



# Center for Connected Multimodal Mobility

## C<sup>2</sup>M<sup>2</sup>

### Program Progress Performance Report

**Submitted to:** United States Department of Transportation (USDOT), Office of the Assistant Secretary  
for Research and Technology (OST-R)

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**Project Title:** Center for Connected Multimodal Mobility C<sup>2</sup>M<sup>2</sup>

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**Recipient Organization:** Clemson University, Clemson, South Carolina 29634

**Grant Period:** November 30, 2016 – September 30, 2022

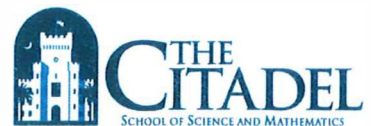
**Reporting Period:** November 30, 2016 – June 30, 2017

**Report Term:** Semi-annual

**Signature of Submitting Official:** \_\_\_\_\_



Benedict College





## What are the major goals and objectives of the program?

### **Mission Statement**

Our vision for the Center for Connected Multimodal Mobility (C<sup>2</sup>M<sup>2</sup>), a Tier 1 University Transportation Center, is to become a globally recognized multimodal mobility innovation center for moving people and goods, specializing in connectivity, data analytics and automation. To achieve this bold vision, our multidisciplinary research team from five leading higher education and research institutions in the state of South Carolina are working together to create and develop new initiatives and inventions by combining our complementary research strengths, our education and workforce development activities, our commitment to diversity, and our expertise in emerging communication and computing technologies.

C<sup>2</sup>M<sup>2</sup>'s main goals are to:

- Conduct interdisciplinary research and drive innovation through data science, data-driven computing, seamless vehicle, traveler, infrastructure connectivity, and automation
- Conduct education and workforce development/leadership activities
- Disseminate C<sup>2</sup>M<sup>2</sup> knowledge and technologies
- Support complementary collaborations with consortium members, private partners, and the public sector
- Broaden diversity by integrating consortium members' existing diversity programs with the C<sup>2</sup>M<sup>2</sup> activities

C<sup>2</sup>M<sup>2</sup> intends to meet these goals through the following means:

- Using data, connectivity, and automation to promote access to opportunities and equity, and assist those with physical and cognitive disabilities, by fostering on demand mobility services for those unable or unwilling to drive
- Creating strategies to improve the mobility of people and goods, and optimize passenger and freight movement, through numerous techniques that will improve vehicle and system performance (e.g., by maximizing existing infrastructure capacity via vehicle-to-vehicle and vehicle-to-infrastructure connectivity)
- Contributing to Smart Cities that collect and process big data, often in real-time. To optimize the transportation system performance (including more intensive use of shared infrastructure)
- Developing innovations to improve multimodal planning and modeling for the movement of both people and goods, using connectivity and data to seamlessly guide transfers between vehicles, infrastructure and modes
- Assisting regional planning and the setting of transportation priorities through innovations that leverage limited dollars to create large positive impacts (e.g., by using Big Data to aid in regional travel demand forecasting efforts)





### What was accomplished under these goals?

In the first six month period of C<sup>2</sup>M<sup>2</sup>'s existence a number of administrative tasks were accomplished, including:

- Establishment of a board of directors which included the following:
  - Dr. Mashrur "Ronnie" Chowdhury, Director, Clemson University, Clemson, SC
  - Dr. Gurcan Comert, Associate Director, Benedict University, Columbia, SC
  - Dr. Nathan Huynh, Associate Director, University of South Carolina, Columbia, SC
  - Dr. Dimitra Michalaka, Associate Director, The Citadel, Charleston, SC
  - Dr. Judith Mwakalonge, Associate Director, South Carolina State University, Orangeburg, SC
- The establishment of an Advisory Board made up of industry and academic members from the transportation community which included:
  - Dr. Imad L. Al-Qadi, University of Illinois at Urbana-Champaign
  - R. Todd Anderson, South Carolina Department of Transportation
  - Dr. Nadim M Aziz, South Carolina EPSCoR/IDeA Foundation
  - Terry Swygert, South Carolina Department of Transportation
  - Tony Fallow, South Carolina Department of Transportation

More members will be added within the next reporting period.

