

# **NORTH CAROLINA A&T STATE UNIVERSITY LOGISTICS AND TRANSPORTATION SYSTEMS CLUSTER WHITE PAPER**

## **Vision and Impact**

The Logistics and Transportation Systems Cluster at NC A&T State University is a collaborative effort among the Schools of Business & Economics and Technology, and the Colleges of Engineering and Art & Sciences, to develop and promote an interdisciplinary research infrastructure by leveraging combined resources to address logistics and transportation opportunity areas. The aim of the cluster is to advance the design, performance, management and technologies of logistics and transportation systems through interdisciplinary research that supports education, outreach and workforce development. In addition to the research impact, the cluster is uniquely positioned to develop logistics and transportation professionals from populations that are underrepresented in the industry.

The Logistics and Transportation Systems cluster has three goals, each to be achieved regionally and nationally:

1. Conduct high quality, human-centered, applied logistics and transportation systems research.
2. Develop the workforce in logistics and transportation, with particular emphasis on military operations and regional logistics/transportation.
3. Build mutually beneficial, long-term partnerships with federal sponsors, other academic institutions, and private corporations.

## **Definition**

Logistics and transportation research focuses on the design and operation of systems to effectively move products and people. Transportation systems research emphasizes the economical and equitable creation of multiple modes for moving people and products. Logistics systems research stresses the synergetic and efficient use of transportation systems to move product (or people) in conjunction with plants that transform product (or people) and warehouses that store and consolidate product (or people). Thus, logistics and transportation are intricately linked. Logistics and transportation systems require:

1. A complex systems approach to manage a multitude of highly interconnected non-linear system components;
2. A life cycle approach to balance design objectives with construction, operation and maintenance objectives;
3. Measurement of system effectiveness by multiple, often competing, objectives involving cost, throughput, delivery time, security, and safety;
4. Advances in information technology to enable increasing system integration and product/people visibility; and
5. Perhaps most importantly, strong consideration of human interface, either as decision-maker interacting with the system or as an entity being transported.

## Background

### *Opportunities*

According to the 1997 economic census, the logistics and transportation industry generates an estimated \$318.2 billion in annual revenue and 3 million jobs, and supports 200,000 establishments nationwide. This estimate is highly conservative because it ignores logistics and transportation professionals within other industry sectors. Perceived traditionally as an expense to be minimized, logistics and transportation systems are increasingly seen as essential strategic components of economic development in the state and nation, and as primary opportunity areas to achieve competitive advantage. Strong growth in this area is expected to stimulate research opportunities in public and private economic sectors. Over the next decade, federal spending in logistics and transportation is expected to be significant led by the Departments of Defense (DoD), Transportation (USDOT), and Homeland Security (DHS).

- DoD spends nearly a third of its total budget, almost \$80 billion annually, on its logistics infrastructure. Thus, even relatively small improvements in performance can save millions each year. Logistics research will focus on three key areas: reducing the footprint / increasing the agility of military logistics; integrating disjoint systems and providing visibility; and logistics support strategies and technologies for aging and new weapon systems. Supported research will include business process improvement and integration, as well as technology development and insertion.
- The USDOT is composed of several transportation-related organizations. The largest and perhaps the most visible unit in the USDOT, the Federal Aviation Administration (FAA) offers funding for research on aviation safety, mobility, and environmental issues. In addition, airports receive grants-in-aid for security, safety, capacity, and noise reduction projects, among others. Another area rich with funding opportunities is the Federal Highway Administration (FHWA) that conducts and manages a comprehensive research development and technology program with emphasis on identifying ways to reduce roadway fatalities by demonstrating the application of innovative technologies in highway safety, and deploying and evaluating safety technologies and innovations. A third major player in the USDOT is the Federal Transit Authority (FTA) that funds research addressing the special transportation needs of the elderly, people with low incomes, and persons with disabilities.

In addition to infrastructure improvement, much DOT funding is likely to be directed toward workforce development. According to Secretary of Transportation Norman Mineta “in the next five years, 50 percent of the workforce responsible for planning, developing, and managing the transportation system will be eligible to retire.” Therefore opportunities exist for the Logistics and Transportation cluster to develop research-based education and training programs to expand the population of transportation and logistics professionals and to help diversify the industry.

- The passage of the Homeland Security Act of 2002 transferred the U.S. Coast Guard and the Transportation Security Administration (TSA) to the Department of Homeland

Security. These two agencies afford additional research opportunities for the logistics and transportation systems cluster.

- In addition to federal funding, many opportunities exist for privately sponsored research, both regionally and nationally. The emergence of enterprise integration and supply chain management as preeminent business strategies has elevated the corporate perception of logistics and transportation systems. As these strategies gained prominence during the last decade, a myriad of prematurely implemented “silver bullet” systems contributed to the “dot com bust” and highlighted the need for more systematic research. As a result, corporations are more likely to fund research related to their specific strategy. Such research would be particularly synergetic if performed for corporations engaged in DoD and DOT activities.

