Program Progress Performance Report
for University Transportation Centers

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Research and Innovative Technology Administration
UTC Program

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National University Transportation Center

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Signature: [Signature]
Major Goals and Objectives of the Program

Research, Development, Deployment
The CMU-Penn 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; and
- Patents and start-ups.

Education and Workforce Development
Education and workforce development are important complements of the T-SET 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, and
- Participants in workforce and educational programs.

Technology Transfer
The CMU-Penn 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.

- 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
Accomplishments Under Major Goals
See Appendix A for specific research project accomplishments.

Research, Development and Deployment
T-SET’s major accomplishment for the period of reporting was hosting the 1st UTC Safety Summit. There were 65 participants including 14 UTCs and national representatives from government, industry and community groups. USDOT Assistant Secretary, Greg Winfree, was the lunch keynote speaker.

Other Research, Development and Deployment activities include:
- Keynote speaker of Annual meeting of the Transportation Research Forum
- Meeting with Pittsburgh Mayor Peduto to discuss parking research
- Participated in the Regional Open Data Portal RFI Review Committee
- Participated in the US DOT ITS JPO Affiliated Test Bed Monthly Meeting
- Met with Intel researchers
- Attended CMU Transportation/Energy Faculty Meeting
- Participated in Mobility Lab’s Transportation Camp DC
- Met with LTV SSW Hot Metal Intersection Meeting with URA to discuss adaptive traffic signals
- Attended the Building a Better Busway meeting
- Attended the PA STIC meeting
- Attended CMU College of Engineering Research Directors Reception
- Meet with Southwestern PA Commission on Mobility Analytics
- Site visit to the Port Authority Bus Garage
- Meeting with Open Roads Consulting to discuss adaptive traffic signals

Education and Workforce Development
During this reporting period, we established a new Women in Transportation Summer Scholars Fellowship for undergraduates in partnership with the Robotics Institute, became active members in Women’s Transportation Seminar Transportation U activities, focused efforts on expanding the programming of the Transportation Club, and partnered with PennDOT on workforce development.

Education and workforce development activities include:
- Presenting at Future of Transportation in Pennsylvania (Student initiated lecture series)
- Presented at Clarion-Jefferson Teen Safe Driving Event
- Transportation Club Speaker Event: Members from Port Authority spoke to the CMU body about data mining and the logistics of the bus systems
- Presented Present UTC Research to the New York Association of Transportation Engineers
- Presented at the Penn State Transportation Engineering and Safety Conference
- Meeting with Aimee Jefferson regarding Transportation U
- Facilitated seminar and faculty meetings at CMU with a visiting professor from Singapore Management University
- Participated in Heinz College Systems Amtrak Synthesis Advisory Board Meeting
- Hosted Transportation Club Happy Hour
- Hosted Transportation Club General Meetings
• Hosted Transportation Research Expo: PhD and Professors had booths set for undergraduate students to learn about research opportunities within the transportation sector.
• Hosted Transportation Club Fair
• Hosted Graduate Women in Transportation Lunch
• Meeting with campus visitors from Ford
• Meeting with PennDOT and other PA Universities for planning research symposium
• Meeting with PennDOT and CMU Design on local transportation improvement near campus
• Transportation Club hosted the Pittsburgh Bike Share Executive Director for a seminar
• Attended Women Transportation Seminar Meet and Greet
• Attended Women Transportation Seminar Kick-Off Meeting
• Attended Women Transportation Seminar Board of Director Meeting
• Attended Young Professionals in Transportation meeting
• Alternative Fuel Institute Case Competition: Students discussed and wrote a paper discussing the future of alternative fuels
• Developed Women’s Transportation Seminar Transportation U Challenge Book in collaboration with Rutgers.
• Lunch with Uber’s Head of People Position
• Transportation club presented at National Engineering Week: Numerous science center attendees visited the transportation club booth to participate on a hands on activity to teach about the autonomous vehicle and smart cities.
• Presented at monthly meeting of American Council of Engineering Companies

Technology Transfer & Collaboration
A Technology Transfer program has been a big focus for T-SET this past reporting period. We have been working with the Center for Innovation and Entrepreneurship on campus to develop an Entrepreneur-in-Residence program. This program should be rolled out in the Fall of 2015.

