STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

ROY COOPER
GOVERNOR

J. ERIC BOYETTE
SECRETARY

July 19, 2022

MEMORANDUM

TO: Researchers and University Officials

FROM: NCDOT Research & Development

RE: NCDOT FY2024 Research Request for Proposals

In this document, please find the official Request for Proposals summarizing NCDOT generated research needs for the Fiscal Year 2024 Research Program. This package contains internally generated NCDOT Ideas. **If you submitted a research idea or ideas directly, you will receive direct communication regarding those ideas.** We are not accepting new ideas at this time, only proposals.

The RFP is being distributed to central research/sponsored program offices and directly to faculty and research staff. Please share this email with any university associates or departments that may be interested in participating.

All proposals should be *submitted electronically* through the NCDOT R&D website.
Note that if you already have an account for the Research Ideas site, those credentials will continue to work for the Proposal site. Please do not wait until the due date to confirm your credentials work or to set-up a new account as it may take up to two days for account set-up or repair.

Instructions on setting up an account and submittal links can be found at the link below.
https://connect.ncdot.gov/projects/research/Pages/research-dev-ideas.aspx

The deadline is Friday, September 9, 2022 @ 5:00 PM.

Detailed instructions for writing NCDOT Research Proposals can be found on the R&D website:

Click here for proposal instructions and templates.

If you have any questions or comments, please contact me or one of our NCDOT Research Engineers or send queries to research@ncdot.gov.

We look forward to seeing your submissions!

Mailing Address:
NC DEPARTMENT OF TRANSPORTATION
RESEARCH AND DEVELOPMENT
1549 MAIL SERVICE CENTER
RALEIGH, NC 27699-1549

Research Office Telephone: (919) 707-6660
Research Office Email: research@ncdot.gov
NCDOT Customer Service: 1-877-368-4968
Web: https://connect.ncdot.gov/projects/research/

Location:
1020 BIRCH RIDGE DRIVE
BUILDING B
RALEIGH, NC 27610

A Few Notes:

Contacting NCDOT Idea Generators

Should you choose to respond to one or more NCDOT research ideas, we strongly encourage you to communicate with the NCDOT professionals who generated the research idea. This will allow you to understand the full intent and desired scope of the research need and prepare the best possible proposal.

If you received this as a forwarded message, and you wish to be added to our database for future communications, please reply with the subject line: **ADD TO NCDOT RESEARCH ROSTER**. Please provide your full contact information including title, university, department, email, phone, fax and address.

Should you wish to be removed from future notifications, please reply with the subject line: REMOVE FROM NCDOT RESEARCH ROSTER.

NCDOT Research & Development

Request for Proposals

Fiscal Year 2024

July 19, 2022

RESEARCH & DEVELOPMENT

Committee	Idea Number	Title	NCDOT SME
EN	2024-049	Use of Artificial Intelligence to Characterize NCDOT's Existing Underground Storm Drainage Network	Ryan Mullins
PV	2024-002	Roller Compacted Concrete	Josh Kellen
PV	2024-003	Development of Accelerated Hardened Concrete Alkali-Silica Reaction Test	Ronald Lichtenwalner
PL	2024-004A	Do Previous Iterations of Forecasts for the Same Project Have Value to the Project Delivery Team?	Joseph Hummer
PL	2024-058	Vehicle Availability and Ownership Trends in North Carolina	Sarah Searcy
TR	2024-001	Managed Freeway Before Study	Jennifer Portanova
TR	2024-006	Quantitative Safety Information on Access Points at Either End of a U-Turn Crossover	Joseph Hummer
TR	2024-008	When Are There Too Many All-Way Stop Intersections?	Joseph Hummer
TR	2024-019	Effectiveness of NCDOT Dynamic Zipper Merge System	Kenneth Thornewell

FY 2024

REQUEST FOR PROPOSAL

Environment

and Hydraulics

RESEARCH & DEVELOPMENT

Research Idea Title:

Use of Artificial Intelligence to Characterize NCDOT's Existing Underground Storm Drainage Network

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
EN	2024-049	2024	5/31/2022 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Mullins	Ryan	Engineer	rmullins@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:

Sponsor/Champion:

Last Name:	First Name:	Title:	Email:

Benefit or Knowledge Gain for NCDOT:

Explain Anticipated Benefits:

Existing methods used to gather information on NCDOT's existing underground storm drainage network are costly and time-consuming. If successful, this project has the potential to dramatically reduce costs associated with field inventory of NCDOT's stormwater system by reducing the manpower needed to gather this information. A detailed assessment of NCDOT's entire stormwater system would require several years and extensive field hours. This study has the potential to generate statewide datasets within a couple of years. The secondary project objective, providing projected service life estimates for the existing stormwater network, has the potential to greatly improve asset management decisions, thereby generating considerable cost savings to the NCDOT over time.

What is the problem or issue needing investigation?