### *Strengths*

#### *a. Technical Expertise*

NCA&T is clearly the strongest HBCU with the capacity to contribute at a national level via a Logistics and Transportation Systems cluster. The College of Engineering (COE) has faculty with research expertise in logistics in the Industrial and Systems Engineering (ISE) and Computer Science departments. The ISE department offers the only Ph.D. degree at an HBCU in the discipline, and has faculty with logistics and human-machine interface expertise. The School of Business and Economics (SOBE) has an undergraduate program and a graduate specialization in Transportation Logistics as well as a number of logistics researchers. Transportation system research is supplemented by the Civil Engineering Programming in the College of Engineering. Enabling technology research such as global positioning systems is performed in the School of Technology.

#### *b. Research Institutes*

The Logistics and Transportation Systems research cluster would build upon two existing related institutes – the Transportation Institute and the Institute of Human Machine Studies, and also involve and coordinate a variety of additional logistics and transportation related research activities.

- *Transportation Institute* – Since its inception in 1970, the Transportation Institute (TI) has increased research and professional development among diverse populations to improve transportation performance through the use of innovative management techniques and advanced technologies in small urban and rural areas. Under this umbrella, the TI has combined transportation research, education, and technology transfer by facilitating and expanding the relationships among transportation officials and emerging transportation professionals. The availability of an established interdisciplinary research unit, inclusive of business, arts and science, and engineering faculty well versed in research in transportation management and transportation engineering, make this possible. During the past five years, the TI has funded 8 ongoing research projects and 15 completed research projects, organized five summer high school transportation institutes, and held the Entrepreneurial Development Technology Program to increase the number of qualified highway contractors, among underrepresented populations. The TI has a strong relationship with both federal and state departments of transportation.

Although this has been the strength and will continue to be a focus of the TI, recent and future changes in the industrial mix in North Carolina's Piedmont Triad region necessitate an expansion of the focus to include all aspects of the supply chain as well as the specialized area of electronic commerce. This expansion in focus is warranted by the impending arrival of Federal Express and the collateral logistics and transportation firms that will follow. Indeed, this aspect of the TI may mirror the FedEx Technology Institute at the University of Memphis where "real world supply chain and transportation issues are solved."

- *Institute for Human Machine Studies* – The Institute for Human-Machine Studies (IHMS) conducts a broad-based program of basic and applied scientific research and technology development directed toward understanding the nature of human performance while interacting with complex technology-driven systems. The IHMS boasts one of the largest staffs of cognitive engineering researchers among all universities. Building on this core competency, the IHMS is interdisciplinary in nature including collaboration with several engineering disciplines, computer science, occupational safety, sociology and psychology. IHMS research emphasizes transportation, health systems, logistics, and training methods. The Institute has sustained research funding from a variety of sponsors including all branches of the military. Additionally, the IHMS is active in outreach programs for high school students and hosts a Human Computer Interaction conference highlighting graduate and undergraduate work.

*c. Other Logistics and Transportation Research*

Other examples of logistics and transportation systems research at NC A&T include:

*Remanufacturing supply chains* – Remanufacturing supply chains focus on the economically attractive and environmentally responsible extension of product life cycles through repair, recycling, recovery, and remanufacturing (returning product to like new condition). Current on-campus research includes modeling of remanufacturing process times, development of object models to support operational optimization and simulation, remanufacturing scheduling, repair scheduling, application of critical chain management to remanufacturing, and the impact of supporting business processes. Projects have been supported by NC A&T FUTURES, NSF, US Army, and the Institute for Defense and Business.

*Hub Scheduling* – This research focuses on the trailer scheduling in distribution system hubs within the small package delivery industry (such as the existing UPS and planned FedEx hubs in Greensboro). Researchers have developed methods that significantly reduce transfer time relative to current industry practice.

*Material Handling System Design Automation* – NSF-sponsored research, in collaboration with Georgia Tech, to automatically generate material handling system design given production/distribution plans, physical system characteristics, and material handling options.

*Military Logistics* – This applied research seeks to identify and analyze effective practices and technology within the military and private industry for general application to military logistics. The research is sponsored by the Institute for Defense and Business and includes interaction with US Army, US Navy, US Air Force, US Marines, Defense Logistics Agency, and US Coast Guard.

*Flexible Simulation Models* - NSF-sponsored research, in collaboration with University of Maryland, to develop best practices and metrics for simulation language and

programming flexibility. Flexibility is defined as the ability of a simulation model to be automatically adapted given structural changes in the production system being modeled.

*Scheduling Policy Classification* – This research focuses on the full utilization of logistics scheduling policy information generated by a policy learning system for policy classification and knowledge extraction.

*Agent-Based Logistics* – A growing approach to logistics research is the development of autonomous computer-based “agents” that mimic the behavior of real-world logistics system participants. These agents may be used to test the effectiveness of possible operational policies or to increase the speed and availability of logistics system operation. Agent-based research has been sponsored by the US Air Force.

*Industry Extension* – Numerous logistics-based projects have been performed as part of the land-grant extension mission of the university.

