North Carolina
Center of Excellence
On Mobility and Congestion

Center Summary

North Carolina Center of Excellence on Mobility and Congestion

The North Carolina Center of Excellence on Mobility and Congestion is one of three centers of excellence launched by NCDOT under the ***Transportation Centers of Excellence*** program created in 2019. The cemter is founded on decades of national and international leadership in traffic operations, management, and control built through the collaborative efforts of faculty and researchers in the Institute for Transportation Research and Education (ITRE) and the College of Engineering at North Carolina State University (NCSU). Under the initiative, leadership, and investment of NCDOT, the Center of Excellence on Mobility and Congestion opens a new era in multi-university collaboration bringing together researchers from Duke, Fayetteville State University, North Carolina A&T State University, and the University of North Carolina – Chapel Hill into the NCSU/ITRE-led consortium.

Center Leadership

The core center leadership team encompasses broad research and institutional leadership experience across a wide range of complementary disciplines. The center leaders are –

- Director
    - **Billy M. Williams, Ph.D., P.E.** – ITRE Director and Professor, NC State University
- Associate Directors
    - **Mary (Missy) Cummings, Ph.D.** – Professor and Humans and Autonomy Lab Director, Duke University
    - **Sambit Bhattacharya, Ph.D**. – Professor, Fayetteville State University
    - **Maranda McBride, Ph.D.** – Associate Professor and University Transportation Center Director, NC A&T State University
- Co-Associate Directors
    - **Noreen McDonald, Ph.D.** – Professor and Thomas Willis Lambeth Distinguished Chair, Department of City and Regional Planning, University of North Carolina at Chapel Hill
    - **Randa Radwan, Ph.D**. – Highway Safety Research Center Director, University of North Carolina at Chapel Hill

Press Release the North Carolina Center of Excellence on Mobility and Congestion:

https://research.ncsu.edu/blog/2019/12/ncdot-center-congestion/

Project Development

Our Center of Excellence on Mobility and Congestion will achieve its aims through the execution of three projects. In developing these projects, the center team began with the mobility and congestion research areas enumerated in the CoE RFP:

- ITS and data usage
- Active/adaptive congestion management
- Alternative intersection and interchange designs
- The role of transit in improving mobility and reducing congestion
- Transit and MaaS role in improving economic and healthcare access for underserved populations
- Other technological solutions to congestion management

These areas were organized into three themes:

- Theme #1: Big Data and Data-Driven Transportation Management and Decision Support
- Theme #2: Active Transportation Management/Integrated Corridor Management
- Theme #3: Transit and Mobility as a Service