NCDOT's renewed NPDES stormwater permit which became effective May 1, 2022 requires the Department to map its drainage network in six of NC's largest municipal areas. NCDOT manages an extensive stormwater drainage network but lacks a comprehensive dataset characterizing the locations or features of that network. Since most of the stormwater drainage network is located underground in these areas, traditional methods used to locate and characterize the features and conditions these underground portions of the drainage network have relied on specialized equipment and lengthy field investigations which are both costly and time-consuming.

Background:

A significant portion of NCDOT's stormwater drainage system is located underground. Knowledge of an existing stormwater drainage system, such as pipe size, location, and direction of flow, is often needed to support new development and redevelopment projects and address drainage and maintenance concerns, in addition to NPDES permit compliance. Gathering this system information is often costly and time-consuming because it involves specialized equipment, training, and substantial NCDOT staff and contractor resources to perform field investigations in and around the NCDOT Right-of-Way.

Though the stormwater pipes themselves are underground, a number of surface elements, such as curb inlets, manhole lids, discharge locations, and other features, indicate the presence of underground stormwater pipes. These features, along with other information, such has topography and elevation, are typically used by field staff to locate existing underground stormwater infrastructure. Many of these features are available as ArcGIS-based datasets and are used to determine where underground pipe networks are likely located, prior to performing field investigations.

Previous NCDOT research (RP2020-22) evaluated the durability of various pipe materials (Reinforced Concrete Pipe, galvanized and aluminized Corrugated Steel Pipe, corrugated aluminum, steel, cast-iron, High-Density Polyethylene, Polypropylene, and Polyvinyl chloride) based on different soil conditions (chloride exposure, soil pH and resistivity) to determine material service life. RP2020-22 and the Pipe Assessment and Selection Software (PASS) allows designers to perform a rapid assessment of pipe options for a given project based on pipe material and subsurface environmental conditions. NCDOT is evaluating application of this research in the selection of pipe material on new projects but the information is also relevant to understanding service life associated with NCDOT's existing underground stormwater assets.

Artificial intelligence (AI) is a wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence. Machine learning (ML) technology is a subfield of AI. ML technology enables computers to learn and function without explicit instructions and programming, but with patterns and inferences extracted from data (Mosavi, et al. 2018). A review of recent machine-learning based technology used to address urban drainage systems highlighted its used in addressing operation (real-time operation control), management (flood-inundation prediction) and maintenance (pipe defect detection) of stormwater systems (Kwon, et al. 2021).

Research Tasks:

This project will explore the use of AI or ML technology to aid in predicting the location and, features and service life of NCDOT's underground stormwater infrastructure. NCDOT and others have performed a number of detailed, storm system inventories throughout North Carolina. This project will build-upon previous NCDOT research (RP2020-22) to predict pipe service life of NCDOT's existing stormwater network, thereby providing an improved understanding of current or anticipated pipe service life conditions throughout the state. The detailed inventory information, along with other existing ArcGIS-based datasets (for example, drainage system inlets, outlets, topography, elevation, and road network, among others), will be used to inform the selected AI or ML technology with the goal of predicting the location, characteristics, and service life of underground pipes and other stormwater system infrastructure features in areas where detailed studies have not been performed.

The researcher will identify applicable AI or ML technology methods, strengths/weaknesses associated with different methods, and recommend method(s) best suited to achieve the project objectives using existing, supportive information. The location and features of existing stormwater infrastructure in watersheds where detailed infrastructure information has already been collected or is otherwise available. Based on an initial evaluation of the perceived value of the technology in predicting location, features and service life in a study area, the researcher will apply the selected AI or ML technology statewide in characterizing the location, features, and service condition of NCDOT's underground stormwater infrastructure network.

Products of the Research:

This project will culminate into a final report detailing all materials, methods and outcomes of the study. Under this study, an AI or ML technology will be developed using existing ArcGIS-based datasets to predict the location, characteristics, and service condition of NCDOT's underground stormwater network and develop an ArcGIS-based dataset(s) representing these features and the underground network. Results of the AI-based technology will be compared to field-verified stormwater infrastructure data (not collected as part of this research study). The report will document the perceived usefulness of the selected technology in developing the ArcGIS-based datasets and recommendations on future use of the technology.

Possible IT Components:

ArcGIS-based datasets. AI or machined based technology tool.

Implementation:

Results of this study can be implemented into the Asset Management Unit, Field Inventory Program, Post-Construction Stormwater Program, Highway Stormwater Program's Retrofit Program, and roadside environmental projects to improve operational efficiency and lower costs.