Other Technology Transfer and Collaboration Activities include:
• Faculty Seminar Presentation: Students listened and asked questions to Haeyong Noh research on bridge monitoring. For those who were not able to attend, a web cast was also presented
• Faculty Seminar Presentation Students listened and asked questions to Anthony Rowe research on bikes with V2V communication. For those who were not able to attend, a web cast was also presented
• Faculty Seminar Presentation: Students listened and asked questions to Al Biehler and Chris Hendrickson on PA 2040 Vision for Autonomous Vehicle. For those who were not able to attend, a web cast was also presented
• Faculty Seminar Presentation: Students listened and asked questions to Zack Rubinstein and Stan Caldwell on Pittsburgh as a connected vehicle bed. For those who were not able to attend, a web cast was also presented
• Co-hosted ITS America 2015 Annual Meeting Host Committee Kick-off event in Pittsburgh
• Meeting with CIE regarding EIR collaboration
• Meeting with Brendan McManus, potential EIR
- I-corps meeting
- Attended CONNECTS: The Benefits and Perils of Using Open Source Code for Your Startup
- Meeting with Center for Technology Transfer and Commercialization
- Presented UTC research to visiting staff of the Federal City Council from Washington, DC
- Panelist at American Association of Motor Vehicle Administrators Workshop & Law Institute
- Keynote speaker of State Transportation Innovation Council Regional Meeting
- Presented UTC research at ITS America Leadership Circle and Smart Cities Council conference in San Diego
- Meet to discuss ITSA Annual Meeting bike ride
- Attended UTC Winter Meeting
- Attended CUTC Winter Meeting
- Attended TRB Annual Meeting
- Attended PA Governor Wolf Inauguration
- Attended City of Pittsburgh recruiting event for Heinz College Students
- Attended Industrial Internet Consortium
- Attended National bike summit
- Attended WOMEN+ Bike Summit
- Participated CMU Smart Infrastructure Incubator Symposium
- Attended Oakland Task Force Meeting
- Participated in the Pittsburgh Supercomputing Center Commonwealth Advisory Committee Meeting
- Attended Allegheny Conference on Community Development Annual Meeting
- Attended the Oakland Leadership Forum
- Met with Caryn Moore from the House Transportation Committee
- Interview with Amanda Waltz from Pop City Media
- Meeting with Debra Lam, City of Pittsburgh Chief of Innovation
- Meeting with Sara Morgan from Delta Development
- Hosted Visit to CMU from City of Pittsburgh Directors of Planning, Public Works and Innovation and Performance
- Demonstration of Downtown Simulation of Traffic Signals
- Hosted and presented at the Carnegie Mellon Community Connections Meeting
- Hosted City of Pittsburgh Department of Public Works meetings with CMU faculty
- Hosted Meeting with ITS America Annual Meeting Media Team
- Hosted visitors from Leadership Pittsburgh and Presented on the future of new technology and autonomous vehicles in Pittsburgh area

Diversity

T-SET continues to push initiatives that support women in the intelligent transportation domain including:

- Supporting the Women in Transportation Fellow to attend TRB Annual Meeting
- Leading the formation of the Pittsburgh Chapter of the Women's Transportation Seminar
- Starting the Women in Transportation Summer Scholars Fellowship, which supports an undergraduate woman in a Robotics Institute lab over the summer and offers mentorship opportunities. This year's Women in Transportation
Summer Scholar will be working with Isaac Kumar in the Surtrac (adaptive traffic signals) lab.

- Formed the Graduate Women in Transportation group
- Joining the steering committee of Women's Transportation Seminar's Transportation U and working to develop the challenge book for high school girls at the Transportation U event to be held in DC, summer 2015.

Products

**General Program Products**

- UTC website [www.utc.ices.cmu.edu](http://www.utc.ices.cmu.edu)
- 597 blog posts
- Consistent weekly distribution of T-SET email newsletter, 978 subscribers
- Continue to use a webinar-based system of linking CMU and UPenn faculty and students for our bi-weekly T-SET meetings. Now a faculty member interactively presents their research at the beginning of each meeting.
- Promotion of various CMU and Penn research news articles in the T-SET blog and newsletter
- Feature article of the UTC in the CMU ICES quarterly magazine

**T-SET In the MEDIA**

*Smart' parking arrives in Dormont (Pittsburgh Post-Gazette)*

PennDOT prepares for 'cars of the future' (FOX43 News)