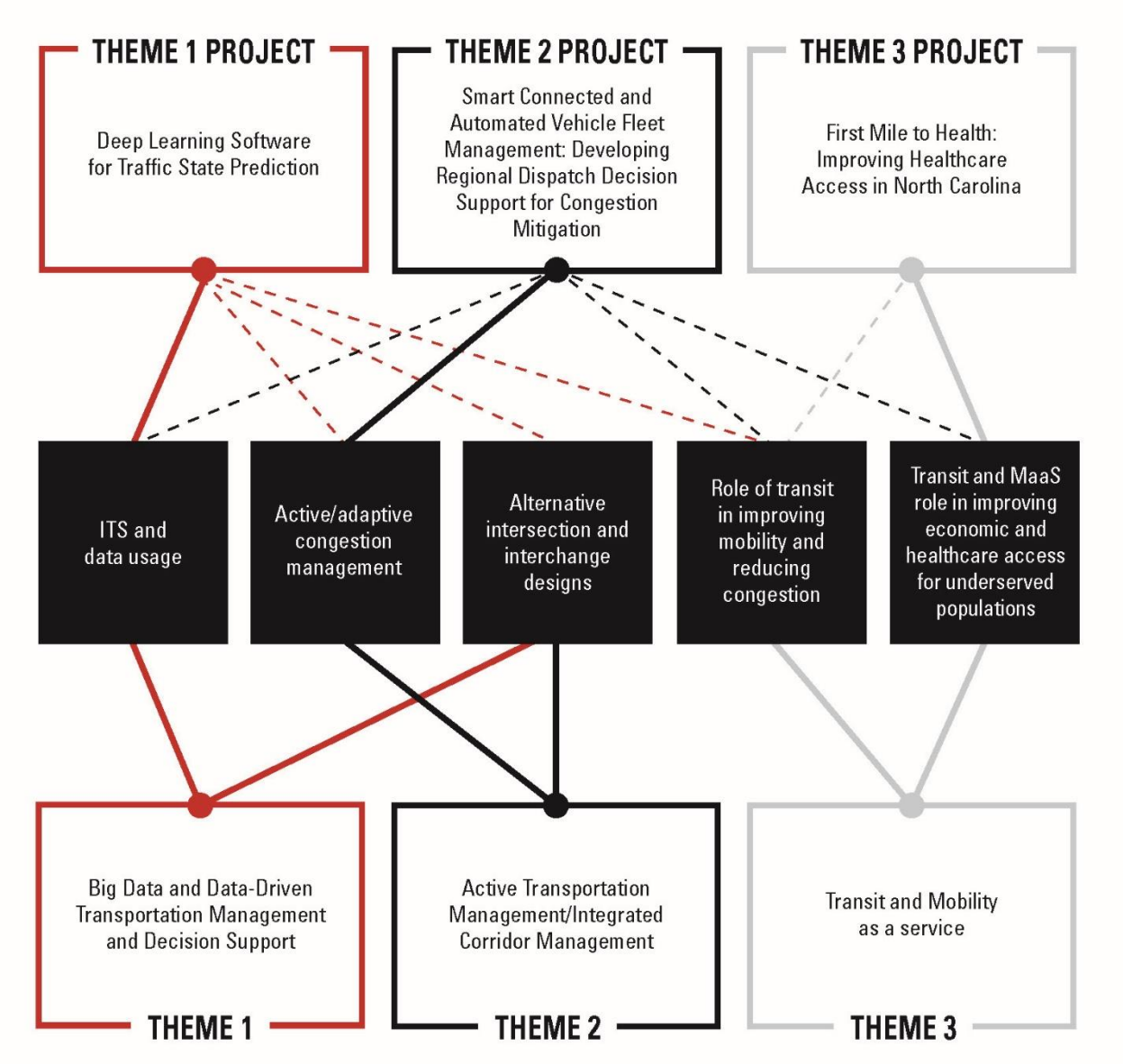
An idea generation team including nearly 40 researchers across the center team's five universities were invited to develop collaborative research ideas under these three themes. This effort resulted in fourteen initial research ideas. A ranking and evaluation process by the same idea generation team resulted in the three CoE projects presented in this proposal, one each for the three themes listed above:

- Theme #1 Project: Deep Learning Software for Traffic State Prediction
- Theme #2 Project: Smart Connected and Automated Vehicle Fleet Management: Developing Regional Dispatch Decision Support for Congestion Mitigation
- Theme #3 Project: First Mile to Health: Improving Healthcare Access in North Carolina

The project development process summarized above was purposely designed to draw on the deep and varied expertise and creativity across the participating universities. The driving aim was to develop projects that address key mobility and congestion issues facing North Carolina. The research project outputs planned for these projects will provide NCDOT with tools, frameworks, prototype systems, and recommendations designed to support proactive decision-making and systems planning across the coming decades.

The mapping of the CoE RFP's research areas to the themes and proposed center projects is illustrated in Exhibit 1 and the following page.