Additional Comments and Information:

Kwon, S.H.; Kim, J.H. Machine Learning and Urban Drainage Systems: State-of-the-Art Review. Water 2021, 13, 3545. https://doi.org/10.3390/w13243545

Mosavi, A.; Ozturk, P.; Chau, K. Flood Prediction Using Machine Learning Models: Literature Review. Water

FY 2024

REQUEST FOR PROPOSALS

Pavement,
Maintenance
and Materials

RESEARCH & DEVELOPMENT

Research Idea Title:

Roller Compacted Concrete

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
PV	2024-002	2024	5/17/2022 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Kellen	Josh	Disaster Recovery Engineer	jlkellen@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:

Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Kellen	Josh	Disaster Recovery Engineer	jlkellen@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings; Cost Savings; Improved Material Structure/Pavement/Performance; Improved Models Performance/Traffic/Financial etc.; Improved Worker or Public Safety

Explain Anticipated Benefits:

By utilizing a product that is not as susceptible to certain loads being applied while versatile enough to be installed quickly with standardized equipment and be back open to traffic quickly, RCC could potentially increase the life expectancy of our pavements resulting in a better cost/performance ratio while improving the safety of the traveling public by improving the condition of the road.

What is the problem or issue needing investigation?

Pavement damage/stress/fatigue/shoving etc. at intersections with heavy truck traffic but also on secondary roadways in general submitted to heavy truck traffic without the proper pavement structure

Background:

It is a goal of MOFM to work with Divisions to identify possible solutions to issues identified in the field by maintenance forces.

Research Tasks:

The properties of roller compacted concrete are documented and available and the product has been used in other southeastern states. Would like to see how the product has held up since installation as well as the installation of the product at specified locations in NC for testing and monitoring

Products of the Research:

Could result in the use of roller compacted concrete in applicable locations to extend the life of facilities and reduce the cost and effort of ongoing maintenance activites at those locations.

Possible IT Components:

Unknown at this time

Implementation:

This could be installed at Division identified "trouble" spots with a history of ongoing maintenance requirements to compare previous maintenance requirement to those following installation. This could be at intersections, industrial/mining entrances, secondary roads with high industrial traffic, etc.

Additional Comments and Information:

Subcommittee Comments:

Research Idea Title:

Development of Accelerated Hardened Concrete Alkali-Silica Reaction Test

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
PV	2024-003	2024	5/17/2022 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Lichtenwalner	Ronald	Lead Chemist	rllichtenwalner@ncdot.gov

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Last Name:	First Name:	Title:	Email:

Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Lichtenwalner	Ronald	Lead Chemist	rllichtenwalner@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

Cost Savings;Improved Material Structure/Pavement/Performance;Improved Models Performance/Traffic/Financial etc.;New or Improved Specifications

Explain Anticipated Benefits:

1) Cost Savings: New guidance that would allow for more flexibility in the use of aggregates and higher alkali cement would allow more sources and thus cheaper concrete. Also, there could be more optimum dosage of SCM's. Identification of structures at risk in the field could also allow preemptive interventions before structures deteriorate significantly.

2) Improved Material Structure Performance: Rapidly testing actual concrete mixes for potential ASR would provide more certainty that concrete placed in the field will not suffer from ASR expansion.

3) New or Improved Specifications: Mix design specifications could be updated and improved to provide better durability and cost-effective performance of concrete structures.

What is the problem or issue needing investigation?

Alkali-silica reaction is a reaction that results in the premature failure of concrete due to a reaction between reactive silica present in some aggregates and alkali present in the

concrete pore solution. NC DOT has identified several structures over the years that appear to be deleteriously impacted by ASR reaction. Currently, there is no standard method to identify field concrete that is suffering from alkali-silica reaction. There is also no reliable, rapid test method to evaluate a specific concrete mix before being used in the field. ASR reaction occurs along a spectrum and a cost-effective, rapid method to determine the threshold of alkalis required in the mix would allow for greater flexibility in designing optimum concrete mixes. The current most reliable method, ASTM C1293, requires significant time to measure the physical expansion of concrete and can take a year for results in a base mix or two when supplementary cementitious materials are used.

Background:

Current ASR mitigation strategies by the department are broad and center around the use of low alkali cement or the addition of supplemental cementitious material (e.g. Class F fly ash, silica fume, etc.). These are imprecise policies that broadly mitigate ASR, but limit the cement and aggregate sources able to be used by the department. Additionally, some aggregates or combination of aggregates may react even with the use of low alkali cement. If the aggregates are not currently known as reactive to the department, concrete may be placed in the field that is assumed to be non-reactive but may experience deleterious expansion in the field.

Recently, the FHWA has developed a new chemical test to evaluate the potential reactivity of aggregates, known as the T-FAST test. Preliminary research at the Materials & Tests Unit adapting this rapid, chemical test protocol to concrete has shown promise in differentiating between reactive and non-reactive mixes and detects mitigation by the addition of supplementary cementitious materials (SCM), such as fly ash. The current draft protocol for evaluating hardened concrete involves placing concrete in a sealed test tube for 35 days with water. Removing the tube, filtering the solution, and analyzing the filtrate with ICP or WDXRF for the concentrations of calcium, aluminum, silicon, sodium, potassium, sulfur and magnesium. The concentrations of those elements, particularly calcium, aluminum and calcium determine the reactivity of the concrete mix. The current most reliable standard for evaluating concrete for deleterious expansion by ASR is C1293. In this research idea, to correlate the chemical results with the actual physical expansions measured, testing of lab produced mixes utilizing C1293 or a modified T 380 would need to be performed. Initial work is being done at the Materials & Tests Unit to correlate T 380 expansion with this new test method.