Peak fender-bender: Technology can prevent car crashes, if consumers will buy in (Washington Post)

Ford drives scheduling with artificial intelligence (ComputerWorld)

On the road to innovation: How Pittsburgh is helping to change state transportation (POP City)

Self-driving car wish list: Safety but not coffee (ABC News)

Study: Most drivers see safety benefits of self-driving cars

What this 'Impact' Specialist says about Autonomous Transportation (Driverless Transportation)

Looking Into The Future On Electric Vehicle Adoption (Roll Call)

Traffic lights on your windshield could get you home faster (CNN International)

7 Ways Self-Driving Cars Could Impact States and Localities (Governing the States and Localities)

Automakers on the road to self-driving cars at Consumer Electronics Show (LA Times)

County, City & Pitt to build joint information infrastructure with R.K. Mellon Foundation (New Pittsburgh Courier)

Heinz Student Highlights the Future of Women in Transportation

'Smart City' Futurists Gather in San Diego for 1st Time (Times of San Diego)

Ottomatika raises $2.6M (Pittsburgh Business Times)

CMU Celebrates 30 Years of the Self-Driving Car (WESA)
Penn researcher studies how regional airport planners can help airports grow sustainably
(Penn Current)
Pittsburgh City Council considers possible 'dynamic' parking pricing (Pittsburgh Post-Gazette)
Related coverage:
CBS Pittsburgh
Pittsburgh Tribune-Review | WPXI.com
City Receives $25K from Heinz Endowments to Study LED Streetlights, Promote Energy Conservation (WESA-FM, Pittsburgh's NPR affiliate)
3 Driverless Car Projects that May Change How the World Travels (Government Technology)
Race for the Mission Viejo Council seat (Orange County Register)
The Secret History of the Robot Car (The Atlantic)
Establishing a Robotics Fellowship at Penn Engineering's GRASP Lab
Tesla's 'D' adds all-wheel drive, safety features (Associated Press)
3 Driverless Car Projects that May Change How the World Travels (Government Technology)
Race for the Mission Viejo Council seat (Orange County Register)
The Secret History of the Robot Car (The Atlantic)
Establishing a Robotics Fellowship at Penn Engineering's GRASP Lab
Appendix A – Research Projects Accomplishments, Products and Participants

Automated Detection of Objects in Rear Camera Images, Prof. Vijayakumar Bhagavatula

Other Collaborators: Dr. Shayok Chakraborty

Technologies / Techniques
At present, we are using background subtraction algorithms (using Gaussian Mixture Models) to learn a robust background model in order to detect the presence of objects (foreground), which do not fit the background description. We are also using a ground surface classification technique (based on pyramid on HOG features and SVM classifier) to classify ground and object pixels. The predictions using the two algorithms are combined through a fusion framework for robust object detection. Our first set of experiments, using this framework, has demonstrated encouraging results.

Impact
A system which can robustly detect the presence of objects in rear-camera images has tremendous potential in reducing the number of back over accidents.

Impact in other disciplines
The proposed framework can be viewed as a generic object detection system. It can also be used in several other applications including security and surveillance to detect abandoned or removed objects in airports and other public places.

Task List
In order to improve the accuracy and the speed of the automated object detection methods for rear-camera images, we plan to investigate the following research topics:

1. Expand the image database by collecting more images at different locations and weather conditions. We will make the dataset and the annotations publicly available to facilitate further research in this topic.
2. The proposed method is developed to detect objects of arbitrary shapes and sizes behind the parked car. We plan to augment our framework to detect the presence of children in particular, so that an alarm can be triggered to alert the drivers. A possible solution is to use a skin color detection algorithm to detect skin colored pixels within the segmented regions. This will be taken up as part of future research.
3. Analysis of our results revealed the fact that most of the pixel-level errors are caused by illumination changes. As part of our future work, we plan to address the effect of illumination in detecting objects. We intend to exploit existing research on shadow removal for this purpose.
4. An interesting direction of future research is to predict the posture of the children (sitting/standing/lying) and its distance from the rear end of the car, besides predicting merely its presence. We plan to take this up as part of our future work.

