

First in Flight: Propelling National and Regional Economic Vitality through Airport/Aviation Research Excellence

Target Category: Future Opportunity and Investment

List of Participating Disciplines/Academic Units/Departments:

1. College of Engineering (COE)
 - a. Civil & Environmental Engineering (CEE) Department
 - b. Infrastructure, Design, Environment, and Sustainability (IDEAS) Center
 - c. Engineering Technology and Construction Management (ETCM) Department
 - d. Systems Engineering and Engineering Management (SEEM) Department
 - e. Electrical & Computer Engineering (ECE) Department
 - f. Mechanical Engineering and Engineering Science (MEES) Department
 - g. Energy Production & Infrastructure Center (EPIC)
2. College of Liberal Arts & Sciences (CLAS)
 - a. Department of Geography & Earth Sciences
 - b. Department of Political Science and Public Administration
 - c. Center for Applied GIS (CAGIS)
3. College of Computing and Informatics (CCI)
 - a. Department of Computer Science
 - b. Department of Software & Information Systems
 - c. Department of Bioinformatics & Genomics
4. College of Arts + Architecture (COAA)
5. College of Business (COB)
6. School of Data Science

Names of Individuals Responsible for Leading and Organizing the Collaborative Cluster:

John L. Daniels, Chair of CEE Department (Lead)

Representative Participants: 1) Srinivas S. Pulugurtha, Professor of CEE Department, Director of IDEAS Center, and 2) Tara Cavalline, Associate Professor of ETCM

Five Keywords: Airport, Infrastructure, Economic Impact, Data Analytics, Sustainability

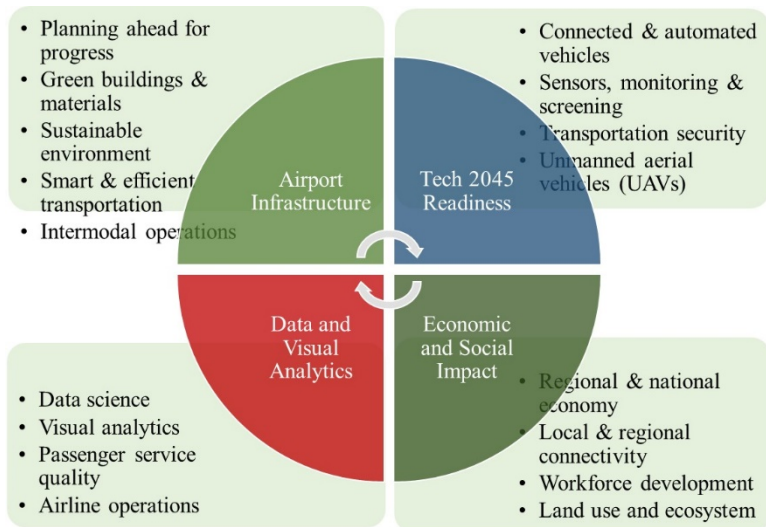


EXECUTIVE SUMMARY

Charlotte Douglas International Airport (CLT) is a transportation hub with many types of physical infrastructure including terminals, aprons, runways, maintenance & operations support buildings, and parking decks, and on-airport businesses such as air cargo, logistics, offices, retail, and hotels. It impacts land uses and ecosystems, and plays a key role in influencing the economic vitality of North Carolina. As such, it is a city within a city. In spite of the ongoing pandemic, current and future aviation activity at CLT is critical to the economic vitality of North Carolina and beyond. As the airport and airspace capacity already constrain flight operations, like at many large airports in the nation, CLT leadership are working on a \$2.5 to \$3.1 billion renovation and construction campaign to expand terminals/concourses and add new airfield facilities over the next decade.

There are grand challenges associated with the planning and expansion of an airport whose operations have domestic and international implications on the flow of goods, services, and humanity while managing current operations. For example, the addition of runways/taxiways at an airport often leads to the relocation/full closure of some of the existing roads and reconfiguring the traffic flow by formulating better access management strategies to proactively improve the road operational performance. Now is the time to introduce disruptive, multi-modal, and shared-mobility designs; as history has taught us that conventional and automobile-oriented designs are ineffective. New and durable materials can be explored to maximize life cycle resilience and sustainability of airport pavements.