An extension of this work, would be to attempt to use concrete cylinders immersed in solution that is then tested and the reactivity of the mix is then determined. This would remove the crushing requirement, provide more representative results of the true material as cast and be able to be easily implemented in the field to generate samples that could then be tested.

Research Tasks:

Performing testing and gathering data are the primary activities anticipated. Testing of a representative quantity of concrete by C1293 or T380 expansion and the modified FHWA T-FAST concrete test containing a range of aggregates, cement alkali content, and SCM to encompass the spectrum of reactivity and aggregates expected in NC mixes. Additionally, collection of field concrete cores from structures with mix designs where the aggregate reactivity is known and correlation to matching mixes cast in the lab.

Products of the Research:

1) The determination of reactivity of concrete mix designs before use in the field, limiting potential problems with failure of structures by ASR in the future.

2) New concrete mix design specifications and guidelines could be created that would allow for a greater variety of aggregate and cement sources and more optimum inclusion of SCM doses.

3) The evaluation of existing structures for ASR that may be exhibiting signs of deleterious ASR expansion. This data could also help identify similar structures, which could be proactively evaluated for ASR before noticeable cracking occurs.

Possible IT Components:

Additional fields and information about mixes, aggregates and cement may need to be added to HiCAMS to automate new guidelines in mix designs.

Implementation:

Implementation could be done by updating the highway specification book for mix designs and altering our ASR mitigation guidelines. Also the implementation of monitoring for structures that could be considered at risk based on their mix.

Additional Comments and Information:

Subcommittee Comments:

FY 2024

REQUEST FOR PROPOSALS

Planning,

Programming,

Policy and

Multimodal

RESEARCH & DEVELOPMENT

Research Idea Title:

Do Previous Iterations of Forecasts for the Same Project Have Value to the Project Delivery Team?

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
PL	2024-004	2024	5/18/2022 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Hummer	Joseph	State Traffic Management Engineer	jehummer@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:

Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Hummer	Joseph	State Traffic Management Engineer	jehummer@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Improved Material Structure/Pavement/Performance;Improved Models Performance/Traffic/Financial etc.;Improved Worker or Public Safety

Explain Anticipated Benefits:

A more accurate traffic forecast will help in many aspects of a project. It would ultimately mean better final products that are safer, result in less delay, save costs, and save impacts. It would also allow for value from previous efforts to be extracted thus maximizing the benefit of funds spent.

What is the problem or issue needing investigation?

Many NCDOT TIP projects take years, even decades to be delivered. Over that time, the project team produces a series of traffic forecasts. Eventually, those forecasts help the team through the environmental process and inform the design. Currently, the assumption is that each new forecast replaces the previous forecasts—project teams put 100 percent of the weight on the latest forecast and do not use any older forecasts.

The problem is that traffic forecasting is really difficult and, understandably, forecasts are often inaccurate by a considerable margin. The best data available on forecast accuracy was published in 2019 in NCHRP Report 934. Generally, Report 934 found that the average error (difference between forecast value and field-measured value) was 6 percent but the standard deviation around that average was 30 percent. That is, about one-third of all forecasts are in error by more than 30 percent.

In thinking about how to improve forecast accuracy, it occurred to several of us that there might be unused value in the older forecasts. In other words, forecast users might not want to value the most recent forecast at 100% and all older ones at 0% as current policy dictates. Certainly, forecasting techniques and available input data improve with time, but a large input into every forecast is the judgement of the forecaster and the resource experts. Those judgements do not necessarily improve with time.

The idea this research will explore is that maybe previous versions of forecasts continue to be useful tools to the project delivery team. This value could potentially be in the form of some sort of average or Bayesian process where each new forecast refines, but does not replace, the older ones. This is a problem that empirical research can solve. That is, a researcher can gather forecasts from cases around the state where there are multiple ones available and measure the extent to which the more recent forecast is more accurate. The research result could answer the question, “How should the users of traffic forecasts weigh the information from each of a series of forecasts?” Is each forecast usually equally accurate (in which case we who use forecasts should just take an average)? Is the most recent forecast typically twice as good as the previous one (in which case users should apply a 2/3 weight on the most recent and 1/3 on the older; or 4/7, 2/7, and 1/7 if we have three available)? Is the most recent always best by a large margin, in which case we maintain current policy and look for other ways to improve accuracy?

Background:

NCHRP Report 934 does not examine the accuracy of a series of forecasts, and we do not know any literature that has done so.

