



STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION


ROY COOPER
GOVERNOR

J. ERIC BOYETTE
SECRETARY

August 23, 2021

MEMORANDUM

TO: Researchers and University Officials

FROM: Neil Mastin, PE 
Research and Development Manager

RE: NCDOT FY2023 Research Request for Proposals

In this document, please find the official Request for Proposals summarizing NCDOT generated research needs for the Fiscal Year 2023 Research Program. This package contains internally generated NCDOT Ideas. **If you submitted a research idea or ideas directly, you will receive direct communication regarding those ideas.** We are not accepting new ideas at this time, only proposals.

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

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

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

The deadline is Friday, October 15 2021, @ 5:00 PM.

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

[Click here for proposal instructions and templates.](#)

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

We look forward to seeing your submissions!

A Few Notes:

Contacting NCDOT Idea Generators

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

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

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



RESEARCH & DEVELOPMENT

**NCDOT Research and Development
Request for Proposals
Fiscal Year 2023**

August 23, 2021

FY 2023

REQUEST FOR PROPOSALS

ENVIRONMENT

AND

HYDRAULICS

Research Idea Title:

Determining a risk-based, performance based hydraulic level of service for NCDOT roadways and assets.

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
EN	2023-001	2023	5/25/2021 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Morgan	Stephen	State Hydraulics Engineer	smorgan@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:
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Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Morgan	Stephen	State Hydraulics Engineer	smorgan@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

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

Explain Anticipated Benefits:

User costs and operational efficiency of the roadway network can be realized by more deterministic HLOS analysis. Future cost savings can be realized through improved HLOS. Design-Build projects will have better defined RFP language and less risk for the DB team. Project savings can be realized if a lower HLOS is sufficient. Pavements and structure performance can be enhanced with better awareness of the various risks associated with extreme events for example; detours are often on lower standard roads. The hydraulic planning specifications will be specific to the project and will be continually relevant. Driver safety can be realized by improved HLOS.

What is the problem or issue needing investigation?

Hydraulic Level of Service (HLOS) determinations have historically been based on roadway type with very little consideration given to highway volume and cost of disruption as an example. This one-size-fits-all approach does not consider the many data streams available now that could more directly determine cost/benefit to a higher, or lower standard.

Background:

Most highway systems use a static hydraulic standard such as a 25 year (for secondary roads) or 50 year event (for primary routes) to determine the hydraulic requirements of the roadway. However, the duration of these events is not considered, nor is the disruption to traffic. For example, a 10 year flood event that floods a road but recedes in 4 hours may be less impactful than a 50 year event that disrupts traffic for a week, even though the 10 year event occurs more frequently. These discussions do occur during planning, but a better understanding of the analysis is needed, and the data sources used for the evaluation need to be consistent.

Research Tasks:

1. Inventory existing practices and guidance.
2. inventory existing data sources and identify needed data sources.
3. Develop schema to determine cost/benefit ratios including user costs and lost opportunity costs, both for project segments and entire roadway segments.
4. Develop tools to assist planners in HLOS and cost estimates.
4. Analyze select sample data sets and determine HLOS for the roadway segment sampled. Compare to existing HLOS.

Products of the Research:

Better planning tools including project prioritization and incremental funding prioritization.
Dynamic and performance-based design standards.

Possible IT Components:

GIS data streams
ATLAS integration for project screening and planning
Data acquisition

Implementation:

During planning, the screening tool will be used to determine the most cost-effective hydraulic level of service. These would be project specific, and site specific. A long-term goal would be to use the tools, coupled with the extensive database of hydraulic models, to set minimum road grades statewide and more programmatically.

Additional Comments and Information:

Performance-based standards have been supported and encouraged by FHWA. Additionally, during disaster recovery, having this tool would allow reimbursements for "betterments" to occur more easily by providing the justification more readily.

Research Idea Title:

Method comparison of electrofishing surveys and eDNA surveys, for presence/absence detection of protected fish species; in cost, reliability, and application.

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
EN	2023-005	2023	6/8/2021 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Burroughs	Anne		amburroughs@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:
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Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Gray	Jared	Aquatic Team Lead	jgray@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Permitting or Regulatory Compliance

Explain Anticipated Benefits:

This research could help USFWS adopt eDNA survey for RLP as an approved survey method, which would reduce costs of detection surveys and improve the knowledge base used to make resource conservation investment for RLP. In addition, eDNA methods review and refinement could increase adoption and research of this technique for other aquatic species, with potential cascading benefits of more reduced survey costs and better data to improve conservation efforts.