- C<sup>2</sup>M<sup>2</sup> Directors met with partner institutions to discuss upcoming center related research, outreach, education and diversity related activities. (March 16<sup>th</sup>, 2017)
- Dr. Mwakalonge, Associate Director, (SCSU) visited Clemson University and met with Dr. Chowdhury, Director, and several students to discuss and plan diversity outreach activities for the center. (March 28<sup>th</sup>, 2017)
- The Director and Associate Directors met with USDOT representatives at Clemson's campus, for a kick off meeting for the center. (April 5<sup>th</sup>, 2017)
- A bi-weekly web meeting with the center's leadership was established to discuss C<sup>2</sup>M<sup>2</sup>'s progress and upcoming activities. (June 6<sup>th</sup>, 2017)
- Charlotte Ryggs was hired as program coordinator, previously McKenzie Keehan had been acting as interim coordinator. (June, 2017)
- A temporary office was set up for the center at Clemson University. The C<sup>2</sup>M<sup>2</sup> office is currently located in office 302 D, Lowry Hall, Clemson University, Clemson, South Carolina.
- An existing Intelligent Transportation Systems Laboratory was dedicated to the C<sup>2</sup>M<sup>2</sup> for research, and renamed as the Transportation Cyber-Physical Systems Laboratory, located at 351 Engineering Innovation Building, Clemson University, Clemson, SC.

Academically, the center has accomplished the following:



- Drs. Chowdhury, Director, (Clemson) Michalaka, Associate Director, (Citadel) and Davis, a C<sup>2</sup>M<sup>2</sup> partner, (Citadel) attended the Transportation Research Board National Conference in Washington, D.C. Dr. Davis presented two papers and a poster at the conference. (January 7<sup>th</sup>-11<sup>th</sup>, 2017)
- Drs. Michalaka, Associate Director, (Citadel) Davis, C<sup>2</sup>M<sup>2</sup> partner, (Citadel) and Brown, C<sup>2</sup>M<sup>2</sup> partner, (Citadel) attended the American Society for Engineering Education Zone 2 Conference in San Juan, Puerto Rico, where they presented their co-authored paper on undergraduate engineering education. (March 2<sup>nd</sup>-5<sup>th</sup>, 2017)
- Drs. Chowdhury, Director, (Clemson) Michalaka, Associate Director, (Citadel) Davis, (Citadel) and a student from Clemson attended the Southern District Institute of Transportation Engineers conference in Columbia, SC. (March 27<sup>th</sup>, 2017)
- Dr. Chowdhury, Director, (Clemson) attended the South Carolina Highway Engineers Conference in Columbia, SC. (April 10<sup>th</sup>-11<sup>th</sup>, 2017)
- Dr. Comert, Associate Director, (Benedict College) and one of his students received funding from the Department of Homeland Security under their Summer Research Team Program for Minority Serving Institutions to conduct research in conjunction with the Information Trust Institute at the University of Illinois, Urbana-Champaign. (April, 2017)
- Drs. Comert, Associate Director, (Benedict College) and Huynh, Associate Director, (USC) received funding from the National Science Foundation to conduct research under a proposal titled "Targeted Infusion Project: Infusion of Active and Problem-Based Learning for Teaching and Research in the Context of Transportation Disruptive Technologies." (May 15<sup>th</sup>, 2017)
- A call for research proposals was sent out to the directors to be disseminated to their respective institutions on May 15<sup>th</sup>.
  - 17 pre-proposal notifications were submitted by May 31<sup>st</sup>.
  - 15 research proposals were submitted to the center by July 7<sup>th</sup>.
  - Proposals currently have been sent out to reviewers for blind review.
- Dr. Huynh, Associate Director, (USC) attended the Innovations in Freight Data Workshop in Irvine, CA. (May 17-18, 2017)
- Dr. Comert, Associate Director, (Benedict College) advised two undergraduate students on a summer research project titled "Analysis of Air Quality and Traffic Volume in Different Counties and Schools of South Carolina."
- Dr. Chowdhury, Director, (Clemson) and Charlotte Ryggs, C<sup>2</sup>M<sup>2</sup> Coordinator, attended the Council of University Transportation Center's conference in Buffalo, NY. (June 19<sup>th</sup>-21<sup>st</sup>, 2017)