The researchers should take into account that there are certain requirements for new forecasts (like applying a fiscal constraint and updated socio-economic projections) that were not necessarily in place in previous years. Those requirements probably make newer forecasts better, although that is testable.

The data set to answer the question should include famous cases like I-26 in Asheville with at least seven forecasts, and should also include less famous cases from smaller projects, projects not on freeways, and projects in rural areas.

Forecasts typically include several quantities for each movement like K, D, seasonal variation, and truck percentage, but the researchers should concentrate on basic AADT in this work. AADT remains the main product of a forecast. Let’s forecast AADT as well as possible and then maybe follow up work can concentrate on some of those other factors.

Research Tasks:

The heart of the research will be a comparison of the accuracy of different forecasts. Accuracy should be based on how close the forecasted value was to a field-measured value. The researchers can compare no-build forecasts to field-measured values collected before the project opened or when the project never got built. The researchers can also compare build forecasts to field-measured values after the project was opened.

Products of the Research:

The main product from the research will be a recommendation on how users of traffic forecasts should weigh the information they have available from a series of forecasts. If older forecasts have some value, the researchers should recommend ways to appropriately identify that value which could include a set of typical weights to apply to each member of the series. The final recommendation should be a simple one to apply, as forecast users may not have access to a wealth of variables.

Possible IT Components:

Other than providing the researchers access to some NCDOT databases, the IT role in this research should be minimal.

Implementation:

Traffic forecast users are fairly widely dispersed across NCDOT so several webinars may be needed to get new information into the hands of all users. Some manuals and guidelines, such as the PDN, may have to be edited to ensure that the research results are institutionalized.

Additional Comments and Information:

Brian Wert, PE, of the Project Management Unit (bmwert@ncdot.gov) is a co-sponsor of this statement.

Joe and Brian request that the statement be reviewed by both the Traffic and Planning Subcommittees since this topic would seem to be of interest to both

Subcommittee Comments:

Research Idea Title:

Vehicle Availability and Ownership Trends in North Carolina

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
PL	2024-058	2024	5/31/2022 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Searcy	Sarah	Deputy Director for Innovations and Data	seasearcy1@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:

Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Searcy	Sarah	Deputy Director for Innovations and Data	seasearcy1@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

Improved Models Performance/Traffic/Financial etc.;New or Improved Specifications;Other (Specify below)

Explain Anticipated Benefits:

The anticipated benefits of the research include improvements to the NCDOT TDI tool to assist in regional and statewide planning efforts, including improved accuracy of transportation models to support comprehensive transportation plans and metropolitan transportation plans. This research will also improve our understanding of transit rider demographics and needs, which will inform transportation planning processes and implementation.

What is the problem or issue needing investigation?

Though household car ownership data is readily available from the American Community Survey and other sources, data is limited in identifying individuals living in households with cars who still have vehicle availability challenges. These may be individuals sharing a car with other adults, individuals who own a car but are not able to drive, or individuals who own a car with frequent maintenance issues. Additionally, current data sources make it difficult to distinguish between households with limited vehicle availability by choice (voluntarily car-less or car-free), and those with limited vehicle availability due to socioeconomic or other constraints (involuntarily car-less).

Understanding this distinction would help understand unmet access and mobility needs, better identify areas with high prevalence of transportation disadvantage, and inform mobility planning and policy decisions. Areas identified as transportation disadvantaged are often identified as such due to low vehicle ownership. However, other modes of transportation may be prevalent and account for some of the disparity in vehicle ownership. A brief literature review was performed to evaluate the existing research performed on the topic of car-less households. A recent study suggests that 79 percent of zero-car households are involuntarily car-less and not car-free (Brown, Anne. (2017). Car-less or car-free? Socioeconomic and mobility differences among zero-car households. Transport Policy. 60. 152-159. 10.1016/j.tranpol.2017.09.016).

Background:

Transportation disadvantage refers to barriers or conditions that make it difficult or impossible for individuals to access transportation services. Involuntarily car-less households do not own a car because of economic or physical constraints, while voluntarily car-less (or car-free) households do not own a car by choice. Research aiming to identify areas of transportation disadvantage may inadvertently label some areas as such due to car-free, rather than involuntarily car-less, households. Car-free households may reflect a transportation advantage granted by a strong public transportation system or access to private transportation services. Distinctions between involuntarily car-less and car-free households should be investigated because these two demographics have different transportation needs.

Research Tasks:

Research tasks include a survey of households and spatial analysis for integration in the NCDOT Transportation Disadvantage Index (TDI) tool. By surveying a representative sample of households, the researchers will determine the proportion of households that choose not to own a car compared to the proportion of households that cannot access or own a car due to constraint. Questions that will be assessed include:
o Estimate vehicle availability beyond simple metrics of number of vehicles per household
o Determine whether households are aware of other transportation options
o Determine whether households choose to live in a certain area due to access to options
o Determine what information households use to make their transportation choices
o Determine the external factors that limit vehicle availability

Products of the Research:

The products of the research will be the analysis of the survey results, a new geospatial layer to add to the NCDOT TDI tool, and improved understanding of transportation disadvantaged populations in North Carolina.