Goals & Timelines
1. Collection of a large image/video rear-camera object detection database together with ground truth annotations (June 30, 2015)
2. Development and evaluation of object detection methods that are tolerant to illumination variations (June 30, 2015)
3. Analysis of the effect of skin color detection in identifying the presence of children behind the parked vehicle (Aug 31, 2015)

Driver Status Monitoring in Autonomous Vehicles Using In-Seat Inertial Sensors, Hae Young Noh (CEE), Pei Zhang (ECE)

Other publications, conference papers and presentations: Initial paper under review
Other Dissemination Activities
informal talks for the CEO of Renault and Nissan, board of directors, as well as
significant research leads for the two companies.

Technologies / Techniques
\- Initial algorithm to detect muscle activity
\- Initial algorithm to detect heartbeat and breathing

Other Products associated
Instruments or equipment

Please explain
We have developed vibrational hardware that can measure multi-point vibration from the
car seats at 200Hz when all 20 sensors are active.

Impact
The outcome of our research will include a hardware that consists of the sensor node,
aggregator, and backend server to infer driver’s physiological states in a car setting. This
system will include both the hardware and software algorithms to determine and classify
the features of the person’s macro-motions (posture and motion) and micro-motions
(muscular and cardiovascular activities), which helps the autonomous car with
understanding the driver’s states, such as attention level, fatigue, and stress. The
system will also include algorithms that separate the driving noise of the car and road.

Task List
1. (Completed 1st version) Develop hardware to capture vibration data in car seat using
   multiple vibration sensors
2. (Completed) Collect initial data in a normal seat to capture signals of breathing and
   heartbeat
3. (In progress) Develop visualization software to visualize multiple vibration sensor
   data
4. (In progress) Develop preliminary algorithm to detect breathing and heart beats
5. Optimize sensor placement within the seat and incorporate the sensing platform into
   seats
6. Collect data in moving vehicle
7. Develop noise reduction algorithms.
8. Evaluate physiological extraction in moving vehicle in different driving conditions

Goals & Timelines
We are in progress with our initial algorithm development. We have developed hardware
that consists of the sensor nodes (16 total nodes), aggregator, and backend server to
collect the physiological information. The system is built in a cushion and can be placed
in a car seat or other seats for testing. We are developing preliminary algorithms base
on initial data collected on muscle activity, heartbeat, and breathing.

Evaluating the Opportunities for Cost Savings and Environmental Benefits of
Coupling Solar Energy and Electric Vehicles in City of Pittsburgh Municipal
Operations, Constantine Samaras

Participant Organizations
City of Pittsburgh
Pittsburgh Parking Authority

Other Collaborators
Jeremy Michalek, CMU
Avi Mersky, CMU

Other Dissemination Activities
10 March 2015 – PI presented project scope and ideas to Deborah Lam (Chief
Innovation Officer of the City of Pittsburgh) and Grant Erwin (Sustainability Manager for
the City of Pittsburgh) as part of set of presentations organized by Rick Stafford, and received helpful feedback from stakeholders.

**Task List**

Task 1. Collect and assemble data set of City of Pittsburgh light duty vehicles in the municipal fleet. Collect, assemble and map data on existing available land area in municipal fleet garages and parking lots. Collect and assemble ensemble of PEV and solar technology options for municipal implementation, including capital cost, operating cost, energy consumption, energy generation, and life cycle environmental air pollutant and greenhouse gas emissions. (Project months 1-3)

Task 2. Model the changes in life cycle local and regional air pollutant and greenhouse gas emissions of multiple PEV and solar PV technology options for the City of Pittsburgh. The model will also include financial outcomes relevant to City decision makers, including expected capital outlays, and changes in operations and maintenance expenses. (Project months 3-6)

Task 3. Generate final report for the City of Pittsburgh and discuss results with stakeholders. (Project month 6)

**Goals & Timelines**

1 June - Project Kickoff
1 Aug - Data collection and assembly nearing completion
1 Nov - Modeling nearing completion
31 Dec - Final report completion

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**Efficient 3D Accident Scene Reconstruction, Luis E. Navarro-Serment**

**Participant Organizations**
Allegheny County Emergency Services, Pennsylvania Turnpike Commission

**Technologies / Techniques**

As part of two other projects, we developed a methodology to take pictures of an accident scene and construct a 3D model; this is based on open-source structure-from-motion software and our own scripts and procedures. At the core of this methodology is an Android App, which we developed to assists users with the task of collecting the photographic evidence that is used to reconstruct the scene. In this project we have made considerable improvements to our assistive image capture application, making it more flexible and easier to use through the introduction of additional visual markers and spoken instructions.