While we are still working to make our airports more secure/safe, the ongoing pandemic emphasized the importance of proactive monitoring/screening. Further, the increasing penetration of connected and automated vehicles will have ramifications on access to the airport, mobility and parking needs at the airport, and revenue generated by the airport (e.g., rental cars, taxis, rideshares). Understanding the economic and social impacts of such



advancements and planning/designing/building for tomorrow is a national and regional priority.

Faculty and research staff of COE, CLAS, CCI, COAA, and COB at UNC Charlotte have the expertise and experience to define and achieve “airport/aviation” research excellence by contributing to the identified subthemes (see figure) and beyond with a well-articulated **short-term, mid-range, and long-term future opportunity and investment plan**. Very few universities have the resources and established partnerships to credibly pursue this effort. The team has actively cultivated a relationship with the City of Charlotte and CLT, the nation’s 6th and world’s 7th busiest airport in operations. In response, **CLT, unlike any other airport in the country, has offered to serve as a testbed for a cross-disciplinary set of research questions, including materials, access/mobility improvement, asset management, optimization, and environmental processes**. There are broader impacts to this partnership as it serves as a platform to retain and continue attracting talent for the future wellbeing of the Charlotte region and to better engage underserved communities and increase social mobility in the disadvantaged sections of the Charlotte region.

EVIDENCE OF STRENGTH AND EXCELLENCE

Strength of the Collaboration: The proposed cross-disciplinary team comprises professors, associate professors, and assistant professors affiliated with COE, CLAS, CCI, COAA, and COB. Within COE, the team comprises faculty from CEE, ETCM, SEEM, ECE, and MEES. The team has registered professional engineers (Drs. Cavalline, Daniels, Hsiang, Pulugurtha, and Tempest), Fellows of American Society of Civil Engineers - ASCE (Drs. Pulugurtha and Daniels), a Fellow of the Regional Science Association International - RSAI (Dr. Thill), and faculty with U.S. patents (Drs. Akella and Ravindran). The team's intellectual capital is being concentrated through the prism of one of the state's largest engines of economic impact, CLT. As a "*testbed*" at the beginning of a once in a generation transformation, CLT offers unrivaled scale, scope, and visibility for cross-disciplinary research.

Evidence of the Success and Collective Impact of the Team: The team has an outstanding and sustained track record of scholarly activity. In the past five years, they have authored/co-authored more than 275 peer-reviewed journal publications and 264 peer-reviewed conference publications and attracted more than \$28 million in external funding. The sponsors of these efforts include federal, state, regional, and local agencies as well as the private sector and not-for-profit organizations.

For the past five years, Drs. Daniels, Pulugurtha, and Cavalline have cultivated a relationship with CLT, for the benefit of faculty throughout the university. Nascent indicators of this relationship include unique airport/aviation coursework taught every semester, jointly by faculty and CLT leadership. The team has collaborated with CLT leadership and held nationally strategic seminars. These events, which attracted ~\$100k in sponsorship and >125 attendees, were a veritable microcosm of key leaders from academia, industry, non-profit, and all levels of government. Seminars included presentations on emerging trends in research, with the added urgency and force provided by experts in policy, finance, technology, and community engagement. The keynote speaker for our most recent seminar was U.S. Astronaut Captain Winston Scott, author of "*Reflections from Earth Orbit*". Captain Scott currently serves as Senior Advisor to the President at the Florida Institute of Technology and is interested in supporting UNC Charlotte's aspiration to lead a multi-institutional airport/aviation network. As anyone who knows Captain Scott can attest, he is uniquely qualified to help UNC Charlotte build a research area of excellence while advancing social mobility.

The team has an excellent track record building multi-year, multi-institutional, and cross-disciplinary collaborations. Dr. Pulugurtha is currently collaborating with faculty and researchers at UNC Chapel Hill, NC Central University, Appalachian State University, and NC A&T on a three-year \$1 million Transportation Center of Excellence sponsored by the North Carolina Department of Transportation (NCDOT) to advance transportation policies and safety of our communities. He is also collaborating with faculty and researchers at San Jose State University, Howard University, and Navajo Technical University on a five-year ~\$7.7 million Tier 1 University Transportation Center sponsored by the United States Department of Transportation (USDOT) to improve transportation mobility and safety of our communities. Drs. Tabkhi, Ravindran, Pulugurtha, and Shoemaker are working on a \$2 million "Smart and Connected Communities" grant funded by the National Science Foundation (NSF). Drs. Cavalline and Tempest have engaged in collaborative research to support NCDOT for over 10 years in the areas of bridges, pavements, and asset management. Likewise, Dr. Daniels is currently leading a multi-year, multi-institutional effort funded by NSF to explore engineered water repellency as an

approach to extend the service life of infrastructure. CLT will serve as the ideal testbed to amplify and build on these successes for airport infrastructure.