Possible IT Components:

Potential for an online survey if needed and integration of the analysis results into the NCDOT TDI tool.

Implementation:

The products of the research will be implemented by integrating the analysis results into

the NCDOT TDI tool where it will be accessible by the public and used by transportation planners statewide. Barriers to implementation could include difficulty in integrating data from the survey results for use in the NCDOT TDI tool. Additionally, surveys of this size may be difficult to conduct, and it may be challenging to achieve an adequate sample size to produce reliable results.

Additional Comments and Information:

N/A

Subcommittee Comments:

FY 2024

REQUEST FOR PROPOSALS

Traffic, Safety & Roadway Design

RESEARCH & DEVELOPMENT

Research Idea Title:

Managed Freeway Before Study

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2024-001	2024	4/28/2022 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Portanova	Jennifer	State Systems Operations Engineer	jportanova@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:

Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Portanova	Jennifer	State Systems Operations Engineer	jportanova@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Improved Models Performance/Traffic/Financial etc.

Explain Anticipated Benefits:

The research will result in data and analysis that can be used for a future after study. Anticipated benefits that can be used when communicating and projecting the value of managed freeway in the state. In addition, this study will provide refined methods for evaluating future North Carolina managed freeway installations.

What is the problem or issue needing investigation?

For the first time North Carolina will implement the Managed Freeway concept on I-40 in Raleigh/Durham (I-6006). Managed Freeway is an active traffic management (ATM) tactic that integrates and coordinates various strategies, like coordinated adaptive ramp meters (CARM), dynamic lane assignment, queue warning, variable speed limits, hard shoulder running, signal system timing, and similar intelligent transportation system (ITS) strategies, to maximize traffic flow on existing facilities. This project is intended to collect pre-treatment data and develop a framework for using this data as part of a before and after evaluation plan that can be expanded to future managed freeway

installations.

Background:

Managed Freeway concept is to optimize traffic performance using network monitoring and intelligence, traveler information, traffic management and control interventions, route optimization, and trip management techniques to reduce peak hour congestion, optimize lane use, automatically respond to incidents, and quickly return the facility to free-flow conditions after an incident. It is anticipated that managed freeway will result in significant benefits to the state, including savings due to decreased delay, decreased crashes, and other outcomes. However, the actual impact of managed freeways on performance measures is still unknown for North Carolina.

Research Tasks:

Tasks for this project will include pre-installation data collection, development of a framework for a before and after study to analyze managed freeway impacts on mobility and safety performance measures, an analysis of anticipated benefit cost, development of criteria for ideal locations for managed freeway locations and recommendations for installation of managed freeways in North Carolina, and a final report documenting the research team's efforts and findings.
The analysis framework should include recommendations for pre-installation microsimulation modeling of the anticipated managed freeway operations; if system controller specifications are known, consider using in-the-loop operation to represent the proprietary algorithms. The benefit-cost analysis should consider the tradeoffs of improvements in traffic flow and capacity on the freeway vs. the added delay on arterials and on-ramps.

Products of the Research:

The primary products of this research will include: 1) data on key mobility and safety performance measures collected before managed freeway installation, 2) framework for a before and after study, 3) anticipated benefits of managed freeways, 4) criteria for ideal locations and recommendations for installations of managed freeways, and 5) a Final Report summarizing the research team efforts and findings during this project.

Possible IT Components:

No IT components are anticipated

Implementation:

This research can be used when projecting and evaluating managed freeway outcomes at future North Carolina sites and can be used in conjunction with community outreach and public relations activities to communicate the value of managed freeways.

Additional Comments and Information:

Clearly outline what data will be collected. Will this research produce fresh observations or harvesting HERE/Inrex or other data already be collected?

Research Idea Title:

Quantitative Safety Information on Access Points at Either End of a U-Turn Crossover

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2024-006	2024	5/19/2022 12:00:00 AM

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Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Improved Models Performance/Traffic/Financial etc.;New or Improved Specifications;Improved Worker or Public Safety;Permitting or Regulatory Compliance

Explain Anticipated Benefits:

With a research result in hand, we can either relax our current policies and reduce project costs or we can maintain our current policies with confidence that we are getting a good return on that investment. By making better decisions on projects travel time savings can be expected (by using an RCI or MUT where one was previously thought to be too costly), project right-of-way costs can be reduced, and crashes will be prevented.

What is the problem or issue needing investigation?

NCDOT has installed many one-way u-turn crossovers on arterial roads in recent years. Usually these crossovers are part of a reduced conflict intersection (RCI), median u-turn (MUT) intersection, or other alternative design. The results from RCI and MUT installations have been superb, with published crash modification factors in the range of 0.4 to 0.8 and unpublished crash analyses sometimes showing even greater reductions. RCIs, MUTs, and other designs that use u-turn crossovers also provide great travel time savings, benefits for pedestrians and bicyclists, and other benefits.