### What opportunities for training and professional development has the program provided?

- Drs. Comert (Benedict College) and Huynh, (USC) Associate Directors, co-hosted a two day workshop titled EFFECT (Environments for Fostering Effective Critical Thinking.) The result of this collaborative workshop was the development of a course to be offered at both USC and Benedict College. (May 22<sup>nd</sup>-23<sup>rd</sup>, 2017)

### How have the results been disseminated?





- Dr. Huynh, Associate Director, (USC) hosted students from the Summer Transportation Institute at the University of South Carolina, introducing underserved minority, high school students to the engineering program at USC and then taking them to speak with professionals within the SCDOT. (May 31<sup>st</sup>, 2017)
- Dr. Chowdhury, Director, (Clemson) and Charlotte Ryggs, C<sup>2</sup>M<sup>2</sup> Coordinator, as well as several C<sup>2</sup>M<sup>2</sup> students hosted another round of Summer Transportation Institute students at Clemson. The STI students were given a tour of a C<sup>2</sup>M<sup>2</sup> lab, and a hands on demonstration of a connected vehicle and connected traffic signals. (June 28<sup>th</sup>, 2017)

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

- The C<sup>2</sup>M<sup>2</sup> board of directors will be meeting in Columbia, at USC, to go over the research proposals and their reviews to then decide which projects to fund. This meeting is scheduled to take place on August 21<sup>st</sup> and funding recipients will be notified and allowed to start their research after the meeting.
- C<sup>2</sup>M<sup>2</sup> will be hosting a one day conference at Clemson in October, for partner institutions and Advisory Board.
- C<sup>2</sup>M<sup>2</sup> will be co-sponsoring the 5<sup>th</sup> Annual UTC Conference for the Southeastern Region with the University of Florida Transportation Institute. (November 16<sup>th</sup>-17<sup>th</sup>, 2017)
- Selected research proposals from the May Call for Proposal will begin their research.

## 2. Products

### Publications, conference papers, and presentations

Dr. Chowdhury, Director, (Clemson) presented “Research Directions for the Center in Connected Transportation Technology” at the following conferences:

- Southern District Institute of Transportation Engineers Conference, March 27<sup>th</sup>, 2017
- South Carolina Highway Engineers Conference, April 10<sup>th</sup>, 2017

### Websites(s) or other Internet site(s)

C<sup>2</sup>M<sup>2</sup>'s website was established and is updated weekly by Charlotte Ryggs, Program Coordinator, Mhafuzul Islam, UTC student partner, and Henry Mayo, C<sup>2</sup>M<sup>2</sup> summer intern. The center's website address is ([cecas.clemson.edu/c2m2](http://cecas.clemson.edu/c2m2)). The website outlines the C<sup>2</sup>M<sup>2</sup>'s goal, participants, research in progress, and events, both upcoming and past.

A C<sup>2</sup>M<sup>2</sup> twitter was also established and can be found at [twitter.com/SC.UTC](https://twitter.com/SC.UTC).

### Technologies or techniques

Nothing to report at this time.



## Inventions, patent applications, and/or licenses

Nothing to report at this time.

## Other products, such as data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments, or equipment

Currently, C<sup>2</sup>M<sup>2</sup> students at Clemson University are conducting research on software-based security architecture to create a security platform designed to protect connected vehicles in a vehicle to infrastructure network. They are also working to develop a toolkit to share data collected by the South Carolina Connected Vehicle Technology (SC-CVT). This SC-CVT toolkit will provide remote access to C<sup>2</sup>M<sup>2</sup>'s testbed data in real time. The center will also offer engineering support to partner institutions once the toolkit is up and running, to support their research. We anticipate a late summer launch for this toolkit.