What is the problem or issue needing investigation?

Electrofishing requires specialized training, expensive equipment, and cooperative weather conditions. Detection probability is highly variable, and electrofishing is a form of harassment on aquatic wildlife. An increasingly popular survey method, environmental DNA (eDNA), has the potential to make aquatic surveys cheaper, easier, and more reliable at detecting the presence of a target fish species with minimal to no harassment.

Background:

Roanoke logperch RLP (*Percina rex*) are a federally protected fish that occur in the Roanoke River basin within North Carolina. These endangered fish are difficult to detect via traditional electrofishing surveys. Electrofishing requires cooperative weather conditions several days before the survey can be conducted, which can delay survey delivery. Even with good weather and stream conditions, RLP have been difficult to detect. Expanding use of an innovative eDNA survey method has the potential to supplement and/or replace electrofishing by detecting RLP DNA within the water column, eliminating the need for actual fish sightings or handling. An approved eDNA survey method would likely greatly reduce survey cost, improve detection rate and lead to better data available for conservation resource planning. However, the method must be proven effective at detecting the fish and be approved by the regulatory agency, US Fish and Wildlife Service. The RLP was selected for this study because foundational research and techniques have been developed (Strickland and Roberts, 2019) which combine to make RLP an excellent candidate for eDNA study.

Research Tasks:

Researcher will conduct detailed literature review of the state of the science and application of eDNA in field surveys. Analysis of results will be used to develop and refine techniques for adapting eDNA use for field detection. This proposed study would conduct an eDNA test for presence of the RLP at all NCDOT electrofishing sites within the RLP habitat over the course of one RLP survey season (March 15-November 15). Water samples from above and below each project bridge would be collected, stored on dry ice and transported to the North Carolina Museum of Natural Sciences. Here the NCWRC conservation geneticist would filter the water samples, amplify the genetic material and run the eDNA analysis to detect the presence of genetic markers left by the RLP.

Products of the Research:

Fish survey results (electrofishing and eDNA) will be compared, considered with past detection rates, and a detection probability calculated. Actual costs of each method (electrofishing and eDNA) will be compared with site variables, and projections of future surveys' needs considered. There are numerous study variables including sedimentation, water velocity, sample depth and more (Strickland and Roberts, 2019) that can impact eDNA survey detection rates, and these will be evaluated and considered as practicable.

Possible IT Components:

N/A

Implementation:

Researchers will work closely with US Fish and Wildlife and NC Wildlife Resource Commission to ensure a quality project is developed prior to next RLP survey window. All surveys will be conducted with scientific integrity to ensure repeatable results. It is anticipated that the study will aid in adoption of a most cost-efficient survey method for RLP and potentially other species in the future.

Research Idea Title:

Bathymetric mapping using unmanned aerial vehicles (UAVs)

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
EN	2023-038	2023	6/24/2021 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
Weatherford	Morgan	Environmental Program Consultant	mdweatherford@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:
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Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
Spain	Benjamin	UAS Program Manager	bcspain@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

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

Explain Anticipated Benefits:

- Cost and time savings through increased capability for infrastructure inspection, especially in hazardous/dynamic areas, particularly during emergency response.
- Data gathered to bolster models is expected to improve model accuracy and reliability and streamline agency approvals.
- More robust measurements of drainage system capacities inform decisions made for stormwater management and resilience planning to protect lives and infrastructure.

What is the problem or issue needing investigation?

The relatively recent development of Light Distance and Ranging (LiDAR), and its subsequent capture on a statewide level has provided a multitude of planning and modeling improvements. Significant information and technology gaps exist in planning, modeling, mapping, and assessment when water resources are present however. Depth measurements of these resources currently involves significant time, cost, and technology-intensive tasks that vary across the remote, dangerous, turbid, and tannic waters across the state.

Background:

The NCDOT and related planning and regulatory communities have realized the immediate benefit of statewide LiDAR data for use in all aspects of planning, permitting, and monitoring. Bathymetric LiDAR has emerged with significant capabilities to fill gaps and improve data collection and quality capabilities for activities including planning, monitoring, and inspections. The ability to incorporate estimated water depths quickly and efficiently is suited to a wide range of project specific and broad planning needs, with significant cost reductions and improvements to worker and public safety.