Additionally, we have built a low-cost 3D scanner, using a Hokuyo line scanner that was purchased for a past project. This is a servo-controlled platform that sweeps the line scanner, and integrates a series of measurements into a 3D point cloud. The point cloud will be used as ground truth for reconstruction evaluation purposes. We plan to focus our evaluation on two properties: geometric accuracy and completeness. Geometric accuracy measures how close the reconstructed model R is to the ground truth model G (meters). Similarly, completeness measures how much of G is modeled by R (percentage).

**Impact**

We anticipate that our tool will have a significant impact in reducing the time and complexity involved in documenting road accidents. More importantly, because emergency personnel are vulnerable while working close to traffic, any improvement to response and remediation times reduces their exposure to danger, effectively reducing risk for responders. Additionally, shorter remediation times reduce traffic delays, congestion and secondary accidents: It has been estimated that one minute of full highway closure can cause up to one mile of congestion. Improving the quality of
accident investigations will give better insight into the causes of accidents and thereby inform strategies to improve safety.

Impact in other disciplines
By making 3D reconstruction more affordable, we expect to see users from other areas adopting this technology, e.g. insurance companies, architects, contractors.

Task List
- Study work practices
- Develop User assist app
- Package code for practical use
- Evaluation of system
- Develop deployment plan

Goals & Timelines
- Our immediate goal is to discuss and review work practices with our collaborators, and select a suitable case study. We expect to complete this within the next two months.
- Subsequent goal include testing and evaluating the effectiveness and practicality of the technology for the selected case study.

Modeling Transit Patterns via Mobile App Logs, Anthony Tomasic

Technologies / Techniques
- Machine learning models to analyze and map tracing information to transit density.

Bumper-To-Bumper: A Vision-Based System For High Efficiency Vehicle Platoons in Metropolitan Areas, Srinivasa Narasimhan

Participant Organizations
- Financial support by grant from the National Science Foundation and a gift by Ford Motor Company.

Other Collaborators
- James Hoe in the Department of Electrical and Computer Engineering at CMU.

Task List
- The goal of the project is to develop a high-speed, hardware and software computer vision that can track vehicles and estimate their relative speed and distance. Fast estimations would permit vehicles to closely follow each other in platoons.
- We have begun to conduct traffic simulations to demonstrate the benefit of the technology on traffic congestion, environment, and commute times in urban areas.
- We are close to completing the system's hardware design, which is an embedded solution via an FPGA.
- We have begun to develop a software pipeline architecture for optimal data throughput and processing.
- We have implemented a tracking algorithm on an FPGA board (Xilinx Zynq).

Goals & Timelines
- By the end of the year, we expect to have 1) a fully operational hardware/software pattern for estimating relative speed and distance, and 2) completed traffic simulations demonstrating traffic and environmental impacts for a variety of platoon sizes and densities.

In-Vehicle Vision-Based Cell Phone Detection, Bernardo R. Pires

Other Collaborators
- Jian Gong
- Christopher Kaffine

Website
- http://www.contrib.andrew.cmu.edu/~bpires/phonodetect.html
Technologies / Techniques
Equipment has been purchased and illustrative data collection has been done.
Novel video annotation tool is under development.

Impact
Current research is likely to make an impact in the computer vision field in two ways:
1. The novel annotation tool developed on this and the pedestrian detection project will greatly facilitate the annotation of large video datasets;
2. We expect to make significant contribution to specific hand-held object detection under constrained environments

Impact in other disciplines
We expect to make a significant contribution to the automotive safety field by detecting the active manipulation of electronic devices by the driver. This is often the most dangerous driver behavior and the one that leads to many of the distracted-driver accidents.

Task List
Selection and purchase of equipment - Completed
Review of methods in the literature - Completed
Development of data labeling tool (shared with pedestrian detection project) - Ongoing
Collection of over-the-shoulder view dataset - June 2015
Labeling and preparation of dataset - September 2015
Training and testing of cell phone detector - December 2015

Goals & Timelines
Collection of a dataset of over-the-shoulder views by September 2015
Creation of a fully automatic in-vehicle monitoring system capable of detecting cell phone usage and evaluating it on the compiled dataset by December 2015.