Supporting airfield pavement research and decision making, Dr. Cavalline has performed laboratory studies on concrete airfield pavements to support the Pavement Management Program at Hartsfield-Jackson Atlanta International Airport (H-JAIA) since 2002. Also supporting airfield pavement research, she served as a technical panel member for the Innovative Pavement Research Foundation (IPRF) Project No. FAA-01-G-002-04-6 which utilized H-JAIA to evaluate technologies emerging at the time.

While Drs. Tempest and Cavalline have partnered with CLT to monitor a first-in-the-nation installation of a sinusoidal concrete joint during the summer of 2019, Dr. Pulugurtha is currently working with CLT by exploring data-driven methodologies, highlighting the inbound/outbound traffic access issues, and evaluating alternatives to meet their future needs.

Dr. Thill and his collaborators have conducted extensive studies of the role of major transportation infrastructures in terms of their local socio-economic embeddedness, as well as in supporting connected global networks. The social, economic, and environmental nexus that intersects at CLT is to be strategically envisioned across mobility systems, across market segments and across communities of stakeholders to frame the future of place-based locational benefits brought by CLT. Dr. Thill's work across urban systems internationally further supports this visionary approach.

These are just a few examples of team members' scholarly contributions and engagement with external entities (federal/state/regional/local communities) and the broader impacts of the research outcomes. They serve as testimonials to indicate that the team has specific and extensive strength in building and leveraging relationships at local, regional, and global scales.

Several team members led international/national/regional/local advisory boards as well as served as editors of journals, and on editorial boards, panels, task forces, international/national professional committees, and conference planning/steering/scientific committees. A few details are presented in two-page CVs of team members in the "Supporting Documents" section.

Additional Resources: The North Carolina General Assembly has a vested interest in ensuring continued success of CLT through research and related programming. CLT leadership have partnered with UNC Charlotte faculty and the Federal Aviation Administration (FAA) to pursue research gaps identified in the FAA's strategic plan. The FAA funds capital projects and research at other airports and universities, but *there is no other partnership between a major airport and a major university as described herein*. The team envisions a university-managed material testing laboratory and conference center at CLT that attracts a continuous stream of projects and thousands of participants each year through required FAA training and continuing education, as well as targeted research dissemination meetings, seminars and workshops. The materials testing laboratory will significantly strengthen the ongoing materials testing research efforts conducted by the faculty of CEE and ETCM for NCDOT and other agencies, and can support educational objectives as well. This initiative has all the ingredients for a major future investment into UNC Charlotte, on a scale similar to the EPIC and School of Data Science.

Contribution to Student Education and Research Training: The team has advised/mentored and graduated 312 graduate students. They are currently advising/mentoring 32 Ph.D. students and 15 M.S. students. The proposed unique opportunity is expected to have a catalytic affect, create an intellectually stimulating environment, and increase student enrolment as well as graduation.

ALIGNMENT WITH REGIONAL AND NATIONAL PRIORITIES

Per “The Economic Impact of Civil Aviation on the U.S. Economy”, a report published by the USDOT’s FAA in January 2020, all aviation activity accounted for more than 5.2% of the United States Gross Domestic Product (GDP), generated \$1.8 trillion in total economic activity, and supported 10.9 million jobs with \$488.2 billion in earnings in 2016. It is also estimated by the International Air Transport Authority (IATA) that the global aviation industry will have to cater to over 14 trillion passengers and 466 billion tons of freight traffic by 2034. The projected growth in the global aviation industry is expected to generate at least 99 million jobs and contribute \$5.9 trillion toward the GDP, a 122% increase from 2014. While the ongoing Pandemic caused a dip in this growth, it is forecasted to recover at an even faster pace owing to the inextricable relationship between aviation, the world economy, and sustainable development.

