SET research projects and faculty are distributed in the Breaking in Smart Transportation, a weekly newsletter that highlights T-SET research and efforts in the local, national and international media as well as industry news. With over 2,100 subscribers (an increase of over 300 people since the last report), and the readership represents a wide range of interests. Before the stories are sent out in the newsletter, they appear as individual updates/articles on the website, and are also posted through our Facebook and Twitter accounts.

All T-SET sponsored seminars are advertised on the website for the general public as well.

T-SET efforts and researchers are frequently mentioned in the news. In addition to what was been reported already in this report, some additional examples include:

- The project, Bystander Interactions with Failing Vehicle Autonomy researchers have been quoted in:
  - http://sandhill.com/article/the-future-of-smart-cars-is-now/

  In addition, researcher have had conversations with:
  - Department of Labor and Society of Automotive Engineers regarding accessibility of AVs for people with disabilities
  - Representatives of the Government Accountability Office regarding the future of work as robots and autonomy become more prevalent.

- The work done of the Safer Roads in Snow Storms and for Pedestrians and Bicyclists is highlighted on the following websites:
  - http://www.cs.cmu.edu/smartheadlight/

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

- We are working with faculty to ensure that they are focusing on the impacts of their research and preparing final reports for the close-out of the grant.
- We continue to promote T-SET work through seminars, partner development, education, workforce development initiatives, however we will begin doing this in tandem with our new National UTC, Mobility21, a US DOT University Transportation Center for the Mobility of People and Goods.

2. PRODUCTS: What has the program produced?

Publications, conference papers, and presentations

Journal publications

• Nikitha S. Poddatur and Christoph Mertz" All about the Road: Detecting Road Type, Road Damage, and Road Conditions" ITS world Congress 2017

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

Nothing to report.

Other publications, conference papers and presentations (listed by date, title, where presented, number of attendees):

• March 9, 2018 - A drive for better air service, ITS Berkeley Seminar
• March 5, 2018 - Surges of Collective Human Activity Emerge from Simple Pairwise Interactions, APS Meeting, 50
• Feb. 24, 2018 - Vulnerabilities of Electric Vehicle Battery Pack to Cyber Attacks on Auxiliary Components, Gordon Research Conference
• February 14, 2018 - A Driver's License Test for Driverless Vehicles, Advanced Autonomous Drive Conference, 200
• February 6, 2018 - Traffic Calming in Crowdsourced Smart Cities, Global City Teams Challenge
2018 Kickoff Conference, 300

- February 2, 2018 - Autonomous Air Traffic Controller project - Fly-by-Logic: Control of Multi-Drone Fleets with Temporal Logic Objective project GRASP/PRECISE Industry Day
- February 2, 2018 - Speed Gun App: Increasing Awareness of Urban Speeding, Video Analytics in Transportation, part of the 2017-2018 Smart Mobility Connection Forum, 30+
- January 18, 2018 - Smart cities and the funding needs and sources for these ventures, Automobili-D conference
- January 8, 2018 - Investigating the Effects of Reserved Lanes for Commercial Truck Platooning on Congestion: Pennsylvania Turnpike Case Study, Transportation Research Board National Academies, 70
- January 8, 2018 - Exploring the Economic, Environmental, and Travel Implications of Changes in Parking Choices Due to Driverless Vehicles, Transportation Research Board National Academies, 70
- December 1, 2017 - Mobility Data Analytics (Wearable DSRC Devices for Workers project), PennDOT District 6-0
- October 11, 2017 – Smart Headlights, Three Rivers Venture Fair, 700+
- October 3, 2017 – Headlights of the Future, Ford Advanced Lighting Innovation Expo, 500+
- Sept. 23, 2017, Data Flows to Support Inspection Programs in Pennsylvania, Keynote Talk to Association of Automotive Service Professionals (AASP), 150

Website(s) or other Internet site(s)

<table>
<thead>
<tr>
<th>URL for Internet site(s) that disseminates the results of the research and/or program activities</th>
<th>Short description of the site</th>
<th>Metrics</th>
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<td><a href="http://www.utc.ices.cmu.edu/utc/">http://www.utc.ices.cmu.edu/utc/</a></td>
<td>The Carnegie Mellon University’s Technologies for Safe and Efficient Transportation National University Transportation Center website</td>
<td>New Posts: 530</td>
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</table>
Technologies or techniques

Inventions, patent applications, and/or licenses

Provisional patents for the research conducted through the Safer Roads in Snow Storms and for Pedestrians and Bicyclists are being developed for submission.