Most of the u-turn crossovers NCDOT has constructed have included control of access on the bulb-out (terminal) side and many have included control of access on the origin side. Sometimes purchasing this control of access is expensive; sometimes it means moving or closing an existing driveway; sometimes it means acquiring an entire property. With the price of real estate increasing quickly in the metro areas of NC, these purchases can add greatly to project costs, sometimes endangering the viability of projects or meaning that fewer other projects can be constructed. In addition, it is difficult to make the public relations case for a project being good for business when we are having to take properties, remove driveways, or move driveways that are not in the direct path of the construction.

The main reason for seeking control of access on both sides of a u-turn crossover is safety. On the origin side of the crossover, we do not want vehicles emerging from a driveway and cutting across travel lanes directly into the crossover. Those vehicles could become caught in a queue, ending up stopped and sticking out into those travel lanes. On the terminal side of the crossover, the safety concern is mostly for vehicle emerging from a driveway or side street and conflicting with u-turning vehicles. In addition, if the design includes a large bulb-out, the best signs, markings, and signals to install to control that driveway or side street traffic is unclear.

NCDOT needs to know where it makes sense to control access near a u-turn crossover and where the cost of doing so is not justified. The research objective will be a method or model to predict crashes at a u-turn crossover with or without access control.

Background:

The NCDOT Roadway Design Manual calls for full control of access on both the origin and terminal ends of U-turn bulbs. The suggestion to reexamine this practice was made through the Department's CLEAR (Communicate Lessons, Exchange Advice, Record) program. The CLEAR submission was brought to the Surplus Right of Way Disposal and Control of Access Committee for review. The Committee determined that there is not enough existing data to issue a judgment on the current practice, prompting this research request. Dozens of project teams across the state each year need to make these decisions and could use good information.

A search of the CMF Clearinghouse did not show any published safety study results that could help. The author does not know of any published research result on the topic. The only national guidance the author knows of is material he wrote in the FHWA RCUT Guidebook from 2014 that qualitatively discusses the risk of not controlling access on the origin side of the crossover. The author has had discussions with engineers from other states who also debate this question.

Michigan has hundreds of MUTs and many of their u-turn crossovers have driveways or side streets on the terminal side. Safety data from the MUTs in Michigan typically show superb savings in crashes compared to conventional intersections. It could be that the MUTs of Michigan could be even safer with access control on the terminal side of their u-turn crossovers, or it could be that those driveways and side streets really do not matter to the safety outcome.

Research Tasks:

This should likely be an effort that collects and analyzes crash data. Data from NC will be useful, but the researchers may have to collect data from Michigan and other states to get a good sample size of different conditions. Before-and-after studies using Empirical Bayes methods are the gold standard of quantitative safety research at this point but may not be best for this effort because the before conditions were a long time on the past or were too varied to be helpful. Therefore, some type of cross-sectional

method will likely be more effective.

Products of the Research:

The main product from the research should be a set of considerations on this issue to include in the Roadway Design Manual. Ultimately, we are looking for clear guidance so project designers can say, “We decided to/not to control access on this bulb because x, y, and z.” That guidance will be largely based on a model or method that predicts the number of crashes that would occur at a u-turn crossover with or without driveways or side streets at one end or the other. The model or method should be simple enough to use that a project team at the early stages of design, or even in the planning stages, could apply it with fuzzy input information and still get a useful result that helps them make the decision to control access or not.

Possible IT Components:

Other than providing researchers with access to some NCDOT databases, IT components should be minimal.

Implementation:

It is likely that several webinars will be needed to disseminate the research results to all of the NCDOT and external stakeholders. Across NCDOT the interested parties include division project, project management, right-of-way, roadway design, mobility and safety, and other staff. The results might have to be written into some policies and manuals, like the Roadway Design Guide, to ensure widespread use.

Additional Comments and Information:

Statement is co-sponsored by Robert Barrier, PE, State Transportation Asset Manager, Chief Engineer’s Office, 919-707-2507, RLBarrier@ncdot.gov.

Subcommittee Comments:

Research Idea Title:

When Are There Too Many All-Way Stop Intersections?

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2024-008	2024	5/19/2022 12:00:00 AM

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Benefit or Knowledge Gain for NCDOT:

Improved Models Performance/Traffic/Financial etc.;Improved Worker or Public Safety;Cost Savings

Explain Anticipated Benefits:

The best case from this research would be that, after a vigorous and multi-pronged search, the researchers found no limit on AWSC density. With that outcome, NCDOT staff can continue to use AWSC in high numbers, and drivers and taxpayers will benefit from great safety at low costs. In case the researchers do find a density limit at which AWSC starts to lose effectiveness, and find why the limit exists, NCDOT staff can start to prioritize installations so that only the best candidates get installed staying within the limits, and drivers and taxpayers will still gain in that way. The only way drivers and taxpayers get a poor outcome is if the research is not done and NCDOT carries on installing AWSC sites that lose effectiveness.