Exhibit 1: Relationship of Research Themes and Projects to NCDOT CoE Aims

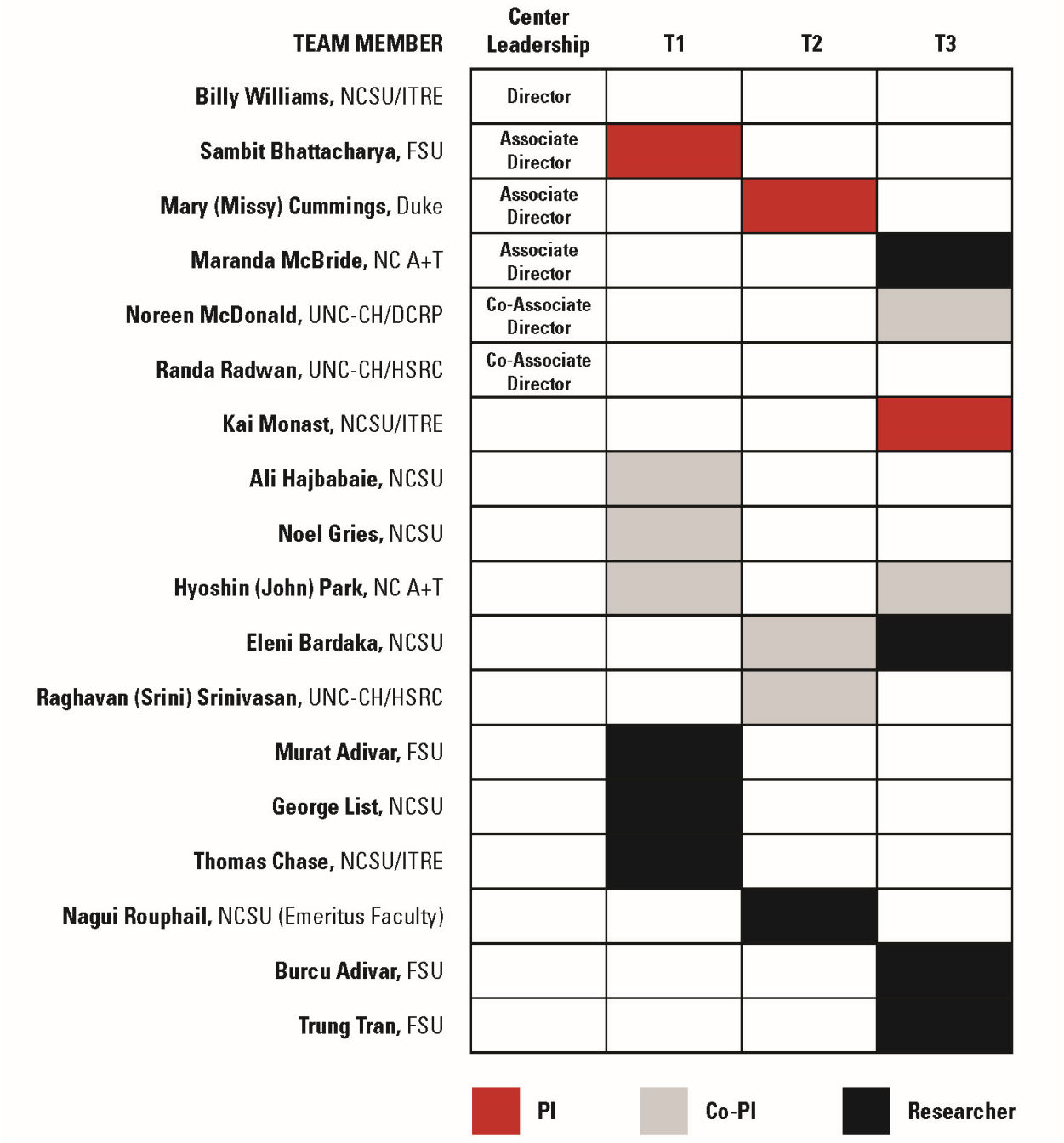


Center Project Leadership

A key factor in developing the projects above was also a commitment to be fully responsive to NCDOT stated desire for the centers to engage in genuinely collaborative research across multiple universities and to include Historically Black Colleges and Universities and Minority Serving Institutions.

Exhibit 2 on the following page provides a listing of all key center leadership and research personnel. Exhibit 2 clearly illustrates the meaningful distribution of roles across the center universities as well as the broad collaboration on each of the center projects.

Exhibit 2: Center and Project Leadership



Center Communications

- A secure Google Shared Drive is established
- Monthly center meetings timed to follow project meetings
- Most meetings will be held using the Zoom video conferencing system
- Face-to-face meetings will be held as needed
- Meetings with NCDOT will be coordinated as needed with Dr. Curtis Bradley

NC STATE UNIVERSITY

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

FAYETTEVILLE STATE UNIVERSITY

NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

Duke

Project 1 – Deep Learning Software for Traffic State Prediction

Research Need

NCDOT maintains over 380 coordinated traffic signal systems which are retimed based on performance through the COST retiming program. This retiming is often performed by contractors and involves a combination of simulation and field observation. COST is also implementing the ATSPM open source software as its field equipment is upgraded which is the beginning of a potential shift toward real-time operations management of signalized intersections. Recent research has identified significant gaps in many critical ATSPM performance measures which supplemental data could improve.