Research Tasks:

The investigators will:

- review the latest research and UAV /remote sensing technologies to help NCDOT potentially procure the most appropriate products.
- identify optimal methodologies for data collection in various parts of the state to maximize data acquisition for various purposes.
- work closely with NCDOT to develop methodologies, GIS tools, and/or models to capture and analyze bathymetric data.
- identify continued opportunities for developments in bathymetric data acquisition, planning, and safety.

Products of the Research:

- Data supporting various models and mapping efforts may include flood, drainage, and stormwater management models, protected species/fisheries habitat models, substrate and sediment transport models, hydrography models and mapping, tidal area models and mapping, underwater archaeological mapping.
- Project-specific planning/monitoring guidance for ferry, bridge, drainage, mitigation, etc. projects.
- Monitoring/inspection guidance for underwater structures or adjacent scour (ie., bridges, dams, flooded roadways).
- Monitoring/inspection guidance for depth-dependent water routes (ie., ferry routes and ports).
- Identification of sedimentation behind, or escaping from, dam structures.
- Improved data quality and availability to streamline Section 10/Coast Guard waters permitting.

Possible IT Components:

N/A

Implementation:

NCDOT can incorporate UAV-based LiDAR data directly into existing models and project planning. The monitoring of debris accumulation, shoaling, or channelizing of areas within ferry or shipping routes or adjacent to in-water structures is anticipated to realize immediate benefits in the time, quality, and safety of data acquisition and utilization. Similarly, immediate and efficient assessments of infrastructure before and during significant flood events can significantly improve response planning and safety.

Additional Comments and Information:

The Hydraulics Unit has also shown interest in this project. This project has potential to provide a wide variety of benefits to the Department but will ultimately depend on outreach and coordination with various units and their current practices.

Subcommittee Comments:

Research Idea Title:

Monitoring Hydrology and Water Quality of Mature SCMs in the NCDOT Environment

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
EN	2023-052	2023	6/25/2021 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
O'Connor	Dan	Roadside Env Engineer	djoconnor1@ncdot.gov

Secondary Generator:

Last Name:	First Name:	Title:	Email:
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Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
O'Connor	Dan	Roadside Env Engineer	djoconnor1@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Improved Material Structure/Pavement/Performance;Permitting or Regulatory Compliance

Explain Anticipated Benefits:

NCDOT's principal benefits will be an evaluation of its current maintenance program. What levels of maintenance appear to be sufficient to achieve specific hydrologic and water quality outcomes? This will likely create more uniform and efficient maintenance and also ensure more reliable/ predictable SCM functioning. Another benefit to the Department will be updating its SCM performance reporting to NCDEQ. The Department will likely be able to share improved results than originally expected, which would help it meet compliance goals.

What is the problem or issue needing investigation?

NCDOT has constructed over one thousand Stormwater Control Measures (SCMs) to treat runoff from roadways, bridges, rest areas, and maintenance yards over the last two decades to meet regulatory requirements including as part of its NPDES obligation. NCDOT has further conducted quantitative monitoring of several of these SCMs installed as part of its NPDES permit required Retrofit or Research Program, with almost all of the evaluation period occurring during the early stages of the SCM's life. This monitoring established levels of performance for the SCMs, which is assumed to then remain constant. Recent research indicates that vegetated SCMs (namely bioretention and constructed stormwater wetlands) might perform better as they mature; however, this performance is likely to vary depending upon maintenance input to the SCM. An important question facing NCDOT is how well do SCMs age – especially vegetated ones. Vegetated SCMs have a built-in element of resiliency: vegetation. How should this vegetation be managed to ensure resilient performance?

Background:

With numerous SCMs maintained by NCDOT annually, practice resilience and the maintenance needed to keep it functioning is an important financial consideration for the Department. Recent research suggests that vegetated SCMs (like bioretention and constructed stormwater wetlands) are more resilient than non-vegetated SCMs (underground vaults and permeable pavement). Moreover, the amount of maintenance needed to keep an SCM functioning (hydrology, water quality, safety) is particularly important when considering limited financial resources.

Because (1) NCDOT has quantitatively monitored several SCMs near the beginning of their life and, therefore, has established a baseline for individual SCM performance and (2) maintenance regimens vary among NCDOT divisions, a valuable opportunity presents itself to the Department. Is SCM performance changing with time and is that impacted appreciably by maintenance and upkeep?