Other products

The Monitoring and Predicting Pedestrian Behavior Using Traffic Cameras project team has developed a video processing pipeline to detect people from images, which is customized for operation with the type of cameras currently used to monitor vehicular traffic. They have also developed an approach to calibrate traffic cameras on-site, which is inexpensive in terms of time and logistics; does not require expensive instruments or software packages; uses a low cost custom-made laser scanner; and can be performed by personnel with minimal training. Using these elements, they have created a software framework that allows further development of the algorithms for pedestrian detection and tracking.

A working prototype of a speed gun app than can be used by a non-expert user has been developed by the Speed Gun App - Increasing Awareness of Urban Speeding project team.

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

What organizations have been involved as partners?

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<tr>
<th>Partner Organization Name</th>
<th>Location</th>
<th>Financial support</th>
<th>In-kind support</th>
<th>Facilities</th>
<th>Collaborative research</th>
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University Transportation Center and Mobility21, A National University Transportation Center for Improving Mobility of People and Goods

Followers: 871
Following: 1,628
Tweets: 5,660

https://twitter.com/Traffic21_T-SET

The Carnegie Mellon University’s Twitter Page for the Technologies for Safe and Efficient Transportation National University Transportation Center and Mobility21, A National University Transportation Center for Improving Mobility of People and Goods
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**Have other collaborators or contacts been involved?**

Within the past year, the CMU’s Metro21: Smart Cities Institute launched. Metro21 takes a forward-looking creative approach to bringing people, technology and policy together to significantly improve the quality of life for metropolitan area citizens. The multidisciplinary effort employs research, development and deployment tactics with key partners to create and test smart city solutions. Traffic21 and T-SET fall under this new umbrella of Metro21 at CMU.

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, and class and capstone projects. Our consortium members include:

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

And lastly, the UTC also has a distinguished Advisory Council of national leaders that provides strategic guidance and counsel. Members include:

• Allen Biehler, Recently retired from CMU as Distinguished Service Professor and Executive Director of the University Transportation Center, formerly Secretary of Pennsylvania Department of Transportation.
• Raymond T. Betler, President and CEO of the American Transportation Research Institute
• Rebecca M. Brewster, President and Chief Operating Officer of the American Transportation Research Institute
• Deborah Butler, Former Executive Vice President and Chief Information Officer, Norfolk Southern Corp.
• Joseph M. Casey, Former General Manager, Southeastern Pennsylvania Transportation Authority
• Douglas I. Foy, President of Serrafix; former Secretary Office of Governor Romney
• Charles L. Hammel III, President and owner, PITT OHIO Express
• Ashley Hand, Co-founder CityFi; formerly Transportation Technology Strategist Fellow for Los Angeles
• John M. Inglish, Former Chief Executive Officer of the Utah Transit Authority
• Jane Lappin, Director, Public Policy & Government Affairs, Toyota Research Institute
• Dr. Michael D. Meyer, Senior Advisor to Parsons Brinckerhoff, Inc and former Director of the Georgia Transportation Institute
• William W. Millar, Past President of American Public Transportation Association
• James A. Misener, Director of Technical Standards at Qualcomm and former Director of UC Berkley PATH
• Leslie Richards, Secretary of the Pennsylvania Department of Transportation
• Robert E. Skinner Jr., Former Executive Director of Transportation Research Board
• Kirk T. Steudle, Director of the Michigan Department of Transportation and past president of AASHTO and ITS America