Project Team

- Principal Investigator – **Sambit Bhattacharya, Ph.D.**
  - Professor of Computer Science – Fayetteville State, Dept of Math & Computer Science
  - Director – Intelligent Systems Lab (ISL)
- Co-Principal Investigators
  - **Ali Hajbabaie, Ph.D.** – NC State, Assistant Professor in the Department of Civil, Construction, and Environmental Engineering
  - **Noel Greis, Ph.D.** – NC State, Research Full Professor, Poole College of Management
  - **Hyoshin (John) Park, Ph.D.** – NC A&T, Assistant Professor in the Department of Computational Science & Engineering
- Senior Researchers
  - **Murat Adivar, Ph.D.** – Fayetteville State, Associate Professor, Broadwell College of Business & Economics
  - **George List, Ph.D.** – NC State, Professor in the Department of Civil, Construction, and Environmental Engineering
  - **Thomas Chase, Ph.D.** - NC State, Research Associate in the Institute for Transportation Research and Education

Project Goals

- Develop edge computing and deep learning software which utilizes video, loop detector and Bluetooth sensor data to better estimate traffic states on arterials
- Test software with traditional signal control and a CV-enabled signal control algorithm in VISSIM
- These capabilities will assist in –
    - Improved performance measures for integration into existing tools like ATSPM
    - Temporary deployment for signal retiming or loop detector calibration
    - Driver information through connected vehicle applications

Methodology

- Deep/machine learning AI approach to prototype software design
- Steps will include –
    - Data collection on real and simulated traffic
    - Develop single stream video analytics
    - Develop multi stream video analytics
    - Develop data fusion methods
    - Test hypothesis that advanced traffic signal control algorithm performs better optimization with this traffic state estimate

Communication Tools

- Bi-weekly team meetings – Teleconference and face-to-face
- NCDOT & Committee Members - interim meetings
- External communication
    - Leverage existing educational programs for high school and undergraduate students targeted at STEM majors
    - Key results made available to transport policy organizations at both the state and federal levels

Final Project Outputs

- Video analytics pipeline
- Robust data fusion techniques
- Prototype application that integrates software and hardware using “edge-computing” design
- Simulation environment for loop testing
- Comprehensive dataset to include all data collected
- Presentation and recorded webinar on the project findings and results
- Final report that documents all findings of the research

Project 2 – Smart Connected and Automated Vehicle Fleet Management: Developing Regional Dispatch Decision Support for Congestion Mitigation

Research Need

The widely ranging predictions on future deployment of autonomy in on the road vehicles and the complexities of mixed traffic environments that are likely across all plausible scenarios point to the need to develop a supervisory capability in regional dispatch centers where state and/or local authorities have the ability to monitor traditional vehicles (TVs) as well as autonomous vehicles (AVs) and connected vehicles (CVs) to ensure safe and expeditious travel. While it is likely that individual on-demand companies like Lyft and Uber will have dispatchers that monitor their own fleets, much like trucking companies do today, there will be a need for independent oversight of the operations of AVs and CVs to provide a layer of safety and public accountability. In addition, as public transportation entities adopt vehicles with varying degrees of autonomy, state and local officials will need to be able to monitor such systems and intervene as needed. Lastly, while not a current capability, it is possible that given future connectivity between cars, a dispatcher could take a specific action, for example in the form of lane openings or rerouting traffic, to ease congestion.

Project Team

- Principal Investigator – **Mary "Missy" Cummings**, Ph.D.
    - Professor – Duke University
        - Department of Electrical and Computer Engineering
        - Department of Computer Science
        - Robotics program
        - Institute for Brain Sciences
    - Director – Humans and Autonomy Lab (HAL)
- Co-Principal Investigators
    - **Eleni Bardaka, Ph.D.** – NC State, Assistant Professor in the Department of Civil Construction and Environmental Engineering
    - **Raghavan "Srini" Srinivasan, Ph.D.** – UNC-CH, Senior Transportation Research Engineer at the Highway Safety Research Center
- Senior Researcher – **Nagui Rouphail, Ph.D.** – NC State, Professor in the Department of Civil Construction and Environmental Engineering