Research Tasks:

The following collaborative research tasks are expected for this project:

- (1) NCDOT will select 3-4 vegetated SCMs that are at least 7 years old and have been quantitatively monitored shortly after construction. Inspection and maintenance records for these SCMs will be obtained from NCDOT, reviewed, and included in the decision-making process.
- (2) University will purchase (or re-purpose) and install monitoring equipment at the selected SCMs.
- (3) University will collect monitoring hydrologic and water quality data for a year, with a specific intent to capture seasonality in performance
- (4) University will analyze and synthesize the data, with emphases on comparing performance to when the SCM was first monitored and the role of maintenance.
- (5) NCDOT and University will conduct quarterly meetings to discuss project progress in addition to completing quarterly reports
- (6) Written documents and oral presentations will be produced, including but not limited to: a Final Report for NCDOT and a Thesis or Dissertation.

Products of the Research:

The following research products are expected:

- (1) Revised Maintenance Protocols for select vegetated SCMs. This will include a cost-benefit consideration. That is, how much maintenance investment was needed to meet a specific hydrologic and water quality performance benchmark.
- (2) Revised performance expectations for SCMs. This information would be communicated by NCDOT to NCDEQ. It would be beneficial to know if some of the SCMs work better than what was reported initially, which would mean that (for example) NCDOT is actually removing more nitrogen and phosphorus than originally expected.
- (3) A Quality Assurance Project Plan (QAPP), a Final Report, a Research Thesis, and multiple NCDOT-approved journal articles
- (4) Multiple research presentations at state and national conferences.

Possible IT Components:

There are no expected IT components.

Implementation:

NCDOT has established inspection and maintenance practices for its SCMs; however, if the Department can update its maintenance guidance and/or reduce some of its vegetation maintenance practices for certain SCMs, this could potentially result in significant cost savings while still maintaining compliance with its NPDES permit. This idea of revisiting several select former NCDOT Research Program SCMs and evaluating their effectiveness again after many years may provide the necessary data to aid the Department in its efforts to streamline some SCM maintenance operations while also demonstrating program compliance. This project will also potentially aid the Department in its ongoing effort to promote the utilization of natural features and drainage pathways to reduce runoff volume and improve water quality while also meeting compliance requirements.

Additional Comments and Information:

Subcommittee Comments:

Research Idea Title:

Predicting Resilience and Reducing Failure of Stormwater Infrastructure to Extreme Storm Events

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
EN	2023-085	2023	6/25/2021 12:00:00 AM

Research Idea Generator:

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

Secondary Generator:

Last Name:	First Name:	Title:	Email:
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Sponsor/Champion:

Last Name:	First Name:	Title:	Email:
McDaniel	Andrew	Project Design Engineer	ahmcdaniel@ncdot.gov

Benefit or Knowledge Gain for NCDOT:

New or Improved Specifications;Other (Specify below)

Explain Anticipated Benefits:

NCDOT's principal benefits will be (1) an understanding of what peak flow mitigation/ flood control its SCMs currently provide and (2) an evaluation of various design improvements the Department could implement to provide further mitigation and reduce the chance of costly reconstruction of stormwater infrastructure damaged by extreme events. This information can inform future SCM designs (or suggest retrofits to existing SCMs) in regions of NC that will be targeted for extreme event resilience.

What is the problem or issue needing investigation?

The state of North Carolina has been struck by several extreme rainfall events over the past few years, which have caused failures in stormwater infrastructure (including but not limited to Stormwater Control Measures (SCMs) regulated under the Department's NPDES stormwater permits (NCS000250)). While SCMs are designed to treat runoff, their principal focus has been treating moderately sized rain storms. How these SCMs fared during larger events, and the restorative maintenance efforts associated with SCM damage is a significant concern for NCDOT. The Department has a substantial investment in stormwater management assets with over 1900 SCMs having been constructed to treat runoff from roadways, bridges, rest areas, and maintenance yards across the state. Moreover downstream stormwater infrastructure is protected by SCMs (e.g., swales and other conveyance channels). Fortunately, NCDOT has conducted quantitative monitoring of several of these SCMs installed as part of its NPDES permit-required Retrofit Program. NCDOT would benefit understanding at what storm size do typically-designed SCMs no longer provided hydrologic mitigation. At what point do SCMs likely fail with significant structural degradation (both to the SCM and downstream) that would lead to costly reconstructive repair? Moreover, are there simple retrofits to existing SCMs (or design features for to-be-built SCMs) that can enhance or extend hydrologic mitigation and reduce the chances of failure?