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

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

The efforts conducted as part of this center have resulted in significant impacts, including where our center leadership and researchers are sought to comment in the media on current events. Some examples:

• March 28, 2018 - Top robotics expert Raj Rajkumar, who leads the autonomous vehicle research team at Carnegie Mellon University, quoted in USA TODAY, on Uber crash questions whether sensors worked, “The car’s LiDAR (light ranging and detection laser system) should have picked the pedestrian up far before it hit her,” says. https://www.usatoday.com/story/tech/2018/03/23/top-robotics-expert-uber-crash-questions-whether-sensors-worked/451420002/


• March 26, 2018 - Megan Ryerson, an assistant professor of city and regional planning at PennDesign, research director of the $14 million PennDOT-funded Mobility 21 transportation research center, and, uniquely, director of a brand-new project that attempts to document not just these crashes, but the many more near-crashes that happen every day, quoted in the Penn Today article. https://penntoday.upenn.edu/news/bike-lanes-experiment-measures-cyclist-response-infrastructure-design?utm_source=Primary&utm_campaign=9348337af1-EMAIL_CAMPAIGN_2018_03_20&utm_medium=email&utm_term=0_3777f2ca8f-9348337af1-44408237.


• March 26, 2018 - Examples of How AI Can Make Cities Smarter article in Government CIO, featured “Surtrac, using technology patented by the Robotics Institute at Carnegie Mellon University, claims its technology can produce 25 percent reductions in travel time and 40 percent reductions in time spent waiting at intersections.” https://www.governmentciomedia.com/4-examples-how-ai-can-make-cities-smarter.

• March 16, 2018 – The partnerships enabling disabled city residents to better explore their surroundings article, mentioned that “…researchers at Carnegie Mellon University developed an artificial intelligence-operated adaptive traffic signal system, Surtrac, that detects traffic and changes the lights accordingly instead of relying on pre-programmed light cycles. Pittsburgh piloted the system at dozens of intersections and found that traffic flowed better, but pedestrians initially weren’t taken into account. The research team tweaked the system based on feedback and also developed a
complementary app for people with disabilities to communicate with the system and receive more
time to cross the street. The changes proved beneficial not just for people with disabilities, but for all
pedestrians...One targeted innovation for which researchers at Ohio State University seek more
partnerships is a road paint that reacts with specially-designed tips on canes for the visually impaired.
The team is testing standard street paint with added light-converted oxides, which have the ability to
convert one wavelength of light to another wavelength.” https://www.smartcitiesdive.com/news/the-
partnerships-enabling-disabled-city-residents-to-better-explore-their-s/519029/.

- February 13, 2018 - Researcher Costa Samaras Drone Delivery Emissions Paper Covered by National
  Media. News outlets including The Guardian, Forbes, and Wired wrote about UTC researcher
  Constantine Samaras’ paper, “Energy use and life cycle greenhouse emissions of drones for
  commercial package delivery.” Says Samaras in Wired, “It’s pretty clear that companies are
  interested in doing this… What’s important is understanding the ways that policy makers could guide
  the beneficial outcomes now before there are a bunch of drones in the sky delivering packages.” Two
  of the research paper’s authors also wrote an op-ed for The Conversation that you can read here.

- February 7, 2018 - Massachusetts City Looks at Smart Traffic Light Software to Ease Congestion
  article in Gov Tech says “… the city is looking at using the new software, likely from a company
called Surtrac, for areas such as the Hancock Street corridor, the Wollaston area and Southern Artery.
The city hopes the software eases traffic, which is one of the most common complaints among Quincy
resident. Surtrac was created by researchers at Carnegie Mellon University. The team behind it says
studies showed the system reduced traffic on some main roads in Pittsburgh by 25 percent. Cassani,
who took over as director of the city department at the start of the year, said every few minutes shaved
off people’s commutes is important.” http://www.govtech.com/fs/infrastructure/Massachusetts-City-
Looks-at-Smart-Traffic-Light-Software-to-Ease-Congestion.html.