Project Goals

- Develop a supervisory capability in regional dispatch center
- Provide state and/or local authorities with monitoring and direct communications with traditional, connected, and autonomous vehicles
- These capabilities will assist dispatcher/operators in –
    - Developing mitigation actions to reduce congestion
    - Managing planned and urgent/emergent scenarios

Methodology

- Systems engineering approach to prototype system design
- Prototype design steps will include –
    - Concept of operations analysis for NC' statewide and regional traffic management centers
    - Develop a dispatch operator interface linked to traffic flow models and AI-empowered solution searching
    - System testing across various concept of operations and edge case scenarios

Communications Tools

- Monthly team meetings – Teleconference and face-to-face
- External communication
    - Journal and conference papers
    - Participation in appropriate conferences and symposia
    - Outreach events
        - Internship opportunities for undergraduate and high school students
        - Participation in regional STEM activities such as NC A&T's Summer Transportation Institute

Final Project Outputs

- Concept of Operations (CONOPS) for regional monitoring and dispatch in a mixed traffic (TV/CV/AV) environment describing the –
    - Operational needs
    - System characteristics
    - Functional requirements
- AI-based algorithms for managing mixed traffic flow
- Prototype decision tool that embeds the AI algorithms and focuses on resource allocation and path planning
- Documentation of algorithm and decision tool testing
- Recommendations for state-level implementation

Project 3 – Transit and MaaS Role in Improving Economic and Healthcare Access for Underserved Populations

Research Need

The transition of Medicaid healthcare delivery from fee for service to Managed Care Organizations (MCOs), along with the emergence of new transportation technologies and healthcare provider/insurer focus on the whole health of an individual, is expected to have substantial impacts for both Medicaid and non-Medicaid-funded community members, as well as on the public transportation industry and healthcare providers. These impacts are expected to be experienced by people using the transportation system for medical, economic, or any other reasons. Emerging transportation technologies and changes in healthcare policy tend to be adopted piecemeal, but Medicaid Transformation has distinct transition periods of November 2019 and February 2020, depending upon the Medicaid regions established by North Carolina's DHHS. The abrupt transition dates associated with Medicaid Transformation provide optimal scenarios for analyzing how the implementation of a policy change of this magnitude ($6 Billion annually) influences community access to healthcare and economic opportunities within the context of gradual changes in transportation technologies and healthcare provider goals.

Project Team

- Principal Investigator
  - **Kai Monast, MRP**, Director, Public Transportation Group – NCSU/ITRE
- Co-Principal Investigator
  - **Noreen McDonald, Ph.D.** – Thomas Willis Lambeth Distinguished Chair, UNC-CH, Department of City and Regional Planning
  - **Hyoshin (John) Park, Ph.D.** – Assistant Professor, NC A&T, Department of Computational Science and Engineering
- Senior Researchers –
  - **Eleni Bardaka, Ph.D.** – Assistant Professor, NCSU, Department of Civil, Construction, and Environmental Engineering
  - **Burcu Adivar, Ph.D.** – Assistant Professor, Fayetteville State University, Broadwell College of Business and Economics
  - **Trung Tran, Ph.D.** – Assistant Professor, Fayetteville State University, Department of Intelligence Studies, Geospatial Sciences, Political Science, and History

Project Goals

- Determine how changes in health care policy (e.g. Medicaid Transformation) and transportation service delivery (e.g. MaaS) impact:
    - Individuals
    - Health systems
    - Public transportation
- Identify how transport system innovation impacts health care access by:
    - Modeling existing services
    - Developing operational scenarios
    - Conducting pilot analysis of patient travel preferences based on the scenarios
    - Assessing needs for transportation information aggregation for patients and care managers
    - Building a decision support tool

Methodology

- Mixed method approach combining:
    - Historic quantitative spatial data trip origins and destinations with tabular data operating statistics
    - Contemporary qualitative perspectives of transport system users and health care systems
    - Operational models for scenario planning
    - Stated preference surveys

Communications Tools

- Monthly team meetings – Teleconference and face-to-face
- Quarterly meetings with the NCDOT and the project committee
- External communication
    - Journal and conference papers
    - Participation in appropriate conferences and symposia
    - Outreach events
    - Webinar on the methodology, findings and implementation concerns

Final Project Outputs

- Final report:
    - Detailing the efforts
    - Interpreting the findings
    - Assisting with implementing the findings/recommendations
- Simulation code, parameters, models, and databases
- Journal articles