#### *d. Innovative Educational Activities*

In addition to applied research, logistics and transportation systems serve as fertile ground for educational activities, both at the university and through extension including:

*ALIVE System* - The ALIVE System is a three-year project sponsored by the National Science Foundation using active learning to teach logistics. ALIVE is a set of 22 teaching tools that integrate engineering and technical business courses as well as business and engineering disciplines. Specifically, each class in the industrial engineering curriculum and many classes in the business curriculum include week long “learning modules”. Where feasible, business and engineering students work collaboratively. The ALIVE System develops these requisite skills and addresses visual, active, collaborative, experiential, deductive and global learning styles. The ALIVE System gives students a series of short intern-like projects in the “Virtual Enterprise”. The Virtual Enterprise is a full-scale supply chain, integrated using information technology, and producing actual product – desk clocks. Laboratories, either physical or virtual, are organized as businesses. These research efforts drive the educational process in terms of external workforce development and internal student instruction.

*Logtech/DAELP* – A&T faculty have developed case studies and regularly teach courses for the Center for Excellence in Logistics and Technology (LOGTECH) – the primary source of logistics executive education for the Department of Defense; and for the Army Material Command Depot and Arsenal Executive Leadership Program (AMC DAELP) – an executive education program for Army manufacturers and remanufacturers.

#### *e. Collaborations*

The university already possesses an established network in logistics and transportation research. University and industry partners in past, present, or proposed research include Georgia Institute of Technology, Massachusetts Institute of Technology, Microelectronics Center of North Carolina, North Carolina State University, Sytronics, University of Illinois, University of Maryland, UNC-Chapel Hill, UNC-Charlotte, UNC-Greensboro, Stanford University, and Virginia Polytechnic Institute. Supporters of past and present research include federal and state departments of transportation, Air Force, Army, Navy, National Science Foundation, and Procter and Gamble.

In addition to this collaboration, partnerships are forming and maturing in two areas: a UNC Transportation Consortium along with NC State, UNC-Charlotte, and UNC-Chapel Hill; and the

Institute for Defense and Business (home of LOGTECH and AMC DAELP) at UNC-Chapel Hill.

The two primary planned activities are a Center for Logistics and Transportation in partnership with UNC-Greensboro to be led by NCA&T and located at the North Millennial campus, and a Center for Military Logistics focusing on applied research and workforce development.

### *Scope*

Research focal areas for the Logistics and Transportation Systems cluster include:

- Small Urban/Rural Transportation Systems – creating economically attractive, secure and equitable policy for transportation system design and traffic management.
- Human Enterprise Systems – designing enterprise systems for logistics integration and visibility with appropriate interface enabling human interaction.
- Supply Chain Management – using operations research and simulation as well as best business practices and information technology to enhance systems performance of supply chains.
- Military Logistics – improving military logistics agility, visibility, integration, and human computer interface.
- Product Reuse – devising economically attractive and environmentally responsible operational policies for recycling, recovery, repair, and remanufacturing.

### **Research Challenges**

Research challenges in the area of logistics and transportation system may be categorized as content or funding challenges. These challenges drive the research focal areas from the previous section. Research content challenges include the development of:

1. Methods to appropriately integrate human decision-makers and technology into the system. Such research involves cognitive engineers, systems engineers, and information system managers. An example of such a challenge is the design and implementation of Radio Frequency Identification (RFID) tags that accompany a product through the system allowing the data associated with the product to remain on the product. In addition to numerous operational and market benefits, such technology presents challenges in information technology and enterprise architectures, security, routing algorithms, and privacy issues.
2. Life cycle logistics systems that support the operational and disposal product life stages. Traditional logistics systems focus on design, production, and initial distribution to a customer. This research focuses on achieving higher levels of sustainable growth, where economic growth is achieved without diminishing the availability of resources in the future.
3. Holistic methods, based on both quantitative analysis and synergistic business process, to assist in the design, implementation and operation of logistics and transportation systems given their complexity. Such research builds on the fields of business strategy, operations research, computer modeling and simulation, and production and inventory systems.
4. The identification of aggregate metrics on which to judge system behavior and to base design and operational decisions. Skills necessary to contribute to this research include data modeling and mining, industrial psychology, business strategy, and statistics.
5. Equitable and effective small urban/rural systems to transport people. Such research requires significant empirical analysis and multi-objective system design and operation.

Research funding challenges include:

1. Overall funding at the federal level (outside of DoD and DHS) seems to be decreasing causing more rationing of total research dollars. Often, the federal emphasis is on research that is high risk in nature and unlikely to attract industry sponsorship. Logistics and transportation research is encouraged to seek funding from industries based on more direct benefit.
2. NC A&T is not the only university to recognize growing opportunities in logistics and transportation systems. A number of universities are pursuing this direction. Thus strategic partnerships and aggressive pursuit of research in the area is critical.

### **Assets**

The Transportation and Logistics cluster will leverage the existing human and facility/hardware resources of the university to achieve stated goals. Additional assets include faculty experts, extensive experience with a variety of research programs and projects, and strategic collaborations discussed previously.

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