What is the problem or issue needing investigation?

All-way stop control (AWSC) is a superb intersection treatment, producing large crash savings and even good travel time results (if used in its niche) at a low cost. AWSC typically produces crash savings similar to roundabouts at about 2 percent of the installation cost. NCDOT began investigating AWSC in earnest around 2009 or so and renewed its interest a couple years ago to the point that AWSC is now among our

leading safety treatments. There are hundreds of installations around the state now, with more to be installed soon. We have documented that AWSC works well with large truck percentages, with unbalanced demands, on high-speed roads, and in other circumstances previously thought to be questionable.

The problem of interest here—probably the most vexing remaining problem with AWSC--is the density of AWSC installations along a corridor or in an area at which motorists start to disregard the stop signs and roll through the intersection more frequently, thereby increasing crash risk. In particular, is there a limit in terms of AWSC installations per mile along a corridor or per square mile in an area at which compliance starts to decline? Maybe motorists facing a series of AWSC intersections are more likely to run them because of real or perceived extra delay, because they do not see conflicting vehicles on the side streets as often, because of annoyance at the stop and go patterns, or some other reasons. Such a density may not exist, and motorist compliance may depend much more on factors other than density. However, if compliance is related to density, we should find out how and then start making traffic control choices with that limit in mind. If the benefits from AWSC are limited due to density, it would be tragic if we wasted those limited benefits on sub-optimal sites.

Background:

Currently, there is no literature available to answer the question, only anecdotes and opinions. There is a considerable literature on stop sign compliance in general, and maybe some of that literature can help with some aspects of this question such as study design.

Research Tasks:

There are a number of ways in which researchers can try to find the density limit in question and why that limit exists, including:

- Observation of current AWSC sites, although finding good sites to study with varying densities might be difficult,
- Analysis of crash data from current AWSC sites, although again finding sites might be difficult,
- A driver simulation study,
- Focus groups, surveys of drivers, expert panels, and
- Streetlight or other big data speed collection method.

One note on crash data collection is that if compliance erodes slowly in an area, it will take some time for that erosion to show up in the crash statistics. Data collection in other states with varying densities in place may be productive. The proposers should describe their data collection methods in good detail.

Products of the Research:

Besides a comprehensive report documenting the literature reviewed, data collected, and analyses conducted, the products of the research should include a brief summary of the findings and presentation slides.

Possible IT Components:

Some access to NCDOT data may need to be provided, but otherwise IT involvement should be minimal.

Implementation:

A limited number of people make decisions on AWSC installation within NCDOT, including division staff, regional traffic engineering staff, and staff in the Mobility and Safety division, so a well-written report summary supported by a webinar or two should be sufficient to get the information to the people who need it. Papers, presentations, and webinars to reach others outside NCDOT with interests in this area (including city staff and other states) would also be good.

Additional Comments and Information:

Statement is co-sponsored by Brian Mayhew, PE, State Traffic Safety Engineer, bmayhew@ncdot.gov.

Subcommittee Comments:

Required to reach out to idea champion, Joe Hummer, prior to submitting a proposal. Other considerations - when do these intersections affect mobility, suggested distance between all-way stops, are there unintended consequences of high concentration of all-way stops?

Research Idea Title:

Effectiveness of NCDOT Dynamic Zipper Merge System

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2024-019	2024	5/27/2022 12:00:00 AM

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Benefit or Knowledge Gain for NCDOT:

New or Improved Specifications;Improved Worker or Public Safety

Explain Anticipated Benefits:

Reseacrch results will be used to improve specifications and work zone safety.

What is the problem or issue needing investigation?

Evaluate the effect Dynamic Zipper Merge systems in NCDOT work zones had on crashes, fatalities, and congestion by comparing projects that had the systems compared to projects that did not have the system.

Background:

NCDOT began implementing Dynamic Zipper Merge systems in long-term interstate lane closures in 2019 in an effort to mitigate and minimize extreme queueing and end-of-queue crashes. Several projects on I-40 and one on I-77 have used the systems and anecdotal evidence points to significantly reduced traffic queueing and a sharp decrease in the number of severe and fatal crashes. We would like for a research team to look at the data and determine whether or not there is a statistically significant decrease in crashes and or queueing.

Research Tasks:

Review crash data related to end-of-queue crashes and queueing/congestion data for projects where Dynamic Zipper Merges were and were not installed

Products of the Research:

NCDOT WZTC unit will use the results of this research to make more informed decisions on the implementation of Dynamic Zipper Merge systems.

Possible IT Components:

Access to crash reporting database

Implementation:

Not sure

Additional Comments and Information:

Subcommittee Comments: