LIST OF RESEARCH NEED STATEMENTS FY-2018

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8102	Reef Link Wave Attenuation for SAV Mitigation	K. Herring	PDEA-NES
8103	A Study to Determine if the Biofuel Crop Camelina is a Wildlife Attractant	J. Fuller	Aviation Division
8104	Selection, Installation and Evaluation of Zoysia Grass	D. Smith	Roadside Envi.
8105	Optimized Design of Dry Detention Basin For Nutrient Load Removal	A. McDaniel	Hydraulics
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8304	Enhanced Maintenance Budget Assessment and Allocation	Watkins/Whitley	Asset Analytics
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8306	Quantifying the Impact of Pavement Preservation in an Area on Market Value and Success of Home Sales	J. Corley-Lay	Materials & Tests
8307	Optimizing use of Fly Ash and Limestone Cement to Improve Durability of Jointed Plain Concrete Pavement	J. Corley-Lay	Materials & Tests
8308	Use of PUC for Performance Characterization of Aggregate in Bituminous Surface Treatments	J. Corley-Lay	Materials & Tests
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8501	Develop Method to Generate AADT on Non-Functionally Classified Public Roads	Bruff, Taylor, Mayhew	Strategic Planning, Traffic Survey, Mobility & Safety
8502	Post-Installation Evaluation of the Effects of Ramp Metering	Troy/Mayhew	Mobility & Safety
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8504	Reasonable Alternatives for Grade-Separated Intersections	J. Hummer	Mobility & Safety
8505	Development of a Model to Predict Wrong Way Crashes By Interchange Type	J. Hummer	Mobility & Safety
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Environment & Hydraulics

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	**July 06, 2016**	**RNS#: (R&D Use)**	**8101**
Submitter Name:	Morgan Weatherford	**Phone:**	919 707-6159
Division / Unit:	Technical Services/PDEA-NES	**Email:**	mdweatherford@ncdot.gov
Research Idea Title:	Using UAV and Remote Sensing Technologies in Road Project Planning		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

As part of the larger streamlining initiative, NCDOT began developing Lidar-based wetland predictive models to reduce costs and project delivery times. However, the Lidar is captured on a statewide level irregularly and offers only a snapshot of current ground conditions. NCDOT desires to capture remotely sensed data that offers flexibility and is best suited to map environmental features on a scale for project specific needs.

Background: *Provide supporting information about the business unit, processes and tools*

UAV and remote sensing technologies are an emerging technology in the transportation industry and recent research has shown it to have the ability to acquire diverse types of data. An opportunity exists to use this technology in conjunction with the NCDOT Wetland Predictive Modeling to provide highly accurate and up to date environmental data during the project planning phase.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

The investigators will review the latest research and UAV /remote sensing technologies to help NCDOT procure the most appropriate products. The investigators will work closely with NCDOT to develop methodologies, GIS tools and/or models to capture and analyze remotely sensed data with UAV to incorporate into wetland prediction model to improve accuracy and efficiency

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Literature and product reviews of the latest research and technologies for UAV/remote sensing with acquisition recommendations, development of methodologies, statistical models and/or GIS tools to capture and analyze data.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☒ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Cost savings, decrease in project delivery times and accurate up-to-date information to improve decision-making thereby reducing risks during project planning.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

NCDOT will incorporate the results of the research directly into the existing process used for the NCDOT wetland predictive models for road project planning.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: PDEA-NES
Title: Environmental Program Supervisor II
Name: Morgan Weatherford

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

Approval (Division Official or Unit Head)

Phillip Harris, III, PE		Section Head-NES-PDEA
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7/17/15	**RNS#:**	**8102**
Submitter Name:	Kathy Herring	**Phone:**	919-707-6128
Division / Unit:	PDEA/NES	**Email:**	mkherring@ncdot.gov
Research Idea Title:	Reef Link Wave Attenuation for SAV Mitigation		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

NCDOT needs a diversity of proven effective, and cost effective methods to effectively mitigate for impacts to submerged aquatic vegetation (SAV) associated with coastal bridge projects. Presently there are a limited range of techniques available; some of which are cost prohibitive and do not support diverse biohabitat development, all of which increases NDCOT's risk and costs.

Background: *Provide supporting information about the business unit, processes and tools*

The NCDOT has two bridge projects planned for NC 12 in Dare County, The replacement for the Herbert C. Bonner Bridge and a bridge in the Rodanthe area that will extend out into the Pamlico Sound. As required by law the NCDOT must mitigate for any adverse effects to submerged aquatic vegetation (SAV) within the project corridors. The proposed Rodanthe bridge spans 10 acres of SAV habitat. In addition to these two projects the NCDOT has agreed to study an alternative that would connect the Rodanthe bridge to the Pea Island area that was breached by Hurricane Irene in 2011. This could result in a 7 mile span over the Sound.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Wave modeling, structure construction, seagrass monitoring, wave /wind data collection, biohabitat colonization monitoring

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

There is no one proven method that works for SAV coalescence. This could result in a proven method for SAV mitigation that would be cost effective.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒	Increase Operational Efficiency / Time Savings	☐	New or Improved Specifications
☒	Cost Savings	☐	Improved Worker or Public Safety
☐	Improved Material, Structure, Pavement Performance	☒	Permitting / Regulatory Compliance
☐	Improved Models (Performance/Traffic/Financial etc.)	☒	Other (Specify)Risk and cost reduction

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

This will provide the data to support a reliable method to encourage the growth of SAV. When combined with other methods, this could result in more diverse ecosystem benefits which would improve compliance with NCDOT's mitigation permit requirements, resulting in potential reduction of mitigation costs.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The results of this research would put into practice in creation of more ecologically diverse wave breaks in support of currently pending NCDOT SAV mitigation permit requirements.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: NES/Biological Surveys

Title: Environmental Program Supervisor II

Name: Kathy Herring

Approval (Division Official or Unit Head)

Phillip Harris, III, PE		Section Head-NES-PDEA
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	**07/20/16**	**RNS#: (R&D Use)**	**8103**
Submitter Name:	Jennifer Fuller, P.E.	**Phone:**	919-814-0560
Division / Unit:	Division of Aviation	**Email:**	jmfuller@ncdot.gov
Research Idea Title:	A Study to Determine if the Biofuel Crop Camelina is a Wildlife Attractant		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

With the rising global fuel demand and decreasing production, non-food crop derived biofuels present a more environmentally friendly alternative than fossil fuels. Increasing operational and fuel costs force airport managers to have significant dollars tied up in maintaining airport green space (i.e. turf grass mowing.) One option to alleviate these financial concerns would be modifying the land use around the airports to support production of oilseeds and other biomass crops that could be used as a fuel resource. A recent NCDOT study assessing wildlife intrusion implications of modifying airport land use for one particular fuel crop, camelina, is in the final stages (RP 2015-14.) The Division of Aviation would like to continue this study to address several questions and concerns raised by aviation stakeholders regarding the potential for crop production at an airport facility.

Background: *Provide supporting information about the business unit, processes and tools*

Initial crop production efforts have shown promise in identifying land characteristics needed for a good crop stand of camelina. With a successful crop this past year, additional observations are needed to make reasonable assessments regarding wildlife attractiveness. In addition, further examination of crop production management including site preparations and input is needed to support development of sustainable production methods.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

As part of the next phase of the project, researchers shall examine (1) crop rotations, tillage practices and planting time to investigate the costs and feasibility associated with transforming fallow grassland into productive crop land and (2) the wildlife impact of this operation shall be fully assessed to mitigate concerns related to the crop attractiveness to wildlife, a safety threat at any airport. Investigate the feasibility of producing camelina and other energy crops at airports in North Carolina and develop criteria to select land available for crop production and visually map selected lands at all airports in the state. Determine how much airport land is available and what criteria should be used to select land to include in this type of activity. Assess the economics of producing crops at airports and converting oilseeds to biodiesel on site to determine the feasibility of the operation. Examine the potential interactions between various forms of wildlife and aviation vehicles. The USDA will provide support for wildlife surveys and assessment of risks to safety.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Cost and return estimates for the individual crops and crop rotations comparing to current turfgrass management activities. Overview of equipment and materials required to cultivate and manage crop rotations and a general production schedule. GIS maps of NC airports including which land areas are potentially available for conversion to agricultural crop production. A users guide to camelina production at airports including use and potential markets.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The GIS metric will be useful in determining the availability of airport lands for crop production. BMP guide for winter oilseed production will allow airport managers to assess implementation of oilseed crop production to support renewable fuel alternatives. Cost and return estimates will allow airport managers to make informed decisions about resources to reduce operational costs. The guide to biodiesel production at airports will allow managers to make informed decisions regarding use of facility resources.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

A possible airport field day (similar to field day for previous project) held on-site to provide managers hands-on demonstration and allow discussion aspects of project with researchers and USDA. Formal publications will provide airport managers guidance for implementing crop production activities. The publications will be disseminated to airport managers across the state. Possible press releases for the Department to draw positive attention for support of both NC airports and the production of cleaner fuels and protect the safety of the traveling public.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Division of Aviation
Title: Planning and Environmental Engineer
Name: Jennifer Fuller, P.E.

Approval (Division Official or Unit Head)

Bobby Walston, PE		Aviation Director
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	June 23, 2016	**RNS#:**	**8104**
Submitter Name:	Derek Smith	**Phone:**	919-707-2939
Division / Unit:	Roadside Environmental	**Email:**	dcsmith@ncdot.gov
Research Idea Title:	Selection, Installation and Evaluation of Zoysia Grass		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

In spring of 1998, NCDOT began a guardrail installation initiative which culminated in over a 1000 miles of newly installed median rail. While dramatically reducing head-on collisions resulting from cross-median collisions, medial rail systems have an increased fiscal impact upon the Department to control weedy vegetation under these structures. A combination of chemical and mechanical weed control management strategies developed as part of previous research projects (FHWA/NC/2004-02 and FHWA/NC/2013-17) have proven to be time consuming and expensive to implement. The use of zoysia grass as part of a 'cultural management philosophy' needs exploration to develop comprehensive, regionalized guardrail management plans that reduce long-term maintenance cost and improve associated aesthetics.

Background: *Provide supporting information about the business unit, processes and tools*

Previous projects were limited in their evaluation and did not fully investigate all commercially available zoysias nor did they evaluate F1 progeny (yet to be released first generation varieties) produced by NCSU's Turfgrass Breeding Program. In late 2015 and early 2016, two 80-hour technical assistance projects were initiated at NCSU to select five zoysia grasses from these F1 progeny. These plants have been evaluated in field trials for drought tolerance, cold hardiness and turf quality at three research sites (Raleigh, Jackson Springs, and Laurel Springs). Zoysia produces both above-ground and below-ground stems that characteristic spread and regenerate areas following injury. These characteristics make it an ideal roadside turf.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Research will compare NCSU's F1 progeny against commercially available zoysias in replicated roadside trials. Among other tasks the primary investigator will be charged to survey southeastern sod producers and develop a list of commercially available zoysia varieties for consideration in this research. The investigator will compare dormant and early spring installations. In addition to longitudinal spread, spread-density, survivability under non-irrigated roadside conditions, and turf quality should be evaluated. The initial F1 progeny selections shall be compared to future F1 progeny.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

An evaluation of commercially available and F1 zoysias to determine the best varieties for NC rights of way and their performance in the State's three geographical regions.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The use of zoysia will reduce traditional maintenance costs while improving roadside vegetation ratings statewide.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

Zoysia has the potential to reduce mowing of traditional fescue routes from 5 to 2 mowing cycles per year. Unlike other turfgrass varieties, zoysia produces a thick vegetative cover that will also naturally deter weed germination.

Who will lead the implementation? *Provide Unit, Position Title and Name.*

Unit: Roadside Environmental Unit
Title: State Roadside Environmental Engineer
Name: Don G. Lee

Approval (Division Official or Unit Head)

Don G. Lee, CPESC		State Roadside Environmental Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	8/5/16	**RNS#:**	**8105**
Submitter Name:	Andy McDaniel, PE	**Phone:**	919-707-6737
Division / Unit:	Hydraulics	**Email:**	ahmcdaniel@ncdot.gov
Research Idea Title:	Optimized Design of Dry Detention Basin For Nutrient Load Removal		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Dry detention basins (DDBs) are a valuable stormwater best management practice (BMP) in NCDOT's BMP Toolbox design manual. DDBs are particularly useful for controlling peak flows and preventing degradation of downstream conveyance channels. The absence of a permanent pool also makes DDBs attractive for use within the right-of-way from a safety and maintenance perspective. Unfortunately, there are very few scientific studies conducted either within NC or nationally which quantify the water quality benefit of DDBs. The NC Division of Water Resources (NCDWR) does not recognize DDBs as a BMP which reduces nutrient loads from highway stormwater runoff. Therefore, NCDOT cannot currently use DDBs for regulatory credit in compliance with nutrient load reduction rules. With design enhancements and additional performance characterization DDBs may be capable of higher levels of pollutant removal than is currently recognized by environmental regulators. NCDOT needs to investigate appropriate design enhancements for DDBs and document the associated pollutant removal performance as the basis for justifying and quantifying regulatory credit for this BMP type.

Background: *Provide supporting information about the business unit, processes and tools*

The Hydraulics Unit has worked in partnership with the NCDWR to develop a nutrient load reduction accounting tool for BMPs in NCDOT's BMP Toolbox. This accounting tool has been formally approved by the NC Environmental Management Commission and is required for use as part of the Department's compliance with the Jordan and Falls Lake nutrient load reduction rules. Due in part to the paucity of scientific studies quantifying the water quality benefit of DDBs, the current version of NCDOT's accounting tool does not credit DDBs as reducing nutrient loads in highway stormwater runoff. Using simulated stormwater runoff it may be possible to test various design enhancements under controlled conditions and quantify an improved nutrient load reduction benefit. Such design enhancements might include increasing volume reduction through improved infiltration and evapotransporation capacity components of the BMP (e.g. influence of driving head and/or internal water storage could be tested); incorporation of woody and herbaceous native plant material to improve nutrient sequestration within biomass; increase settling and capture of nutrient bound particulate matter through increased flow pathways.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

1. Perform a literature review of DDB performance in the linear environment.
2. Identify key design enhancements of DDBs which impact nutrient removal performance and which could be varied within typical right-of-way constraints.
3. Conduct a controlled test of DDBs to quantify the effect of design enhancements.
4. Corroborate the findings of controlled test via monitoring of DDBs in the highway right-of-way.
5. Develop a computer model to quantify the nutrient load performance of the various design enhancements.
6. Provide DDB design and computer model training to NCDOT hydraulic design engineers.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Performance data and recommendations on optimal design of DDBs; pre- and post-retrofit data that could be used to recommend changes to the NCDOT-specific

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐	Increase Operational Efficiency / Time Savings	☒	New or Improved Specifications
☒	Cost Savings	☐	Improved Worker or Public Safety
☐	Improved Material, Structure, Pavement Performance	☒	Permitting / Regulatory Compliance
☒	Improved Models (Performance/Traffic/Financial etc.)	☐	Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

This research would allow NCDOT to optimize DDB design to improve nutrient removal performance in impaired watersheds where large nutrient load reductions are mandated. It would also potentially allow NCDOT to claim regulatory credit for DDBs in meeting these load reductions in the JFSNAT.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The Hydraulics Unit would update its BMP Toolbox manual to reflect the design enhancements tested. The improved guidance would then become the design standard for DDBs Department-wide. Hydraulics Unit staff would update the nutrient load accounting tool in partnership with NCDWR in order to achieve regulatory credit for projects proposing DDBs.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Hydraulics Unit
Title: Highway Stormwater Program Manager
Name: Andy McDaniel, PE

Approval (Division Official or Unit Head)

David Chang, Ph.D., PE		State Hydraulics Engineer
Print Name	Signature	Title

Planning, Program, Policy & Transit

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7/15/16	**RNS#: (R&D Use)**	**8201**
Submitter Name:	Mark Kirstner	**Phone:**	336.291.4308
Division / Unit:	Piedmont Authority for Regional Transportation (PART)	**Email:**	markk@partnc.org
Research Idea Title:	Piedmont Triad Freight Study Phase III: Truck Driver Survey		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

The Piedmont Triad Regional (Travel Demand) Model treats all vehicles, i.e. cars and trucks, the same. Currently it is trip-based model and does not capture the true nature of truck and freight movements. The trip-based model simplifies assumptions and the limited behavioral foundations for freight modelling and policy making. The four Piedmont Triad MPOs and the Piedmont Authority for Regional Transportation desire to develop a tour-based model for truck and freight vehicle movements in the region. The tour-based model will more accurately account for truck and freight vehicle movements. The Piedmont Triad Freight Model Study will enter Phase III in the Spring of 2017. Further data investigation is needed through an extensive number of driver diary surveys. The methodology of this investigation, its completion and the analysis of the data are needed in order to calibrate and validate the advanced disaggregate tour-based freight model to ready it for future freight demand analysis and scenario planning. This investigation should be conducted using advanced GPS technologies to reduce the traditional issues of burdening drivers and industry worries regarding competitiveness when sharing data.

Background: *Provide supporting information about the business unit, processes and tools*

PART is developing an advanced disaggregate tour-based freight model to run along with the PTRM (Piedmont Triad Regional Model) and provide much needed insight to expand our understanding of transportation demands in the Piedmont Triad region. Phase I and II of the development process are complete. The data required for Phase III has been recommended through Phase II.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Passive GPS data collection with GPS logger: the only thing truck driver needs to do is to ensure that GPS devices have sufficient battery power and satellite visibility with turning it on/off before and after making trip.
Supplemental Web-based Trip Diary Survey: to obtain additional information about the trip such as the stop purpose, types and quantities of goods delivered, and the order of delivery location
Freight business establishment survey: industry code, type of commodity produced or consumed, # of truck bays, # of trukcs, etc.
Investigate Freight Clusters

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Individual behavioral freight data including activity and tour characteristics; e.g. stops, durations, routes….
Detailed data related to the routing and temporal patterns of freight/commercial vehicle trips
Highly accurate geospatial information
Methodology for frequency of updating the data for future input into the freight model

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☐ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

An advanced disaggregate tour-based Piedmont Triad freight model for use in informing land use planning, transportation planning, policy scenario analysis and project prioritization
Estimate truck trips
Identify characteristics supporting freight clusters
Understanding of dynamics between congestion and freight (for policy makers and staff)
Better understand of impacts of land use decisions on freight movement (for policy makers and staff)
Benefits to industry through identifying and developing significant truck route(s)

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

To calibrate and validate the disaggregate tour-based freight model incorporated into PTRM
To implement PTRM running with the incorporation of disaggregated tour-based freight model component
To utilize more detailed information about freight trips for the policy-making, logistics plan, transportation plan, etc through analyzing and better understanding the behavioral aspects of freight vehicle activities
To share the survey methodology with the practitioner groups in North Carolina

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Piedmont Authority for Regional Transportation: Planning Dept.
Title: Regional Transportation Modeler
Name: John Kim, PhD

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

PART invites the opportunity to work with NCA&T, NCSU or any other universities to complete Phase III of the Study.

Approval (Division Official or Unit Head)

Mark Kirstner		Director of Planning
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7/25/2016	**RNS#:**	**8202**
Submitter Name:	Majed Al-Ghandour and Frank Bowen	**Phone:**	919-707-4620
Division / Unit:	Division of Planning & Programming Project Management Unit	**Email:**	malghandour@ncdot.gov
Research Idea Title:	Determining Best Practices to Improve on-Budget Future Project Expenditure Payout Predictions		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Previous work defined mega project time lines from project inception through completion, assessed the cause of delays at key project milestones, created a project monitoring checklist, and determined preliminary methods to estimate future monthly project expenditure payouts. The current proposed work will quantify the rate at which those expenditure payouts occur over the entire project life cycle, enable their estimation at any point in time, and provide a projection of the change in payouts over time as a project matures. The work will improve the accuracy of future project expenditure payouts. It will incorporate a probabilistic component to assess payout variability. It will result in better guidelines, business practices, and models for estimating future monthly large project payout estimates.

Payout curves differ between STIP project types. Differing project constraints and organizational constraints result in different payout curve trends. The need is to identify these trends for different project types and to identify the constraints and conditions that cause them. If this is done, NCDOT will be able to better optimize the match between funding acquisition and expenditures for large projects.

Background: *Provide supporting information about the business unit, processes and tools*

NCDOT seeks to implement strategies to develop more accurate large STIP project expenditure estimates earlier in the project development phase, to understand how those estimates change over the life of the project, and to more accurately pinpoint the final actual expenditure payouts. Significant cost management benefits could be realized if the rate of future project expenditures could be more accurately forecast over incremental project time periods, thereby better enabling NCODOT to meet scheduling and budget requirements. Optimizing project expenditure payout estimates over the project life cycle will provide cost savings, improved efficiency in the allocation of limited funding, and a reduction in uncertainty of future costs.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

- Review current literature relevant to future cost estimation based on financial & scheduling constraints & best practices.
- Evaluate current standards to assess cost prediction methods.
- Collect data on past projects and expanding previous work to include all projects over $20 million.
- Determine and quantify the factors affecting cost variations.
- Develop a conceptual framework, methodology, and tools for estimating cost and duration of large highway projects.
- Incorporate probability into the model.
- Develop a spreadsheet to demonstrate the model.
- Validate the spreadsheet using actual project data.
- Perform case studies to assess different project groups based on their characteristics.
- Develop a set of best practices for implementing the model.
- Identify NCDOT business process enhancements to better implement the model.
- Identify project control metrics to stabilize future costs and payout estimates.
- Provide new knowledge on which NCDOT engineers and practitioners can base their decisions about future funding and project scheduling needs.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Tools, models, and innovative practices.
A real-time interactive spreadsheet to demonstrate the model.
Graphs, guidelines, and recommendations.
Steering committee and NCDOT personnel meetings.
Presentations of oral and quarterly and final written reports.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒	Increase Operational Efficiency / Time Savings	☐	New or Improved Specifications
☒	Cost Savings	☐	Improved Worker or Public Safety
☐	Improved Material, Structure, Pavement Performance	☐	Permitting / Regulatory Compliance
☐	Improved Models (Performance/Traffic/Financial etc.)	☐	Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The results of this project will allow NCDOT managers to evaluate project expenditure payout curves of individual projects, consolidate payout curves across active projects, and forecast trends that would impact the payout rate. Identification of trend changes can be used to alter budget allocations in a manner that optimizes financial resources. Additional benefits include the following.

- Bring the organization to a state-of-the-art standard of project cost prediction.
- Improve the practice of future project estimating to enhance budgeting.
- Deliver projects to the public at the anticipated cost.
- Deliver accurate future cost payout estimates to planners.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

Engineers will use future cost payout estimates for producing, manipulating, and assessing future payout scenarios. Staff will be able to use the model to identify future costs and to assess their future variability.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Funds Administration Section
Title: Business Systems Analyst Supervisor
Name: Frank Bowen

Approval (Division Official or Unit Head)

Patrick Norman/ David Tyeryar		Director/CFO
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 22, 2016	**RNS#:**	**8203**
Submitter Name:	Jessica Kuse	**Phone:**	919-707-4810
Division / Unit:	Technical Services/TPMU/Value Management	**Email:**	jkuse@ncdot.gov
Research Idea Title:	Product Evaluation Tracking Tools and Product Categories		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

NCDOT currently does not uniformly track products placed in the field to be able to monitor long term performance.

Background: *Provide supporting information about the business unit, processes and tools*

Value Management manages the Approved Products List (APL) for the Department. The APL is currently managed through the HiCams/Vendor database. This database is used to track certain categories of products submitted to the Department for evaluation. It is also used to pay the contractor for work completed which may correlate to materials used. HiCams has a function that could track products used on a specific project and ITS uses a prequalification strategy to track product usage. However, a uniform, user-friendly tracking tool which would also provide the ability to monitor long term performance is not currently utilized. Have this type of tracking tool would enhance the Department's selection of products allowed for use on North Carolina transportation infrastructure. For product submittals and evaluations, there is currently an IT project being developed to create a SharePoint based application and evaluation portal. A vision of the Department is to have specified products evaluated and used within the Department tracked for usage and performance reporting.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

(1) Research tools for tracking product usage in the field for each category currently in NCDOT APL. Define tracking tool inputs and reporting outputs needed to allow long term performance monitoring and feedback. Identify which categories of products are typically tracked by other states and are necessary to be tracked by the Department. Analyze tracking tool for ease of use in the field.
(2) Survey a minimum of 20 other state DOTs (or state equivalent) to gather best practices for processing and organizing product submittals. This would include the recommended categories for Approved Product Lists and definitions, a summary of practices, recertification procedures (how do states keep their APLs current), tracking tools used, product categories tracked, evaluation fees (if applicable), explanation of evaluation processes for current products, new products and new technologies being investigated, and best practices for creating a culture of innovation.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

(1) Analyze and identify the optimal tool for tracking product usage in the field with the resources currently available within the Department. This tool should provide information on the product name, manufacturer, NCDOT tracking number (NP Number), date of installation, etc.
(2) Analyze and recommend optimal tools for tracking product usage which may be available with additional Department resources.
(3) Develop recommended best practices for processing and organizing product submittals by analyzing a minimum of 20 other states current processes and procedures. This would include the recommended categories for Approved Product Lists and definitions. Additionally, as an appendix, all data collected should be provided and categorized by the state from which the data was collected. This would include, but isn't limited to, a summary of practices, recertification procedures, product categories used, and an explanation of evaluation processes for current products, new products and new technologies.
(4) Recommend best practices other states have used when creating a culture of innovation within a Department of Transportation or state's equivalent.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☐ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Providing recommendations for effective tracking tools for field product usage and innovative product procedures will help NCDOT increase operational efficiency.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The Department will use the recommendations and best practices to determine the best direction to take product evaluation and innovative technology tracking into the future for NCDOT to promote the vision to become a global leader for innovative transportation solutions.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: TPMU/Value Management
Title: State Value Management Engineer
Name: Jessica Kuse

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

Additional units to involve in this research are the Construction Unit, Divisions, Materials and Tests Unit, Mobility and Safety, Structures, Geotechnical Engineering, Hydraulics, IT and Contracts and Standards Unit.

Approval (Division Official or Unit Head)

Jessica Kuse, PE, CPM		State Value Management Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	**July 18, 2016**	**RNS#:**	**8204**
Submitter Name:	Brian Wert	**Phone:**	919-707-0974
Division / Unit:	SPL (Transportation Planning Branch)	**Email:**	bmwert@ncdot.gov
Research Idea Title:	Peak Spreading Tool Implementation		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

North Carolina is growing rapidly and both the pace and location of growth is shifting such that the state is becoming much more urbanized than it previously was. Urbanized areas have different travel patterns that impact traffic forecasting and ultimately project design.

Background: *Provide supporting information about the business unit, processes and tools*

TPB is currently working on a research project to pull together information about how density and peak travel are linked. This study will examine how traffic has changed as development increased throughout the State and throughout the southeast. This project will take the results of that study and the beta tools and develop a final tool and implementation strategy that will help traffic forecasting understand how traffic spreads and how to implement this tool in the forecasting process.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Working off of previously collected data the project team will make recommendations as to where and how peak spreading may occur and also develop a tool to assist traffic forecastors determine the amount of spreading. This tool will likely be in the form of an excel spreadsheet. There will also be documentation associated with this task that can withstand legal challenge and provide the necessary information to support this task.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

A best practices report as well as a tool that may be in excel to determine the likely amount of peak spreading in a future year.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Having a tool and the research complete will allow TPB to add this service in a time effective manner. Cost savings should be realized by the department as projects could be better tailored to future needs and thus either allow for smaller projects or projects sized such that an additional project in the near future will not be necessary. A localized model or tool will provide NCDOT with the ability to forecast these conditions for North Carolina conditions and not simply rely on national averages based on limited data.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The best practices report and the tool will be immediately incorporated in to the forecasting process to provide better future year data. The forecasting process already includes a review of conditions to determine future year design data. The tool and report will be incorporated in to that phase and likely reduce time associated with this task.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: TPB
Title: State Traffic Forecast Engineer
Name: Brian Wert

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

Approval (Division Official or Unit Head)

Print Name	Signature	Title
Jamal Alavi, PE		Branch Manager - TPB

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 28, 2016	**RNS#:**	**8205**
Submitter Name:	Sterling Baker	**Phone:**	252-482-1850
Division / Unit:	Ferry Division	**Email:**	Sbaker@ncdot.gov
Research Idea Title:	Update on the March 2010 study by ITRE on the Economic Impact of the Ferry Division's Operations		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

The economic impact of the Ferry Division's operations was determined in a 2010 study be ITRE. These numbers need to be revised and updated to reflect current real world conditions as many contributing factors to this original number have changed since 2010.

Background: *Provide supporting information about the business unit, processes and tools*

The Ferry Division operates 21 vessels at 7 locations in eastern North Carolina. The nature of these routes vary from heavy tourist use to daily commuters depending on the locations. The Ferry Division also operates a fleet of support vessels to assist in their own dredging and marine maintenance activities. The Ferry Division also owns and operates its own shipyard where vessel repairs are performed.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

To update the 2010 study in order to better define and present up to date data on the impact the Ferry Division has in eastern North Carolina and across the State. Previous year's traffic data can be provided by the Ferry Division, but the study should perform detailed traffic counts in order to better determine the types businesses and varying uses of the Ferry System customers. This data will then look at seasonal trends develop ridership models and determine growth percentages for the respective routes. The study will perform market surveys and use industry data to then determine economic impacts related to the operations of the ferries.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The finished study should be a document that provides traffic data and breakdown analysis for each route in order for Ferry personnel to better develop optimized schedules. The study will detail the type of traffic utilizing each route and then determine and overall economic benefit of the Ferry System. This should also include the impact of the shipyard and dredging activities performed by the Ferry Division.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☐ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The traffic data will assist the Ferry personnel in optimizing schedules across the system and to better determine and document what type of traffic is utilizing each route. This will aid in better decision making for operational efficiency improvements. The information provided in relation to the economic impact will be of great benefit to the Department and others (Commerce, Legislature, etc.) in order to have better and more informed discussions and decision making related to Ferry Division projects and operations.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

Data will be used to optimize services and improve scheduling efficiencies. The ecomic numbers will be used by the Department for future discussions and business decisions.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Ferry Division
Title: Ferry Director & Multimodal Special Projects Eng.
Name: Ed Goodwin & Sterling Baker

Approval (Division Official or Unit Head)

Sterling Baker, PE		Multimodal Special Projects Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 28, 2016	**RNS#:**	**8206**
Submitter Name:	Sterling Baker	**Phone:**	252-482-1850
Division / Unit:	Ferry Division	**Email:**	Sbaker@ncdot.gov
Research Idea Title:	Manpower and Efficiency Study of the Manns Harbor Shipyard		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

The Ferry Division's 20 year Capital Improvement Plan includes vessel rehabilitation as a critical asset management component in order to make the plan sustainable and the best utilize existing assets. The NC general Assembly has funded a facility expansion to facilitate these rehabilitations, but a thorough manpower study is needed to best determine the actual number of personnel and contractors needed to make this plan successful. It is recognized by all that the shipyard is understaffed to successfully implement this program.

Background: *Provide supporting information about the business unit, processes and tools*

The Ferry Division operates 21 vessels at 7 locations in eastern North Carolina. The nature of these routes vary from heavy tourist use to daily commuters depending on the locations. The Ferry Division also operates a fleet of support vessels to assist in their own dredging and marine maintenance activities. The Ferry Division also owns and operates its own shipyard where vessel repairs are performed.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

To review the vessel needs and CIP demands that will create demand on the Ferry Division's shipyard and use sound and proactive business approaches to provide detailed manpower recommendations in order to achieve target levels of service. This will include mostly data gathering and market research and analysis.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The finished study should be a document that provides manpower and staffing recommendations for efficient operations at the Manns Harbor Shipyard. This study should provide guidance in organizational structure, manpower numbers, types of positions, shift scheduling, etc.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☒ Cost Savings	☒ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The data supplied will allow Department Leadership to have sound discussions with Legislative personnel on how to implement this program for rehabilitations while providing a satisfactory level of service as required t o meet Coast Guard requirements. This data will be used to develop business plans, staffing plans, and assist in making informed decisions about delivery of the Ferry Division Capital Improvement Plan.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The numbers generated by this study will allow NCDOT to justify any positions that may be needed to implement and sustain this CIP program along with the daily needs of the shipyard in regards to normal vessel maintenance and repair.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Ferry Division
Title: Ferry Director & Multimodal Special Projects Eng.
Name: Ed Goodwin & Sterling Baker

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

Approval (Division Official or Unit Head)

Sterling Baker, PE		Multimodal Special Projects Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 22, 2016	**RNS#:**	**8207**
Submitter Name:	Jesse Day, PTRC Planning Director	**Phone:**	336 904-0300
Division / Unit:	RPO	**Email:**	jday@ptrc.org
Research Idea Title:	Transportation Infrastructure Investment that Supports Economic Development		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Better impact data is needed to see how different transportation investments support or do not support local economic development efforts. There are many factors that influence the impact: design, adjoining land use, activity centers, adjacent infrastructure, and transportation options. Are there other analyses beyond IMPLAN and other modeling tools that may inform economic impact.

Background: *Provide supporting information about the business unit, processes and tools*

This concept was mention at a Piedmont Triad Regional Development Corporation sub-committee on regional infrastructure.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Gathering data, historical data, tax records, some field survey data and traffic analysis.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Case studies, cumulative and indirect impact analysis, market studies.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Understanding case studies on economic impact will allow better decision making in which projects are built and best practices and policy that support transportation infrastructure investment. The investment in other non-transportation infrastructure may also benefit from this analysis (e.g. water, sewer, natural gas, etc.)

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

This could influence transportation prioritization, but also may be used by other partners in the State.

Who will lead the implementation? *Provide Unit, Position Title and Name.*

Unit: _____

Title: _____

Name: _____

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

The Piedmont Triad Regional Council planning department would be interested in participating in the research to better identify outcomes. We can also work with our committees on Regional Infrastructure to further define inputs and outcomes.

Approval (Division Official or Unit Head)

Jesse Day		PTRC Planning Director
Print Name	Signature	Title

Pavements & Materials

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7/7/16	**RNS#:**	**8301**
Submitter Name:	Emily McGraw	**Phone:**	919-835-8445
Division / Unit:	State Maintenance Operations	**Email:**	emcgraw@ncdot.gov
Research Idea Title:	Develop Laboratory Test and Specifications for Cold Patch Material		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

NCDOT is responsible for patching potholes within a 48 hour period. There are numerous products on the market at varied prices. There is not a consistent standard used for evaluating cold patch material. Based on interviews conducted by the State Maintenance Field Coordinator, most County Maintenance Engineers stated they needed a better, more effective, longer lasting cold patch product.

Background: *Provide supporting information about the business unit, processes and tools*

State Maintenance Operations is a field support unit that assists Division personnel. SMO reviews new products and processes as part of the Department's product evaluation team. This group dealt with a similar need over a decade ago. Then State Road Maintenance identified that Divisions had concerns with choosing asphalt solvent products. There was an initiative to develop a testing program and specification for asphalt solvent material. Through a collaborative effort including a researcher, the Department developed a specification, and a testing program for asphalt solvents. NCDOT needs a similar program and specification for selecting cold patch materials that work and are cost effective.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

- Literature review/Data Gathering – determine how other states select their cold patch material. Research cold patch specifications. Research laboratory/field tests for cold patch
- Data Gathering – Survey NCDOT to determine what cold patch material is used and gather qualitative data on performance
- Recommend/Formulate tests for determining cold patch material performance
- Conducts tests on cold patch material and validate with qualitative data from survey

Products of the Research: *Examples of products could include models, specifications, policies, general guidance…etc.*

- Specification for cold patch material
- Tests for validating cold patch material performance
- Recommendations for selecting cold patch material

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The benefit of this research will be to have a specification and test(s) to make sure the department is using good cold patch material. Once a specification and testing program is developed, the Department could pursue establishing a Qualified Product List and have a statewide contract for cold patch material. Having a statewide contract will reduce costs and improve efficiency. The Product Evaluation team will no longer need to review cold patch products on an as needed basis. A unit will be able to conduct a testing program at one time during the year.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

Upon receiving the cold patch specification and tests, the Department will establish a Cold Patch Evaluation team comprised of field, central maintenance, M&T and purchasing personnel. The team will develop a formal testing program, establishing a Qualified Products List. Purchasing will develop a statewide contract and only products on the QPL will have an opportunity to place a bid for the statewide contract.

Who will lead the implementation? *Provide Unit, Position Title and Name.*

Unit: State Maintenance Operations
Title: State Maintenance Operations Engineer
Name: Emily McGraw

Approval (Division Official or Unit Head)

Scott Capps, PE		State Maintenance and Equipment Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 18, 2016	**RNS#:**	**8302**
Submitter Name:	Mustan Kadibhai, PE	**Phone:**	919-508-1819
Division / Unit:	Research & Development	**Email:**	mkadibhai@ncdot.gov
Research Idea Title:	Quantifying Oxidation of Asphalt Pavements		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Asphalt surfaced pavements in NC experience significant oxidation drying that results in top down cracking. Current pavement condition survey regarding oxidation is very subjective. Having a method of measuring and quantifying the oxidation drying will allow maintenance and preservation treatments just prior to cracking.

Background: *Provide supporting information about the business unit, processes and tools*

Oxidation drying is a major pavement distress in NC. Currently it is subjective and categorized visually as "Low" or "Severe". Two new non-destructive methodologies developed at NCSU – surface wave testing and colorimeter damage ratio will enable objective quantification of visual oxidation drying and in situ field measurement of material properties using non-destructive wave propagation technique. Both tests are relatively simple to conduct and are done using portable devices. These tests will enable NCDOT to make maintenance and pavement preservation decisions before cracking damage occurs.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

1. Literature review of factors affecting oxidation drying and link to stiffness increase/cracking propensity.
2. Identify test mixes and field sites for study.
3. Adopt surface wave test methods for pavement characterization.
4. Monitor oxidation using both colorimeter and surface wave testing over time.
5. Analyze results and make recommendations regarding use of the two test methods to quantify oxidation drying.
6. Recommend next steps and implementation plan.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

This study will result in test procedure recommendations for objective quantification of oxidation drying in terms of visual color change and material property – increase in stiffness of surface layer with time.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

If the method is feasible, it will enable NCDOT to develop a program for use of fog seals or rejuvenators to prevent cracking as the surface dries resulting in improved pavement performance and substantial cost savings.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

NCDOT will be able to model objectively oxidation drying in their pavement management system program.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit:	Materials & Tests
Title:	State Pavement Design Engineer
Name:	Clark Morrison, Ph.D., PE

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

The construction, materials and tests, and pavement management units will be critical partners in this project.

Approval (Division Official or Unit Head)

Chris Peoples, PE		State Materials Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7/22/2016	**RNS#:**	**8303**
Submitter Name:	Clark Morrison, Ph.D., PE	**Phone:**	919-835-8202
Division / Unit:	Materials and Tests Unit	**Email:**	cmorrison@ncdot.gov
Research Idea Title:	Evaluation of Methods for Detection of Delamination in Asphalt Pavement Layers		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Asphalt pavement is constructed in layers. Optimal performance of the pavement depends on adequate bond strength between the pavement layers. When this bond fails, premature cracking, shoving and tearing may occur. Portions of the surface layer may also be lost in plate-like chunks. This debonding can occur in both new pavement construction, and overlays of existing pavement. When the loss of bond is widespread in a project, the cost of repair can be very large. If the delamination could be detected during construction or within the warranty period for the project, financial loss may be avoided. Early detection may also assist in identifying the cause of delamination so it could be avoided in the future.

Background: *Provide supporting information about the business unit, processes and tools*

SHRP2 recently (2013) completed a project evaluating nondestructive testing methods to identify delamination between HMA Layers. (Report available at http://www.trb.org/Main/Blurbs/167281.aspx.) This report identified two promising technologies:

1. Frequency Sweep Ground Penetrating Radar by 3D-Radar
2. Impact Echo/Spectral Analysis of Surface Wave Technique Developed by Olson Engineering.

The GPR data can be collected at highway speeds, and if enough antennas are used, over a full lane width. Processing of the data may be labor intensive and require specialized training. 3D-Radar has told the writer of this RNS that the analysis software has been improved since the SHRP study, and is easier for a non-expert to use.

The IE/SASW technique requires a lane closure. Processing of the data may be complex and time consuming.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

1. Identify sections of pavement that have delamination and sections of pavement that do not have delamination. These sections could be parts of North Carolina roads, or they could be pavement sections created in a laboratory setting, or both.
2. Use the techniques listed above, and any others that may be appropriate, to identify delamination of pavement layers.
3. Evaluate whether the techniques can be used to successfully identify pavement delamination. A successful techniques should be able to identify delamination where it occurs without an unacceptable number of false positives.
4. Evaluate whether the data collection and analysis techniques are suitable for use by NCDOT engineers and/or technicians.
5. For suitable techniques, develop guidelines for use, and if necessary a simplified user's guide for software.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Recommendations regarding the suitability of the evaluated techniques for identifying delamination in HMA pavement layers.

Recommendations regarding the suitability of the evaluated techniques for use by NCDOT engineers and/or technicians. For suitable techniques, guidelines for use and simplified user's guide for software.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Repair of delamination after acceptance of a project can be very expensive. If delamination can be identified during construction, or during the warranty period, this cost may be reduced. If pavement delamination could be identified during construction, construction processes that lead to the delamination may be identified and avoided. Eliminating delamination or repairing them in a timely cost-effective way will lead to improved condition of the pavement, and safer, more comfortable use by the travelling public.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

If a techniques is found to be suitable, it could be used as a forensic tool to identify delamination as the cause of pavement distress. A suitable technique could also be used on selected resurfacing projects as a quality assurance tool during construction or to identify flaws in the pavement structure before the warranty period expires.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Materials & Tests
Title: State Pavement Design Engineer
Name: Clark S. Morrison

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

I believe this project can be done without purchasing the equipment. I believe both suppliers of the equipment can perform the testing as a service, for a cost that would be less than the purchase price. The Construction Unit, and Highway Divisions will need to assist in the execution of the project and implementation if a suitable technique is identified.

Approval (Division Official or Unit Head)

Chris Peoples, PE		State Materials Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	07/22/2016	**RNS#:**	**8304**
Submitter Name:	Lonnie Watkins and Matthew Whitley	**Phone:**	919-835-8421
Division / Unit:	Transportation Asset Analytics	**Email:**	lrwatkins@ncdot.gov / mpwhitley@ncdot.gov
Research Idea Title:	Enhanced Maintenance Budget Assessment and Allocation		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

There is a need to better understand the relationship between roadway condition and maintenance expenditures, to accurately model that relationship, and to use the model to predict future expenditure needs (or determine future condition for a given expenditure level). There is also a need to optimize the relationship between budget allocation and locale (State, Division, County), road classification (I, P, S), and asset feature (currently 11 for roadways).

Background: *Provide supporting information about the business unit, processes and tools*

With deteriorating infrastructure and limited funding it is important to identify innovative ways to manage infrastructure asset features. The goal is to determine an optimal maintenance plan to efficiently balance expenditures and condition roadside features, on 3 road types (Interstate, Primary, and Secondary) by state division and county. Presently there isn't a solid link between condition and expenditures. Thus, there is no current method for predicting future asset conditions and preparing a budget for the preservation and enhancement of a feature.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Literature review of NC highway sampling, condition assessment, and condition-expenditure technical reports and journal articles. Survey the practices and procedures of other states. Acquire the needed NCDOT MCAP data. Assess at least 5 NCDOT Divisions and 5 counties geographically dispersed across NC. Develop a model for condition deterioration. Develop a model for linking present condition, condition improvement, condition deterioration, and expenditures to future condition. Test and verify the model. Use principles of data analytics to determine and model the linkage between condition and budget over locale, road class, and features. Optimize the model(s). Benchmark and assess the optimization model using past data. Project future budgets out 5 to 8 years. Identify possible improvements in the current NCDOT maintenance business process. Present results. Submit report.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

State of the art literature review. A new verified model. A spreadsheet demonstrating the model. A list of potential business process improvements. Technical solutions to existing condition/expenditure linkage problems. Identification of additional resources needed by NCDOT (if any). An improved budget allocation process soundly based on NCDOT data.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational **Efficiency** / Time Savings	☐ New or Improved Specifications
☒ **Cost** Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement **Performance**	☐ Permitting / Regulatory Compliance
☒ Improved **Models** (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Overall, this work will enable NCDOT to optimize its cost/condition/budgeting relationships to better meet Department maintenance objectives.

Efficiency. This work will reveal possible improvements in condition assessment and maintenance budget allocation for highways. In turn, this will result in better internal utilization of maintenance manpower and budgets, thereby improving the overall maintenance business process.

Cost. Statewide, within Divisions, and within Counties the relationship between Interstate, Primary, and Secondary road condition and maintenance cost is not clear. This work will add the required clarity. In doing so it will enable NCDOT to better estimate and allocate future maintenance budgets to meet needs while clearly understanding the impact of those budgets on condition. Through an optimized allocation process budgets will be better allocated.

Performance. A maintenance budget dictates maintenance activities which in turn determine improvement that finally can be quantified by a condition rating. This work predicts that future condition rating. Conversely, a desired condition rating determines a needed condition improvement which is met by maintenance activities whose cost is known, thereby revealing the required budget. Predicting future required budgets will reveal critical and much needed cost/budget information about highway asset feature performance.

Model. The benefit of the model is that it implements and quantifies the relationship between cost, maintenance, condition, and performance enabling NCDOT to optimize the allocation of maintenance funding and of asset feature condition. Both budgets and highway feature condition will be optimized.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

Who will lead the implementation? *Provide Unit, Position Title and Name.*	**Unit:**	Transportation Asset Analytics
	Title:	State Management Systems Engineer
	Name:	Lonnie Watkins, PE

Approval (Division Official or Unit Head)

Lonnie Watkins / Matthew Whitley		State Management Systems Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	07/22/16	**RNS#:**	**8305**
Submitter Name:	Nilesh Surti, PE	**Phone:**	919-707-2403
Division / Unit:	Highways / Construction	**Email:**	nsurti@ncdot.gov
Research Idea Title:	Durable and Sustainable Concrete Through Performance-Engineered Concrete Mixtures		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Consistent with the focus of MAP-21 legislation on performance, there is a desire by FHWA, public agencies, and Industry to move towards performance-engineered construction materials. Performance-engineered concrete mixtures include optimized mixture designs (materials selection, gradation, cement content, etc.) that provide improved durability and sustainability. Concrete mixtures that are engineered to meet or exceed design requirements are predictable, durable, and have increased sustainability. The FHWA provides the following keys to implementation of performance-engineered concrete:

- Design and field control mixtures around engineering properties related to performance
- Development of practical specifications
- Incorporating this knowledge into an implementation system (Design/Materials/Construction/Maintenance)
- Validate and refine by performance monitoring

Currently, FHWA is moving towards development of a concrete pavement performance system and a software tool (PaveSpec 4.1) to assist state highway agencies with performance specifications, QC/QA protocol, and implementation of emerging test methods. Ongoing concrete materials research is beginning to provide NCDOT data to support use of performance engineered concrete mixtures. However, additional work is needed to identify appropriate performance measures, performance goals, and QC/QA protocol.

Background: *Provide supporting information about the business unit, processes and tools*

Products from this research would be utilized by several units, including the Materials and Tests Unit with Pavement Management Section, Structures Management Unit, and the Construction Unit. Findings could revise specifications, create provisional specifications, design, and construction.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

1. Analyze historical data on concrete mixtures, QA/QC test results, maintenance, and field performance.
   - Correlate mixture characteristics and performance characteristics with observed condition data and prediction models.
   - Identify materials, proportions, construction techniques, QA/QC test results, and link to unacceptable, acceptable, and excellent performance.
2. Evaluate traditional and emerging test methods utilized to evaluate performance characteristics.
3. Establish performance criteria and target values for concrete mixtures utilized in different types of applications, along with appropriate testing methods and QA/QC protocol.
4. Provide implementation guidance.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Products of this research would include:

- Analysis of performance of currently utilized and historically utilized concrete mixtures.
- Recommendations regarding appropriate performance measures, performance goals, test methods, and QA/QC protocol for more durable, sustainable concrete mixtures.
- Recommendations regarding use of this information in design, specifications, construction, and QA/QC testing.
- Resources for training and technology transfer.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	6/20/16	**RNS#:**	**8306**
Submitter Name:	Judith Corley-Lay, Ph.D., PE	**Phone:**	919-835-8201
Division / Unit:	Highways/M&T/Pavement Management	**Email:**	jlay@ncdot.gov
Research Idea Title:	Quantifying the Impact of Pavement Preservation in an Area on Market Value and Success of Home Sales		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Pavement Preservation has been known to maintain roads in good condition for longer. We have struggled, however, to demonstrate the effectiveness of Pavement Preservation in terms that the average citizen relates with. I recently did a driving tour of neighborhoods. In some, the pavement had deteriorated far beyond the point where preservation treatments can be done. Does the lack of maintenance and preservation convert into decreased market value of homes and a longer time to sell relative to similar homes with well-preserved residential roadways?

Background: *Provide supporting information about the business unit, processes and tools*

The Pavement Condition Survey is conducted annually and will provide information on the existing and historical condition of secondary roads. The researchers will need to gather corresponding information on home sales and home values from real estate records. The researchers will also need to identify "similar" neighborhoods with different road maintenance practices. A two phase project is envisioned: phase one will determine the extent to which data is available to support the study and phase two will compare home value and time to sell for neighborhoods with pavement preservation to similar neighborhoods without preservation.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

The following tasks are anticipated, although the research team may suggest alternate approaches:

1. Conduct a literature review
2. Identify criteria for defining "similar neighborhoods."
3. Explore various sources of real estate values and times to sale. Can data be extracted in a reasonable amount of time?
4. Identify data in the Pavement Management System that represents condition in residential areas.
5. Prepare 2-3 page feasibility report for Phase 1.
6. If given approval for Phase 2, prepare database of real estate and condition information.
7. Conduct comparisons and identify impact of pavement preservation.
8. Prepare final report.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

This research will provide a methodology to express the value of pavement preservation in terms of home value and time to sale of homes. This will improve communication with the public.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☐ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☒ Improved Communication of Benefits to the Public

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The public is our ultimate customer. This project will, if successful, allow us to explain the benefit of pavement preservation in terms that the average citizen can understand: home values and time to sell.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The methodology will allow the study to be repeated at five year intervals.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: M&T/ Pavement Management
Title: State Pavement Design Engineer
Name: Clark Morrison, Ph.D., PE

Approval (Division Official or Unit Head)

Chris Peoples, PE		State Materials Engineer
Print Name	Signature	Title

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

This research would capitalize and expand on recent research findings from a number of concrete materials and pavement/structures management projects. Additional findings from this work, along with extension of findings from ongoing related research would result in benefits including:

- Improved durability performance of concrete materials used in pavements, bridges, and other infrastructure
- Enhanced focus on quality during construction
- Guidance on interpretation of laboratory testing results and the impact on performance
- Improved QA/QC testing and acceptance
- Cost savings associated with longer service life structures and pavements, along with better infrastructure performance over the lifecycle

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

- Performance goals and measures could be utilized in design, specification, and construction of new concrete infrastructure with enhanced durability and sustainability.
- Enhanced knowledge regarding current and historic concrete mixtures could be utilized to improve models utilized for design of structures and pavements, as well as in prediction models used for maintenance, repair, and replacement decisions.
- Performance measures and goals for existing QA/QC test methods could be assessed and modified if needed.
- Recommended emerging test methods could be evaluated for future specification and use.
- Technology transfer tools would be utilized for training of NCDOT personnel.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Construction Unit
Title: State Pavement Construction Engineer
Name: Nilesh Surti

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

Involvement from the Materials and Tests/Pavement Management Unit, Structures Management Unit, and Construction Unit would result in a broad range of applications for the products of this research.

Approval (Division Official or Unit Head)

Chris Peoples, PE		State Materials Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	April 25, 2016	**RNS#:**	**8307**
Submitter Name:	Judith Corley-Lay, Ph.D., PE	**Phone:**	919-835-8201
Division / Unit:	Highways/Materials and Tests/PMU	**Email:**	jlay@ncdot.gov
Research Idea Title:	Optimizing use of Fly Ash and Limestone Cement to Improve Durability of Jointed Plain Concrete Pavement		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

In a recent research panel meeting, researchers at UNC Charlotte showed that adding fly ash to Portland cement improved performance of the resulting concrete. Further they showed that adding both fly ash and limestone cement to Portland cement resulted in improved durability and reduced permeability. These results are encouraging, but that research (focused on developing a catalog of inputs for pavement design) did not result in optimizing the blend to achieve best performance. Optimizing the blend will require testing at varying levels of both fly ash and limestone cement and will consider the benefit versus cost of each blend.

Background: *Provide supporting information about the business unit, processes and tools*

Limestone cement is produced from the same materials as Portland Cement, but omits part of the heating process. As a result it is less costly to produce. In the presence of fly ash, it results in a closer packing of particles in the cement paste, resulting in reduced permeability and improved durability. With our increasing use of salt brine to pretreat roads in advance of winter weather, reduced permeability could provide longer effective life of dowels and steel reinforcement in bridge decks. This project would develop an optimal blending of the three materials.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

It is anticipated that the following tasks would be required:

1. Literature review on limestone cement and fly ash, methods of measuring permeability and durability of concrete, and other directly related topics
2. Develop testing plan for range of material contents; types of tests; number of specimens, etc
3. Acquire materials and prepare samples
4. Execute the testing plan and collect data
5. Develop unit cost of each blend based on pricing at the time of analysis. Calculate benefit/cost.
6. Identify optimal blend.
7. Recommend changes to standard specifications, or a special provision, for use of the blended cement and fly ash.
8. Final report will detail all aspects of the project.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The results of the research will include: the optimal blend of fly ash, limestone cement and Portland cement to achieve the best performance; the benefit versus cost analysis for each of the blends; recommendations for changes to NCDOT specifications or a special provision.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☐ Cost Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☒ Other (Specify)Environmental Sustainability

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Improved concrete durability could result in reduced maintenance costs and longer pavement life. This could result in cost savings as well as improved pavement performance. Limestone cement is a more sustainable product than is Portland Cement so its use will result in a lower carbon footprint overall.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

With an optimal blend that improves performance, NCDOT can more strongly encourage use of limestone cement and fly ash in concrete pavement and bridges. This will occur initially by disseminating the results at the Construction conferences and to Division Construction Engineers and Resident Engineers.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Construction Unit
Title: State Roadway Construction Engineer
Name: Lamar Sylvester, PE

Approval (Division Official or Unit Head)

Chris Peoples, PE		State Materials Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	June 3, 2016	**RNS#:**	**8308**
Submitter Name:	Judith Corley-Lay, Ph.D., PE	**Phone:**	919-835-8201
Division / Unit:	Highways/Pavement Management	**Email:**	jlay@ncdot.gov
Research Idea Title:	Use of PUC for Performance Characterization of Aggregate in Bituminous Surface Treatments		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

While earlier research identified the percent uniformity coefficient as an important component of surface treatment performance, no threshold values or range of values was identified.

Background: *Provide supporting information about the business unit, processes and tools*

NCDOT has conducted a series of research projects over the last 12 years to improve performance of surface treatments which are the dominant treatments for our SR routes. These research projects have identified 4 components to performance: PUC, fine's content, emulsion application rate and embedment. Identifying the threshold values for PUC will, along with fine's content, allow us to improve our materials specification for aggregate in BST to improve seal performance.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

The research is expected to include the following tasks, although other approaches can be proposed:

1. Literature review on aggregate characteristics contributing to good performance of surface treatments, as well as work on uniformity coefficients for aggregate in surface treatments.
2. Develop aggregate mixes with a range of PUCs by gradation fractionating and then re-blending to specific PUC values.
3. Laboratory test the surface treatments using tests already developed.
4. Analyze results to determine threshold PUC to assure good performance..

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Threshold values of PUC to use in specification for aggregates used in bituminous surface treatments. Recommended specification.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☐ Cost Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details of the benefits checked above.*

If successful, we will be able to improve BST performance by controlling the uniformity of the aggregate. Even a small improvement in performance will have significant impact because of the 40,000 miles of surface treated roads on the NCDOT system.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The results will be implemented as an improved specification and testing procedure for aggregates used in surface treatments.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: State Maintenance Operations Unit
Title: State Maintenance Operations Engineer
Name: Emily McGraw, PE

Additional Comments and Information: *See guide. Recommend including info on involvement from other units here*

Materials and Tests and State Maintenance Operations should be part of this research.

Approval (Division Official or Unit Head)

Chris Peoples, PE		State Materuals Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	June 15, 2016	**RNS#:**	**8309**
Submitter Name:	Judith Corley-Lay, Ph.D., PE	**Phone:**	919-835-8201
Division / Unit:	Highways/Pavement Management	**Email:**	jlay@ncdot.gov
Research Idea Title:	Use of Rejuvenator Prior to Chip Seal on Aged Flexible Pavement		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Many roadways in North Carolina are aged when treated with a chip seal. The aged pavement is drier and more porous than it would be if treated earlier. Would a rejuvenator make the chip seal perform better and would the life extension be sufficient to overcome the cost?

Background: *Provide supporting information about the business unit, processes and tools*

Oxidation drying is a significant factor in top down cracking of flexible pavements in NC. Since this occurs from the surface, it results in stiff, dry asphalt at the surface and a drying gradient through the depth of asphalt. The dry surface will absorb liquid from the chip seal, reducing the amount of asphalt available to bind the aggregate in the chip seal. This project will address use of a rejuvenator prior to the chip seal to see if performance is improved.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

It is anticipated that this research will consist of at least the following tasks (although alternate approaches will be considered):

1. Literature review of impacts of oxidation or aging on chip seal performance, impact of rejuvenator on existing pavement surface and subsequent treatment and other directly related topics
2. Develop test plan including laboratory and field trials.
3. Laboratory tests to test the concept (it is anticipated that this will consider a variety of "existing pavement ages" with and without rejuvenator)
4. Field trials may be considered, but will depend on identifying desirable sites and willing contractors.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Guidelines for when use of rejuvenator will result in improved chip seal performance.
Benefit in terms of life extension as a function of degree of aging.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☐ Cost Savings	☐ Improved Worker or Public Safety
☒ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details of the benefits checked above.*

If a fairly low cost treatment can improve the performance of a chip seal on an aged pavement, it will assist maintenance forces in using their funds optimally.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

Results will be shared with the Division Maintenance Engineers and the Division Bituminous Supervisors with guidelines for when and how to use rejuvenators.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: State Maintenance Operations
Title: State Maintenance Operations Engineer
Name: Emily McGraw, PE

Additional Comments and Information: *See guide. Recommend including info on involvement from other units here*

Approval (Division Official or Unit Head)

Chris Peoples, PE		State Materials Engineer
Print Name	Signature	Title

Structures & Construction

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	07/29/16	**RNS#:**	**8401**
Submitter Name:	Mohammed Mulla, PE, CPM	**Phone:**	919- 707-6866
Division / Unit:	Geotechnical Engineering Unit	**Email:**	mmulla@ncdot.gov
Research Idea Title:	Reducing Erosion Susceptibility of Coastal Highways using Biologically-mediated Methods		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Coastal highways in North Carolina (e.g., Highway 12) are susceptible to damage during large storm events. Damage occurs to the highways when the supporting subgrade or embankment is eroded from the direct storm wave action on the seaward side or weir-flow damage on the landward side undermining the pavement. Preventing erosion will reduce damage to the coastal highways and help maintain open highways during the recovery period after storm events. Biologically-mediated or bio-inspired soil improvement methods offer an innocuous and natural way to stiffen the soil and reduce its susceptibility to erosion during storm events.

Background: *Provide supporting information about the business unit, processes and tools*

Soil improvement methods can be used to stiffen the subgrade and slopes of coastal highways and reduce the soil's susceptibility to erosion during storm events. In addition to traditional chemical methods, natural biological processes or bio-inspired processes have been shown to improve the behavior of sand deposits by increasing the sand's strength, stiffness, and erosion resistance. Bio-mediated or bio-inspired soil improvement methods utilize natural soil bacteria or enzymes to produce carbonate cementation within the soil matrix. This carbonate precipitation bio-cementation process can be used to mitigate damage to coastal highways by implementing the process in situ. The bio-cemented reinforced sand deposits would ultimately improve the resiliency of the coastal infrastructure by reducing the susceptibility to storm-induced erosion in an innocuous, natural, and cost-effective manner.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

1. Develop bacterial and enzymatic treatment processes to minimize erosion from wave action and weir-flow loading.
2. Quantify improvement in erosion resistance and shear strength from bacterial and enzymatic treatment techniques.
3. Monitor the permanence of the bacterial and enzymatic treatments when subjected to seasonal inundation.
4. Establish ability of vegetation to rebound after treatments.
5. Cost assessment and comparison to traditional treatment processes.
6. Assess implementation process of bacterial and enzymatic treatments (e.g., surficial application, in conjunction with permeable piers, etc.).

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The research product will include an in situ treatment procedure that can be implemented by the Department to improve the performance of coastal soil, with an emphasis on soil susceptible to storm-induced erosion.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

✓ ☒Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
✓ ☒Cost Savings	☐ Improved Worker or Public Safety
✓ ☒Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The products will improve the resiliency of coastal highways by preventing damage from storm events. The coastal highways will remain open and connected after a storm event, increasing the ability of the communities to recover quickly after an event. The repair and maintenance costs will also decrease due to improved performance of the coastal highways. The Department will be able to use the research products to treat regions susceptible to erosion in anticipation of a large storm event to prevent pavement failure or road closure.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The findings from this study will be presented to the Project Steering Committee at the end of the project. The newly developed soil improvement process will be developed for the Department to implement in areas susceptible to erosion.

Who will lead the implementation? *Provide Unit, Position Title and Name.*

Unit:	Geotechnical Engineering Unit
Title:	Assistant State Geotechnical Engineer Contract & Services Manager
Name:	Mohammed A. Mulla, PE, CPM

Approval (Division Official or Unit Head)

John Pilipchuck, LG, PE		State Geotechnical Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7/29/2016	**RNS#:**	**8402**
Submitter Name:	Mohammed Mulla, PE, CPM	**Phone:**	919 707-6866
Division / Unit:	HWY/Geotechnical Engineering Unit	**Email:**	mmulla@ncdot.gov
Research Idea Title:	Nondestructive Testing for Embedded Depth and Integrity of Pile Foundations		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

There are still many bridge piles in NC with unknown embedded depth due to missing records. Many of the piles have reduced integrity due to distributed damage. It is thus important to assess the embedded depth as well as the pile integrity for continued use, and when appropriate re-use of these foundations. It would be desirable to have an nondestructive evaluation (NDE) technique that can assess both embedded depth and integrity of pile foundations.

Background: *Provide supporting information about the business unit, processes and tools*

Given the lack of reliability of existing techniques, NCDOT funded a short project at NCSU to refine and laboratory-test an NDE technique based on wave propagation. The technique is proven to be highly successful in the lab. Encouraged by this, outside the scope of the original project, preliminary field testing was conducted on concrete piles with promising results. This follow-up project is related to developing the method for different types of piles, and importantly, extend the technique to assess the condition of the pile, i.e. the distributed damage inside the pile. Having both embedded length and distributed damage would lead to reliable safety assessment for continued use and reuse of pile foundations.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

1. Updated literature review related to nondestructive testing of piles for length and integrity.
2. Classify the piles that need to be evaluated with respect to depth range, material type and integrity/damage; Identify candidate piles for testing
3. Develop laboratory and field testing procedure for integrity testing of piles
4. Develop a software for estimating pile integrity (pile-depth estimation software would be ready by then)
5. Develop data acquisition parameters (hammer, accelerometer spacing etc.) for different types of piles
6. Perform field testing on candidate piles, some for calibration and the rest for validation.
7. Develop a test protocol and present in the final report

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

A test protocol and data processing tool for estimating the embedded depths and integrity of various types of pile foundations.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☒ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☒ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Will help ensure that (a) NCDOT meets the FHWA requirement for managing the unknown foundation by estimating the length of the piles, and (b) test the integrity of these piles to ensure safety of the supported bridges. Will provide a testing method to evaluate exiting piles embedment, load capacity, and integrity for future reused.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The research report will include step-by-step approach to performing field testing, as well as software that would automatically process the data for estimating the embedded depth as well as pile integrity.

Who will lead the implementation? *Provide Unit, Position Title and Name.*

Unit: Geotechnical Engineering Unit
Title: Assistant State Geotechnical Engineer Contract & Services Manager
Name: Mohammed A. Mulla, PE, CPM

Approval (Division Official or Unit Head)

John Pilipchuck, LG, PE		State Geotechnical Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 12, 2016	**RNS#:**	**8403**
Submitter Name:	Conzuela Cogdell, MSCE PE	**Phone:**	919-661-5995
Division / Unit:	ITS and Signals	**Email:**	cbcogdell@ncdot.gov
Research Idea Title:	Effects of Torsion and Moment on Traffic Signal Structures' Foundations in Coastal Conditions.		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

After years of performing structural reviews for structural signal supports and foundations (Based on site specific boring reports) we discovered that the soil characteristics found on the coast made the installation of traditional drilled shafts (caissons) economically and structurally unrealistic. The steel structure designs were either replaced by wooden pole installation, the drilled shafts increased in size equal to that of a bridge pier (due to poor soil conditions), or shallow foundations or grade beams were employed. Wooden Pole installation has a low service life and limiting span lengths, yet large drilled shafts, foundations and other reinforced concrete foundations require large amounts of excavation and right-of-way which may not be readily available under all projects. We need a means to provide foundations that have a small footprint, are economical, and have the ability to maximize the soil properties found in saturated sandy silts and alluvial soils often found on the coast of North Carolina to resist torsion as well as moment loading.

Background: *Provide supporting information about the business unit, processes and tools*

In 2001, ITS and Signals was given the responsibility of designing, reviewing and troubleshooting traffic structures and their corresponding foundations across all 14 Divisions within NCDOT. Over the years the efforts of the Structural Review Group has led to the creation of Standard Strain Poles for five separate wind zones, standard drilled shaft foundations, and multiple in-house programs that have propelled the Section from hand calculations to performing time and economically efficient reviews performed by Excel Spreadsheets, development of a database to track our Signal Structure Inventory, and administering routine inspections on our existing intersections. We also have the capacity to design Traffic Structures using the most current codes and foundations, as well as to resolve construction related problems that may arise. The tools we have available are: in-house programs, LPILE, APILE, FB Pier, STAAD.Foundation, STAAD.PRO, MicroStation, LT Base, Brass Pole and HILTI Profis Anchor.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

We anticipate the need for a synthesis study on Foundations used to address Torsion on Traffic Structures, the development of alternative foundation designs (Large Diameter Open Ended Pipe Piles or Pile Groups), finite element modeling (STAAD or ANSYS-LSDYNA), utilization of test pile (see static load testing (ASTM D1143-07e1), rapid load testing (ASTM D7383-08), or high-strain dynamic testing with (or without) signal-matching analysis (ASTM D4985-08) to develop driving criteria, interaction with NCDOT Materials and Tests for welding procedures and possible certification (welding and nondestructive testing), including research of FHWA, AASHTO, AISC and the US Army Corps of Engineers to verify the most relevant and current code provisions are followed. Determining the effects of Vibratory versus Impact Hammer installation on the overall capacity of the pipe pile and surrounding buildings/soils is instrumental in determining the viability of a chosen pile driving method within an urban area when applicable.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

We seek a synthesis report on how DOTs across East Coast address similar loading conditions and an alternative foundation design(s) and procedures that will meet the design capacity constraints of our Cantilever Structures with arm lengths of 50ft to 75ft. NCDOT ITS and Signals have utilized Micro-Pile Groups in the past and have considered the possibility of Large Diameter Opened Ended Pipe Piles with Spin Fin Technology developed by PND Engineers, Inc.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒	Increase Operational Efficiency / Time Savings	☒	New or Improved Specifications
☒	Cost Savings	☐	Improved Worker or Public Safety
☒	Improved Material, Structure, Pavement Performance	☐	Permitting / Regulatory Compliance
☒	Improved Models (Performance/Traffic/Financial etc.)	☐	Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

There are a number of anticipated benefits. One benefit is reduction in construction time. Regarding cost savings, the smaller footprint, so the need to purchase additional right-of-way or the need to build large substructures is removed.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

We will use the alternate foundation design provided in lieu of wooden piles, excessively large drilled shafts and shallow foundations when boring reports indicate poor soils, the right-of-way is not available and the Division, Municipality, or Developer requires Steel Traffic Structures.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: ITS and Signals
Title: Structural Engineer-Journey
Name: Conzuela B. Cogdell, MSCE PE

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

We have spoken to the Geotechnical Unit, Materials and Tests, Dan Brown and Associates, PC and PND Engineers, Inc. for guidance regarding the alternative concept of Steel Pipe Installation. We also recommend involving Steel Fabricators who currently provide poles for NCDOT projects. ATS-Sales, Valmont, and Millerbernd Manufacturing have all expressed willingness to share technical expertise by answering questions that may arise.

Approval (Division Official or Unit Head)

Kevin Lacy, PE, CPM		State Traffic Engineer
Print Name	Signature	Title

Traffic & Safety

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7/15/2016	**RNS#:**	**8501**
Submitter Name:	Mike Bruff, Kent Taylor, Brian Mayhew	**Phone:**	919-707-2818
Division / Unit:	Traffic Mobility and Safety, Traffic Survey Group, Strategic Planning	**Email:**	mbruff@ncdot.gov
Research Idea Title:	Develop Method to Generate AADT on Non-Functionally Classified Public Roads		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Generate AADT on individual non-functionally classified public roads to be used for HPMS and performance reporting.

Background: *Provide supporting information about the business unit, processes and tools*

The Traffic Survey Group currently counts traffic and produces AADT's for a full coverage of all functionally classified (FC) roads as required by FHWA. A selection of non-FC public roads (locals) are counted and an AADT is generated for individual business unit purposes. These local AADT's are also used as an estimate in the calculation of local VMT as required by FHWA/HPMS. Traffic Mobility and Safety is responsible for developing and reporting performance measures for the Highway Safety Improvement Program. While the HSIP requires an AADT for all paved roads open to the public, it leaves it up to the states to determine how best to meet this requirement for local roads. This includes the use of models for the estimation of AADT when count based AADT are not available.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Task 1: Literature review of how other states currently develop and calculate local VMT as well as how other states are meeting the HSIP requirement

Task 2: Identify requirements of VMT on local roads

Task 3: Develop a sustainable and repeatable process/model that calculates AADT/VMTs on all local paved roads. This may include:

a. Estimation of statewide Local VMT
b. Disaggregation of statewide local VMT to subareas
c. Allocation of subarea local VMT to individual local routes (and subsequent calculation of AADT)
d. Specification of minimum monitoring/sampling requirements of count based AADT on local routes needed for model calibration/validation
e. Development of growth monitoring process to adjust AADTs in years when counts are not taken.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Literature Review of local (non-FC) AADT and VMT generation
Requirements for local AADT development and calculation of VMT
Model or process for calculating local VMT
Monitoring requirements for model calibration/validation
Process for developing and applying growth factors to AADTs

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Results will provide AADT/VMT for non-FC paved roads in order to allow the department to meet the performance reporting requirements of the HSIP. They will also provide more accurate local VMT to meet HPMS reporting requirements. These requirements will be met using synchronized data sets supporting all levels of reporting.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The statewide and subarea VMT estimation processes are anticipated to be implemented by Transportation Planning Branch staff. The generation and management of local AADT is anticipated to be implemented by the Traffic Survey Group. This includes the allocation of subarea VMT to local routes, collection and generation of validation/calibration AADT, and generation and application of growth factors. Generation of a statewide table providing a full coverage of AADT on local routes is the anticipated product. The TMS will review/audit the results and use the table to meet HSIP data reporting requirements and for generation of mandated performance measures.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Traffic Mobility and Safety
Title: Traffic Safety Systems Engineer
Name: Brian Mayhew, PE

Additional Comments and Information: *See guide. Recommend including info on involvement from other units.*

Mike Bruff from Strategic Planning will co-lead project. Kent Taylor from Traffic Survey will provide oversight and technical guidance.

Approval (Division Official or Unit Head)

Kevin Lacy, PE, CPM		State Traffic Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	07/12/16	**RNS#:**	**8502**
Submitter Name:	Shawn A. Troy / Brian K. Mayhew	**Phone:**	919-773-2800
Division / Unit:	Mobility and Safety / Traffic Safety	**Email:**	stroy@ncdot.gov / bmayhew@ncdot.gov
Research Idea Title:	Post-Installation Evaluation of the Effects of Ramp Metering		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

For the first time North Carolina will install ramp meters, beginning with four locations on I-540 in 2016 to address freeway congestion resulting from population growth. There are currently no uniform guidelines for how to evaluate the outcomes of ramp metering. Consequently, NCDOT is undergoing a project intended to collect pre-treatment data at the four sites and is developing a framework for using this data as part of a before and after evaluation plan that can be expanded to future ramp metering installations. While the aforementioned evaluation will include pre-installation data collection at each I-540 site, after installation data collection will be needed in order to accurately evaluate the impact of the treatments.

Background: *Provide supporting information about the business unit, processes and tools*

Ramp metering is designed to reduce congestion and other traffic problems by controlling the number of vehicles that are allowed to enter the freeways, disrupting platoons of vehicles released from an upstream traffic signal for a smoother merge at freeway on-ramps, and increasing the capacity of the freeway merge segments. A study designed to examine the feasibility of implementing ramp meters in Raleigh/Durham area was funded in 2012-2013, and in 2014 NCDOT conducted a further study of the four I-540 sites. It is anticipated that ramp metering will result in significant benefits to the state, including savings due to decreased delay, decreased crashes, and other outcomes. However, the actual impact of ramp metering on performance measures is still unknown for North Carolina sites. At this time, only estimations can be made because no state-specific post-installation data is available.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Tasks for this project will include post-installation data collection at all four sites on the I-540 (freeway, on-ramp, and arterial sections) in order to analyze ramp metering impacts on mobility and safety performance measures, an analysis of collected data including comparison of prior and post-installation data and an update to the prior benefit cost analysis, the development of a white paper summarizing lessons learned from the first experience of ramp meters in North Carolina, and a final report documenting the research team's efforts and findings.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The primary products of this research will include: 1) data on key mobility performance measures collected after ramp meter installation at each of the four on-ramps on I-540, 2) a white paper on empirical impacts of ramp meters to be utilized later in future ramp metering installations in North Carolina, and 3) a Final Report summarizing the research team efforts and findings during the course of this project.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

The research will result in data and analysis that the NCDOT can use into the future when communicating and projecting the value of ramp metering in the state. In addition, this study will provide refined methods for evaluating future North Carolina ramp meter installations.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

This research can be used by NCDOT planners when projecting and evaluating ramp metering outcomes at future North Carolina sites and can be used in conjunction with community outreach and public relations activities to communicate the value of ramp metering.

Who will lead the implementation? *Provide Unit, Position Title and Name.*

Unit: Traffic Safety Unit
Title: Safety Evaluation Engineer
Name: Shawn A. Troy

Approval (Division Official or Unit Head)

Kevin Lacy, PE, CPM		State Traffic Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	7-21-2016	**RNS#:**	**8503**
Submitter Name:	Joseph E. Hummer	**Phone:**	919-773-2830
Division / Unit:	Mobility and Safety Division	**Email:**	jehummer@ncdot.gov
Research Idea Title:	Effects of New MUTCD Curve Signage Requirements		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

The 2012 MUTCD requires compliance in signage on certain highway curves. The extent of the required changes on NCDOT roadways is currently unknown. Related, the benefits and costs of these signage requirements are not clear. A determination of the impact on NCDOT of this change is needed.

Background: *Provide supporting information about the business unit, processes and tools*

By December 31, 2019 states must be in compliance with new MUTCD curve signage requirements. An assessment of the impact of this change has not been made.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

This research should include the following tasks at a minimum:
Review current and proposed MUTCD signage requirements. Survey the implementation plans of other states. Define a methodology for the study. Identify curves that will be affected. Assess the data that should be collected for these curves. Monitor the existing curve signage and safety performance prior to new sign installation. Monitor and assess the new curve signage after installation. Perform a benefit analysis. Assess the costs of the implementation and compliance. Determine the crash impacts due to new signs.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The primary products of this research are the benefits and costs of horizontal curve signage required by MUTCD. Additionally, any implementation guidance should be specified to increase the impact of these signs.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☐ Cost Savings	☒ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☒ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

NCDOT will better understand the degree to which the safety benefit obtained by the new MUTCD curve sign requirements is achieved, the cost of compliance, and the impact of implementing the requirements. Because the requirement does not address all roadways an assessment of the overall true value of the implementation will enable NCDOT to better handle signage.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

NCDOT has to comply with the FHWA mandate on curve signs. However, the research results will affect future actions. If the research shows a strong benefit from the new signs, the Department could invest in more similar signs at places not covered by the mandate. If, on the other hand, the research shows that the new mandated signs are not producing a benefit in line with the costs, the Department could try to minimize future installations and advocate to FHWA for relaxation of the mandate.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Signing and Delineation Unit
Title: State Signing and Delineation Engineer
Name: Ron King, PE

Approval (Division Official or Unit Head)

Kevin Lacy, PE		State Traffic Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 15, 2016	**RNS#:**	**8504**
Submitter Name:	Joseph E. Hummer, PhD, PE	**Phone:**	919-773-2830
Division / Unit:	Mobility and Safety	**Email:**	jehummer@ncdot.gov
Research Idea Title:	Reasonable Alternatives for Grade-Separated Intersections		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Grade-separated intersections are junctions between two roadways that are not freeways with at least one bridge. An example near the NCDOT headquarters is just south of downtown Raleigh where Western Boulevard/Martin Luther King Jr. Boulevard meet South Dawson Street/South McDowell Street. NC has dozens of these junctions, needs to rebuild many, and plans to build more in the next few years. The bridge and other aspects make grade-separated intersections relatively expensive, at a minimum cost of ten million dollars. Most grade-separated intersections are at junctions with very high traffic demands where at at-grade intersection would not provide enough capacity. Like the downtown Raleigh example, many of these junctions have borrowed freeway interchange designs (a parclo A in the case of downtown Raleigh). However, using freeway interchange designs at grade-separated intersections typically results in many negative impacts, including taking large rights-of-way, not metering traffic thereby encouraging high speeds on one road, inhibiting signal progression on the other road, creating a hostile environment for crossing pedestrians, restricting roadside access for long distances along one or both roads, and others.

Background: *Provide supporting information about the business unit, processes and tools*

There is almost no literature or published guidance available on grade-separated intersections. They are not covered in the AASHTO Green Book, the Highway Capacity Manual, the Highway Safety Manual, or other common books and manuals used by traffic engineers and designers. Consequently, when the NCDOT decides to build or rebuild a grade-separated intersection, they are often designed like an interchange with sub-optimal results as noted above. In addition, there are promising new designs available for grade-separated intersections that deserve exploration before NCDOT builds or rebuilds another. The echelon, the two-level signalized, and the half-superstreet half-single-point are just three of the new designs that have been published in the past few years that seem to have promise in some niches. The new designs have not been researched thoroughly, and some new designs have questions about their patent status that need to be clarified before they can be used. Without a strong knowledge base available, designers and traffic engineers will not use a new design.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

The objectives of the research project would be to estimate the relative operational, safety, cost, pedestrian, patent, and other important impacts and facets of current and promising designs for grade-separated intersections; make recommendations on which designs should fit where in NC; and provide a knowledge base that engineers and designers can call upon when considering a design. Tasks to achieve the objectives should include:

1. Literature review and discussions with experts around the world.
2. Development of typical designs for each candidate.
3. Operational modeling of vehicles and pedestrians using a microscopic simulation package.
4. An estimate of safety impacts using existing models and analogies to similar existing designs.
5. An estimate of rights-of-way needed, access restrictions, construction costs, and other impacts.
6. Authoritative information on the patent status of each new design.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The main product of the research would be estimates of the relative operational, safety, cost, pedestrian, patent, and other important impacts and facets of current and promising designs for grade-separated intersections; recommendations on which designs should fit where in NC; and a knowledge base that engineers and designers can call upon when considering a design. The knowledge base would include the designs and simulation models developed during Tasks 2 and 3 that could serve as the basis of future work by NCDOT staff and consultants at particular locations throughout NC where a grade-separated intersection is being considered.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☒ Cost Savings	☒ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☒ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

At a candidate location, using the optimum grade-separated intersection design could save motorist travel time (with corresponding energy and environmental benefits), prevent crashes, save construction costs, conserve right-of-way, reduce business impacts, encourage pedestrian use, and provide other benefits when compared to just using a current standard interchange design. The proposed research will also provide sample microscopic simulation models that staff and consultants can use and will provide sample designs that can serve as the basis for later development of standard sign, signal, structure, geometric, and other specifications. The proposed research will also clarify the patent status of several new designs.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The recommendations developed in this research would need to be distributed to roadway designers and traffic engineers in several central units, to the field Divisions, and to consultants. Conducting presentations at meetings and roundtables are the usual ways to get information like this to these engineers. Development of standard drawings for signs, signals, structures, geometrics and other aspects for the most promising designs is a necessary step to full implementation.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Mobility and Safety
Title: Staff Engineer
Name: Joseph E. Hummer, PhD, PE

Approval (Division Official or Unit Head)

Kevin Lacy, PE, CPM		State Traffic Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 15, 2016	**RNS#:**	**8505**
Submitter Name:	Joseph E. Hummer, PhD, PE	**Phone:**	919-773-2830
Division / Unit:	Mobility and Safety	**Email:**	jehummer@ncdot.gov
Research Idea Title:	Development of a Model to Predict Wrong Way Crashes By Interchange Type		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

There are not many crashes caused by drivers moving the wrong way on a freeway, but when they happen they are severe and spectacular. Of course driver error plays the largest part in wrong way crashes on freeways, and a large array of devices has been developed to warn drivers of a potential wrong way movement or stop them before they proceed too far. However, interchange design plays a role in wrong way crashes as well. It is almost impossible to unintentionally enter a freeway going the wrong way at a cloverleaf interchange where the arterial has a strong median barrier (at Toll NC-540 and US-64 in Apex for example), but an interchange like a parclo AB with two loop ramps on the same side of the arterial (at Hillsborough and I-440 in West Raleigh for example) is much more vulnerable to a wrong way movement.

Background: *Provide supporting information about the business unit, processes and tools*

Designers of new or rebuilt interchanges, or people attempting to put wrong way countermeasures in place at existing interchanges, have almost no way to judge the relative threat from wrong way movements at a particular junction. Even at an interchange that has been operating for years, wrong way crashes are so rare that a statistically valid sample of crash data is impossible to obtain. Designers and those working with wrong way countermeasures need a model to predict the number of wrong way movements as a function of traffic demands, interchange geometry, and other key features. No such model currently exists. Using the meager literature that exists on this topic, the author of this statement has assembled and applied a five-point scale rating the wrong way potential of interchanges based upon whether there are median openings, whether the off-ramps meet the arterial roadway at a shallow angle, whether the left turn lanes are at unusual locations, the number of off ramps, and whether the overall design is unfamiliar. However, while the five-point scale could serve as the framework for a model, it has not been validated against field data.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

The objective of the research project would be to develop and validate a model predicting the wrong way movement potential of a freeway interchange as a function of traffic demands, interchange geometry, and other key features. Tasks to achieve the objectives should include:

1. Literature review and discussions with experts around the world.
2. Assembly of draft model framework.
3. Collection of a sample of crash data and a judgement on whether the sample sizes would be sufficient.
4. Collection of crash data (if sufficient sample) or collection of wrong way movements on video.
5. Collection of traffic, geometry, and other data.
6. Model calibration and validation.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The main product of the research would be a model predicting wrong way movements as a function of traffic demands, interchange geometry, and other key features.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☐ Increase Operational Efficiency / Time Savings	☐ New or Improved Specifications
☐ Cost Savings	☒ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☒ Improved Models (Performance/Traffic/Financial etc.)	☐ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

NCDOT roadway designers and traffic engineers would use the model developed in this research to better judge interchange designs that are proposed for new locations or are being rebuilt at existing locations. The Mobility and Safety Division, State Highway Patrol, Governor's Highway Safety Program, and others can also use the product of the research to prioritize locations for wrong way movement countermeasures, whether those are signs, active devices, enforcement, or education. The ultimate result from the research should be a reduction in the horrific toll wrong way crashes exact.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

The model developed in this research would need to be distributed to roadway designers and traffic engineers in several central units, to the field Divisions, to the State Highway Patrol, to the Governor's Highway Safety Program and to consultants. Conducting presentations at meetings and roundtables are the usual ways to get information like this to these professionals.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Mobility and Safety
Title: Staff Engineer
Name: Joseph E. Hummer, PhD, PE

Approval (Division Official or Unit Head)

Kevin Lacy, PE, CPM		State Traffic Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	July 15, 2016	**RNS#:**	**8506**
Submitter Name:	Joseph E. Hummer, PhD, PE	**Phone:**	919-773-2830
Division / Unit:	Mobility and Safety	**Email:**	jehummer@ncdot.gov
Research Idea Title:	Appropriate Guidelines for Left Turn Signal Phasing Where Peak Period Congestion Is the Issue		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

Some signals in NC have protected-only left turn operations where the only reason for installation of the protected phase is peak-period congestion mitigation, indicated by a high cross product. At such places, with single or dual left turn lanes, there are no sight restrictions, the oncoming vehicle speeds are reasonable, the number of oncoming lanes is reasonable, and there never was a permissive phase so there was no previous crash problem associated with a permissive phase. However, during many hours of the day at these locations, left-turning motorists have to endure much seemingly needless delay since the protected phase is not needed during time periods when the left and oncoming demands are lower. Many motorists experiencing that delay become frustrated and may act out by running the red, speeding up after getting green to make up lost time, or exhibiting other unsafe behaviors, either at that intersection or later in their journeys. In addition, the vast majority of vehicle hours traveled at any intersection occur outside of the peak period, meaning that the majority of traffic would be impacted by suboptimal phasing.

Background: *Provide supporting information about the business unit, processes and tools*

Safety, congestion, and signal engineers in Mobility and Safety and in the field Divisions lack a full set of tools to make phasing decisions at locations described above. The engineers have crash modification factors (CMFs) for conversion from protected to flashing yellow arrow (FYA) protected-permitted (all day or time-of-day) from an excellent study by Carrie Simpson and Shawn Troy of Mobility and Safety published in 2015. However, the Simpson and Troy study was limited in that they did not make a field visit to each site to collect sight distances and such and the sample sizes of sites and crashes from the conversion of protected to FYA was small. More such conversions have occurred in the couple years since Simpson and Troy collected their data, and an ongoing national-level pooled fund study might supply additional qualifying sites. In addition, capacity analysis procedures and cross product limits only apply to peak hours. Engineers making decisions on signal phasing at locations described above need more refined CMFs, the ability to consider delays over 24 hours, and a way to make a more holistic analysis of all of the effects of either protected or permitted phases.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

1. Literature review, contacts within NCDOT, and contacts with other agencies and organizations.
2. Collect relevant crash data; this could include new data at relevant locations in NC or a re-analysis of crash data at sites that were part of a previously-collected sample in NC or elsewhere.
3. Develop refined CMFs for the conversion from protected to protected-permitted or permitted for the locations of interest.
4. Develop operational analysis method.
5. Assemble draft guidelines, including how to quantify expected time savings.
6. Apply draft guidelines at existing locations within scope; refine as test results indicate.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

Recommended guidelines on the installation of permitted or protected-permitted left turn signal phasing (e.g., single or dual flashing yellow arrow) in the case when there are no sight distance issues, when oncoming speeds are reasonable, number of opposing lanes is reasonable, and when there is no history of crashes with a permissive phase in place.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒ Increase Operational Efficiency / Time Savings	☒ New or Improved Specifications
☒ Cost Savings	☐ Improved Worker or Public Safety
☐ Improved Material, Structure, Pavement Performance	☐ Permitting / Regulatory Compliance
☐ Improved Models (Performance/Traffic/Financial etc.)	☒ Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Increased operational efficiencies and improved specs. are obvious benefits from the research. Cost and time savings are likely from engineers not having to field so many citizen complaints about the types of sites in question and not having to re-analyze previous decisions. Revised guidelines backed by thorough research are also necessary to defend against lawsuits and to discourage the filing of lawsuits after crashes at such locations. The Department can also expect positive public relations from implementing the guidelines, removing unneeded protected phasing, and quantifying the expected time savings. If adopted in whole or part by municipal partners, these guidelines will also promote consistency in approach by other transportation agencies and expectations by the public.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

Improved guidelines on signal phasing would need to go to engineers in the safety, congestion, and signal units of Mobility and Safety (including regional staffs), to field Division engineers working on signals, and to consultants hired by NCDOT. Placing the revised guideline in the TEPPL and conducting presentations at meetings and roundtables are the usual ways to get information like revised guidelines to these engineers.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: Mobility and Safety
Title: Staff Engineer
Name: Joseph E. Hummer, PhD, PE

Approval (Division Official or Unit Head)

Kevin Lacy, PE, CPM		State Traffic Engineer
Print Name	Signature	Title

RESEARCH & DEVELOPMENT

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH NEED STATEMENT

Submission Date:	1 July 2016	**RNS#:**	**8507**
Submitter Name:	Richard Mullinax, PE / G. G. Murr, Jr., PE	**Phone:**	919-733-8015
Division / Unit:	Rail / Design and Construction	**Email:**	remullinax@ncdot.gov
Research Idea Title:	Traffic Signal Preemption Clearances at Highway-Rail Grade Crossing		

What is the problem or issue needing investigation? *Be specific and detailed. (Click Here for Form Instructions)*

This research project will investigate nationwide practices for pedestrian and vehicle clearance timing intervals at highway-rail grade crossing preempted traffic signals, statistically evaluate and determine benefits of the different practices using historic data including crash reports and case studies, and develop metrics for a best practice for both, heavy rail and light rail infrastructures, based on findings.

The length of approach circuitry along a railroad track for detection of a train approaching a highway-rail grade crossing is directly proportional to the amount of clearance time required for a traffic signal in close proximity to the crossing. The cost for these approach circuits increases exponentially as the circuitry length increases, and longer lengths of these approach circuitries may push the technological limits of the industry resulting in possible decreased reliability of train detection for activation of highway-rail grade crossing warning devices. As train, vehicle, and pedestrian volumes increase not only in North Carolina, but throughout the nation, there is a need to quantify and validate various standards of practice to ensure safe, effective operations are maintained with efficient obligation of limited funds for these vital safety devices.

Background: *Provide supporting information about the business unit, processes and tools*

Traffic signals located in close proximity to a highway-rail grade crossing must provide sufficient green clearance time to clear vehicles off the crossing or limit the ability of vehicles to enter the crossing to prevent a crash during the approach of a train. In addition, these traffic signals may include a pedestrian clearance interval to allow pedestrian to complete their roadway crossing at the signalized roadway intersection.

Two primary methods used by various highway agencies throughout the nation by professional engineers responsible for the design of traffic signals generally adhere to either the Greenshield's formula or the Texas Transportation Institute method. There are other methodologies being used. In addition, the current edition of the FHWA's Manual on Uniform Traffic Control Devices (MUTCD) allows truncating or elimination of the pedestrian clearance interval during a preemption event at these locations. Depending on the methods selected and a highway agency's practices, the selection of clearance intervals can have a major impact on the reliability and cost of the highway-rail grade crossing warning devices, requiring longer track approach circuitry which can push the technological limits of industry.

By CFR and NCGS, the Department is required to comply with the MUTCD. The MUTCD prohibits the design, application, and placement of traffic control devices not in the MUTCD. Currently, the MUTCD does not provide a method or standard for calculation of green clearance intervals. However as noted prior, the MUTCD does contain provisions allowing the shortening or omission of the pedestrian clearance interval during a preemption event. Generally, changes to the MUTCD should be supported through research and evaluation. Therefore, in addition to impacting NCDOT's current design standards and utilization of safety funds, this research project will afford NCDOT the opportunity to enhance and provide justification for its position on possible future changes to MUTCD standards by its participation on AASHTO's Subcommittee on Traffic Engineering and the National Committee on Uniform Traffic Control Devices.

Research Tasks: *Describe specific activities that are anticipated (gathering data, structural testing, traffic analysis, etc.)*

Research tasks to be performed include:

- Literature research of various methods for calculation of traffic signal preemption clearance intervals for both heavy and light rail infrastructures.
- Investigation of various methods for calculation of traffic signal preemption clearance intervals including identifying practices adopted by highway agencies throughout the nation and interviewing representatives of those agencies as to their experiences, knowledge, and reasoning for use of their agencies adopted method.
- Investigation and statistical analysis of crash data available from highway agencies throughout the nation for locations that have highway-rail grade crossings with traffic signal preemption and determine if there is an analytical correlation between those crashes and the methods used to calculate traffic signal preemption clearance intervals.
- Investigate and research technological capabilities and limitations of track circuitry technology for providing train detection as it may relate to detecting a train approaching a highway-rail, grade crossing and activating the highway-rail, grade crossing warning devices.
- Using research proposal investigative findings, evaluate safety benefits of the various methods for calculating traffic signal preemption clearance intervals and perform a Benefit/Cost analysis of the different methods.
- Develop a comprehensive report with a matrix of recommended "best practices" for calculation of traffic signal preemption clearance intervals for heavy and light rail infrastructures.

Products of the Research: *Examples of products could include models, specifications, policies, general guidance...etc.*

The product of this research will be a comprehensive report on the "state of the practice" throughout the nation as well as a matrix of recommended "best practices" for calculation of traffic signal preemption clearance intervals for both, heavy and light rail infrastructures.

Benefit / Knowledge Gain for NCDOT: *Check all that apply.*

☒	Increase Operational Efficiency / Time Savings	☒	New or Improved Specifications
☒	Cost Savings	☒	Improved Worker or Public Safety
☐	Improved Material, Structure, Pavement Performance	☐	Permitting / Regulatory Compliance
☒	Improved Models (Performance/Traffic/Financial etc.)	☐	Other (Specify)

Explain Anticipated Benefits: *Provide details for the benefits checked above.*

Results of this research as documented in the comprehensive report will be used to develop and enhance NCDOT's current design practice for calculation of traffic signal preemption clearance intervals in a safe, fiscally responsible manner. Further, results will be shared on a national level with other practitioners to facilitate future development of design standards and practices as they may relate to the MUTCD and AASHTO guidelines.

Current construction costs for highway-rail grade crossing warning devices in North Carolina range from $250K to $500K depending on the complexity of the crossing approach circuitry as well as any overlapping circuitry for train control devices along the tracks. There is anecdotal evidence that installation of similar warning devices in other states' highway agencies are approaching, and even exceeding, $1M due to variations and design philosophies associated with green clearance intervals and truncating of pedestrian clearance intervals which are associated with the traffic signal needs.

Implementation: *Describe how the results of research will be put into practice at NCDOT.*

This is a joint research proposal submittal from NCDOT's Rail Division and the Transportation Mobility & Safety Division. Both of these Divisions have a deeply vested interest in ensuring the success of the proposal and will use the results in determining, and modifying as appropriate, NCDOT's standards and practices for calculation of traffic signal clearance intervals.

Who will lead the implementation?
Provide Unit, Position Title and Name.

Unit: ITS and Signals Unit
Title: State ITS and Signals Engineer
Name: Mr. Greg Fuller, PE

Approval (Division Official or Unit Head)

Mr. Paul Worley, CPM		Rail Division Director
Mr. J. Kevin Lacy, PE, CPM		State Traffic Engineer
Print Name	Signature	Title