- January 23, 2018 - Alex Hauptmann, a professor at Carnegie Mellon who specializes in this sort of
  computer analysis, says that although AI has propelled the field forward hugely in recent years, there
are still fundamental challenges in getting computers to understand video. And the biggest of these
is a challenge for cameras we don’t often think about anymore: resolution. Take, for example, a
neural network that’s been trained to analyze human actions in a video. These work by breaking
down the human body into segments — arms, legs, shoulders, heads, etc. — then watching how these

- December 18, 2017 - Mobility21 Researchers provide a field demonstration of Surtrac adaptive
  traffic signal research to the Pittsburgh Complete Streets Committee and discuss urban applications
  of connected and adaptive signals for all modes of transportation. Included in the picture are Dr. Greg
  Barlow and Dr. Steve Smith of Rapid Flow Technologies.

What is the impact on other disciplines?

The Risk, Liability and Insurance framework for Autonomous Vehicles project effort is a key bridge between
Intel Labs and MobilEye in the blame assignment problem for AV accidents. T-SET researchers are
developing a formal framework for safety which complements MobilEye's Responsibility-Sensitive Safety
(RSS) model. Efforts have also led to collaborations with LG and GM on the development of a Verification
Processor Unit that would enforce safety properties at runtime for an AV. Students engaged in this are
working at GM R&D this summer to develop the first prototype.
The Crowdsourced Traffic Calming project has also improved ability to quantify traffic flows (both spatial and temporal accuracies are improved by virtue of a dense sensor network) through its development of TrafficDOT.

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

The startup RoadBotics was founded in 2016 with the technology of earlier work of the Up-to-date City Maps for Modeling, Planning, and Assistive Technologies project. The company has direct and significant impact on employment, attracting private investment, and improving infrastructure maintenance:

Within 15 months of founding, RoadBotics has:

• Raised $1.2 M in capital, including from multiple out of state institutional investors. About to close an additional +$2M in capital from still more out of state institutional investors.
• Acquired 31 paying customers in 10 US states and 2 countries (i.e., US and Australia) with total annual contract value of ~$260K
• Created a customer pipeline of $1M in outstanding proposals
• Assessed 5,000 lane miles to-date with another 2,500 in the queue scheduled to be collected and assessed
• Employed 10 full-time and 8 people part-time professionals as well as 4 full and part-time interns
• Secured active channel partnerships with 4 publicly traded multi-billion dollar companies. Also secured three regional channel partnerships and are in discussions with 4 large transportation, tech and civil engineering companies for further deployment of our offering.
• Piloted a rail and parking lot versions of our product for these two verticals respectively

And just on March 22, 2018, the Tribune-Review reported that: “An analysis of almost 80 miles of roads in Hampton Township will be performed this year by {Carnegie Mellon Spinoff} RoadBotics, a firm specializing in advanced road monitoring technology. Specifically, Hampton council approved to hire the company to do a one-time analysis on all of the township roads, which total 77.9 miles.”

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

The Risk, Liability and Insurance framework for Autonomous Vehicles project work has resulted in a $3 million Intel Science and Technology Center at The University of Pennsylvania, with a focus on Connected Autonomous Vehicles.

What is the impact on technology transfer?

The Risk, Liability and Insurance framework for Autonomous Vehicles project has led to collaborations with LG and GM on the development of a Verification Processor Unit that would enforce safety properties at runtime for an AV. Students engaged in this are working at GM R&D this summer to develop the first prototype.

What is the impact on society beyond science and technology?

Through the research, development, and deployment happening through the research, the end goal of increasing safety in transportation impacts all users of the transportation system:

The system of metrics and GIS-based web application to allow visualization of the bikeability scores that were developed through the Building an accessible, low-stress, safe, and sustainable, bicycle infrastructure network
for the City of Pittsburgh’s project.

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

The PI for the Sharing Connected Vehicle Infrastructure for Safety Applications, Smart City and Internet Access project has been invited to serve as an (unpaid) advisor to the City of Pittsburgh on deployment of wireless technology for smart city applications such as transportation. In this way, the PI is putting research results and concepts to work for the benefit of Pittsburgh and its citizens.