### **3. Participants and Collaborating Organizations**

#### What organizations have been involved as partners?

The C<sup>2</sup>M<sup>2</sup> consortium is made up of five South Carolina schools, Clemson University, the lead institution; the University of South Carolina; The Citadel; South Carolina State University; and Benedict College, the last two of which are Historically Black Colleges/Universities. These five schools work together, collaborating on research projects, workshops, developing courses, and supporting the C<sup>2</sup>M<sup>2</sup> with financial and in-kind support. Since the creation of this consortium, Clemson's Board of Trustees approved the creation of the Center for Connected Multimodal Mobility at Clemson University and pledged their support of its ongoing programs.

The center also partners with the South Carolina Department of Transportation, which provides data, and research support.

#### Have other collaborators or contacts been involved?

Along with the five institutions that make up the C<sup>2</sup>M<sup>2</sup> consortium partnership, C<sup>2</sup>M<sup>2</sup> has and is collaborating on projects with or received support from the following:

- BMW, Munich, Germany/ Greenville, SC – facilities, data collection, research collaboration, in-kind support
- Mobi Mobility Insight, Tel-Aviv, Israel - data collection, research collaboration
- Bureau of Transportation Statistics, Washington, D.C. - data collection, research collaboration
- City Council of Beaufort, South Carolina – data collection, research collaboration, facilities
- Norfolk Southern Corporation, Atlanta, GA - data collection, research collaboration





- CSX Corporation, Jacksonville, FL - data collection, research collaboration
- Mermec Inc., Columbia, SC - data collection, research collaboration
- National Science Foundation, Arlington, VA – financial support
- Department of Homeland Security, USA- financial support
- University of Illinois, Urbana-Champaign, IL – facilities, in-kind support, data collection, research collaboration
- EPSCoR, Columbia, SC- Advisory Board support

#### 4. Impact

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

As the C<sup>2</sup>M<sup>2</sup> is in the first six months of existence, there is no impact to report at this time, however, we expect to see significant impact in the future with the completion of the first round C<sup>2</sup>M<sup>2</sup> research. With the current scope of research we expect to see an impact on the security of connected vehicle software, accessibility of real-time data, improvements in the mobility of people and goods, as well as connected infrastructure throughout South Carolina. C<sup>2</sup>M<sup>2</sup> also expects to see an impact on the diversity of up and coming engineering students directly related to its outreach activities to minority students, from underserved communities and partnership with two of South Carolina's HBCUs.

##### What is the impact on other disciplines?

Nothing to report at this time.

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

This spring, over sixty minority high school students, from underserved communities, visited two of C<sup>2</sup>M<sup>2</sup> consortium campuses to spend the day with some of our center's directors. Drs. Chowdhury, Director, (Clemson) and Huynh, Co-Director, (USC) gave presentations on their specialties, gave tours of their respective labs, answered questions, and introduced these students to the different types of engineering programs offered in South Carolina. The participants of these visits were also able to interact with current graduate students working for the center and were given a hands on demonstration of the projects that those graduate students work on.

Currently, Clemson has two graduate students supported by research assistantships provided by the C<sup>2</sup>M<sup>2</sup>, and one undergraduate student working on an internship. Benedict College has three undergraduate students working on center supported summer research programs, and four graduate students collaborated on curriculum development with C<sup>2</sup>M<sup>2</sup> Associate Directors.

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



Nothing to report at this time, but C<sup>2</sup>M<sup>2</sup> expects to see multiple field tests on connected transportation technology throughout the state of South Carolina with the funding of their upcoming research projects. The center also expects to see improved data sharing between consortium members with the completion of Clemson's proposed toolkit.

What is the impact on technology transfer?

Nothing to report at this time.

What is the impact on society beyond science and technology?

Nothing to report at this time.

### **5. Changes/Problems**

Nothing to report at this time.

### **6. Special Reporting Requirements**

N/A