CLT is ranked 6th nationwide based on operations and ranked 11th nationwide based on passenger totals in 2019. More than 50 million passengers traveled through CLT in 2019 making it the 37th busiest airport worldwide based on passenger totals and 7th busiest airport worldwide based on total operations. Further, CLT drives the economy by generating more than \$17 billion for the Charlotte region and \$24.6 billion for North Carolina (4% of state’s GDP). It is the second-largest hub for American Airlines after Dallas-Fort Worth, TX with the airline occupying around 90% of flights in and out of CLT. It has become an essential asset for the continued growth of the Charlotte region and a catalyst for business success and relocation to Charlotte. It is crucial to Charlotte as it becomes a command and control center in World City Networks. To proactively plan and provide these infrastructure needs, CLT and state/regional leadership have initiated a \$2.5 to \$3.1 billion renovation and construction campaign called “Destination CLT” to expand terminals/concourses and add new airfield facilities over the next decade. ***CLT has offered to serve more broadly as a testbed for cross-disciplinary research.*** Good connectivity between CLT and the Charlotte region by road and public transportation (e.g., the Lynx system) will be a continued draw for the region’s talent. The unique opportunity to conduct creative research by engaging undergraduate and graduate students and the impact on the economy aligns well with the regional, national, and international priorities and supports the mission of UNC Charlotte.

In summary, the United States, North Carolina and Charlotte region are poised to increase airport/aviation infrastructure spending by an order of magnitude. There are massive needs to ensure an adequate supply of skilled professionals nationally. Similarly, airport related research on planning, materials, optimization, sensing, environmental processes, and intelligent transportation systems (ITS) is needed to yield next generation solutions for the safe and effective travel of a growing population. The envisioned area of research excellence does not exist anywhere else and will be of such quality as to attract a pipeline of aspiring airport/aviation professionals from throughout the country. Training, workshops and continued education, in conjunction with the FAA and CLT, will keep them returning throughout their careers.

Establishing and coalescing the proposed future area of research excellence will help explore the grant opportunity from the FAA to establish a “FAA Air Transportation Centers of Excellence” in the next two to three years. Additionally, opportunities could be explored by working with CLT and other collaborators by submitting proposals for funding through the Airport Cooperative Research Program (ACRP), an industry-driven applied research program authorized by Congress, sponsored by FAA and managed by the Transportation Research Board (TRB). Furthermore, there are synergies with NSF’s big ideas such as “Future of Work at the Human-Technology Frontier” and “Harnessing the Data Revolution”.

LIST OF PARTICIPATING FACULTY

1. Srinivas Akella, Professor of Computer Science
2. Tara Cavalline, Associate Professor of Engineering Technology and Construction Management
3. Badrul H. Chowdhury, Professor of Electrical and Computer Engineering
4. John L. Daniels, Professor and Chair of Civil & Environmental Engineering
5. Airhossein Ghaesmi, Assistant Professor of Mechanical Engineering and Engineering Science
6. Cynthia Gibas, Professor of Bioinformatics
7. Simon Hsiang, Chair of Systems Engineering and Engineering Management
8. Ming-Chun Lee, Associate Professor of Architecture
9. Suzanne Leland, Professor of Political Science & Political Administration
10. Brian Magi, Associate Professor of Atmospheric Sciences, Geography & Earth Sciences
11. Glenda K. Mayo, Associate Professor of Civil Engineering Technology & Construction Management
12. Micahel (Mike) S. Mazzola, Executive Director of EPIC
13. Mariya Munir, Assistant Professor of Civil & Environmental Engineering
14. Vincent Ogunro, Associate Professor of Civil & Environmental Engineering
15. Dimitris Papanikolaou, Assistant Professor of Architecture, and Software and Information Systems
16. Srinivas S. Pulugurtha, Professor of Civil & Environmental Engineering; Director of IDEAS Center
17. Arun Ravindran, Associate Professor of Electrical and Computer Engineering
18. Mohamed Shehab, Associate Professor of Software and Information Systems
19. Doug Shoemaker, Director of Research and Outreach, Center for Applied GIS
20. Jake Smithwick, Assistant Professor of Civil Engineering Technology & Construction Management
21. Mei Sun, Assistant Professor of Civil & Environmental Engineering
22. Hamed Tabkhi, Assistant Professor of Electrical and Computer Engineering
23. Brett Tempest, Associate Professor of Civil & Environmental Engineering
24. Jean-Claude Thill, Knight Foundation Distinguished Professor of Public Policy, Dept. of Geography & Earth Sciences and School of Data Science
25. Lei Zhu, Assistant Professor of Systems Engineering and Engineering Management