Olivia Mobayed, second year master’s student in City and Regional Planning at University of Pennsylvania, Women in Transportation Seminar Sylvia Alston Scholarship recipient, and T-SET professor Erick Guerra’s advisee – also spent the semester with Southeastern Pennsylvania Transit Authority’s Long Range Planning Department analyzing bicycle access to subway and regional rail stations. By tracking changes in bike ridership and facility improvements, she has identified the next round of stations to receive upgrades on their bicycle parking facilities. Tasker-Morris Station, pictured here in December, saw a 90% increase in bike ridership to the station in just two years with the installation of mezzanine-level bike parking.

The February 26, 2018, meeting the Transportation Club hosted a presentation by Margaret Edwards and Gaurav Gupte, two Ethics, History, and Public Policy students who shared their capstone presentation: a report on autonomous vehicle and transportation equity in Pittsburgh. The larger team of eight students presented their work before the Pittsburgh City Council at the end of 2017. T-SET’s Chris Hendrickson also talked about Traffic21’s history and initiatives.

On February 3rd and 4th, over 30 CMU students from a variety of colleges and disciplines participated in a Micro-Mini course to learn about the impact of autonomous vehicles in the City of Pittsburgh. The weekend course was strongly supported by T-SET UTC staff and faculty, and was well attended by UTC student leadership.

Over the weekend, students were instructed to prepare a presentation and report to the Mayor on the impacts of autonomous vehicles might have on the future of Pittsburgh’s Central Business District (CBD). The final reports were presented to the City of Pittsburgh Director or Mobility and Infrastructure Karina Ricks and the Pennsylvania Department of Transportation Executive Deputy Secretary Leo Bagley to inform policy makers on what challenges they will face, and the research that should be done to ensure a sustainable and equitable CBD.

Students heard from experts in transportation, disruptive technology, and infrastructure. To prepare for the class, students studied pre-work materials from UTC Director Raj Rajkumar. Speakers throughout the weekend included UTC Executive Director Stan Caldwell, UTC researcher and Director of Mobility Data Analytics Center Sean Qian, and UTC researcher Costas Samaras. Heinz College Alumnus Alex Pazuchanics, a Smart City Challenge leader from the City’s Department of Mobility and Infrastructure, informed students of challenges specific to the Pittsburgh CBD.

Facilitators included former Secretary of the Department of Transportation Al Biehler, and UTC/Mobility21 faculty and Smart City Challenge leader Don Carter. In attendance were four UTC student leaders – Ph.D. students Allanté Whitmore and Matthew Battifran, and Heinz graduate students Ngani Ndimbie and Amanda Johnson.

Students worked with speakers and facilitators to learn more about the impact of autonomous vehicles, interact
with real-world policy makers, and determine policy interventions that may be a model for other mayors and other cities. UTC faculty, staff, and students were integral in this effort in ensuring that Carnegie Mellon students are well-informed about the societal consequences of autonomous vehicles.

On March 13, 2018 - T-SET Executive Director Stan Caldwell spoke at the PA Chamber of Business and Industry’s Policy Roundtable and led a discussion about workforce, economic development and policy implications of disruptive transportation technologies. Caldwell’s presentation followed a policy discussion with Pennsylvania Governor Wolf where vehicle automation was also discussed.

On January 30, 2018, UTC’s Raj Rajkumar provided rides in CMU’s autonomous Cadillac to board members of the National Safety Council. The board members also received a tour of CMU’s College of Engineering to learn about how automation and AI can improve road safety.

### 5. CHANGES/PROBLEMS

**Changes in approach and reasons for change**

Nothing to report.

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

Nothing to report.

**Changes that have a significant impact on expenditures**

Nothing to report.

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

Nothing to report.

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

Nothing to report.

**Additional information regarding Products and Impacts**

Nothing to additional to report.

### 6. SPECIAL REPORTING REQUIREMENTS

Nothing to report.