Background:

With numerous SCMs maintained by NCDOT annually, the potential for hydrologic mitigation (flood prevention) exists. Exactly how well these many SCMs functioned during the storm events of the past one-half decade is unknown. Because NCDOT has monitored many of these SCMs, it is possible to develop sound computer simulation models using existing data to predict practice performance during large storms. One particularly accepted hydrologic and hydraulic model is the Stormwater Management Model (SWMM), which could be "trained" using existing collected data from NCDOT-monitored SCMs. Once SWMM is calibrated and validated with existing data, it can then be used to predict how individual practices would fare during extreme storm events. At what point does the SCM no longer provide peak flow mitigation? When does an SCM fail to the point that it is damaged, requiring costly restorative maintenance? Is downstream infrastructure impacted – and to what extent – by failed SCMs? A range of storm depths, distributions, and durations can be tested using this model.

Once a "breaking point" for the monitored SCMs has been reached, design adjustments can be made to each of the modelled practices to understand how much more mitigation is possible by either retrofitting existing SCMs or incorporating new design specifications into future SCMs. Because several SCM types have been monitored by NCDOT, many sets of design recommendations might be able to be made as a result of this study.

The study can specifically include investigating several SCMs managed by NCDOT that failed under extreme events. Modelling these SCMs would help determine the failure mechanism(s). By understanding failure mechanisms, future SCMs can be designed to avoid failure.

Research Tasks:

The following collaborative research tasks are expected for this project:

- (1) NCDOT will select 6-8 SCMs with at least one year of reliable hydrologic data. Detailed design plans will be provided so that this information can be translated into a model.
- (2) NCDOT and researchers will select a model (e.g., SWMM) to conduct the study.
- (3) Researchers will model each of the SCMs in the model using existing hydrologic performance data and design details provided by NCDOT.
- (4) NCDOT and researchers will determine what storm depths, distributions, and durations each of the SCMs will be modeled against to predict extreme event performance.
- (5) NCDOT will provide researcher with pictures and other information on SCMs that have failed after extreme events.
- (6) Researcher will run the model-trained SCMs against the extreme events determined in (4). "Breaking points" (where hydrologic mitigation no longer appreciably occurs) will be determined for all SCMs.
- (7) NCDOT and university will choose design enhancements (which may be unique to SCM type) that potentially would improve hydrologic mitigation and resilience to failure. These design enhancements will be tested with the model. Any hydrologic improvements will be noted.
- (8) Researchers will analyze and synthesize the data, with a focus on identifying the most cost-effective design enhancements from a hydrologic mitigation and failure resistance perspective. Special attention will be given to downstream infrastructure benefits associated with SCM design enhancements.
- (9) NCDOT and researchers will conduct quarterly meetings to discuss project progress in addition to completing quarterly reports
- (10) Written documents and oral presentations will be produced, including but not limited to: a Final Report for NCDOT and a Thesis or Dissertation.

Products of the Research:

The following research products are expected:

- (1) SWMM (or other model) Input/Output files for future modelling efforts for at least 6 different SCMs.
- (2) Documented understanding of the functional limit of NCDOT SCMs with respect to flood control/ hydrologic mitigation, and when SCMs might fail to the point where costly restorative maintenance is needed both at the SCM and with downstream infrastructure.
- (3) Design recommendations (in a document) about improving SCM hydrologic mitigation and failure resistance. Moreover, the extent of potential improvement will be clearly stated.
- (4) A Final Report, a Research Thesis, and multiple NCDOT-approved journal articles
- (5) Multiple research presentations at state and national conferences.

Possible IT Components:

There are no expected IT components.

Implementation:

The findings of the research, if successful, will be made available to hydraulic design engineers supporting project delivery through integration of the findings in NCDOT's Post-Construction Stormwater Program, its SCM decision support matrix, and the Best Management Practices Toolbox manual.

FY 2023

REQUEST FOR PROPOSALS

**TRAFFIC, SAFETY, AND
ROADWAY DESIGN**

Research Idea Title:

Development of Interchange Crash Modification Factors

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2023-014	2023	6/17/2021 12:00:00 AM

Research Idea Generator:

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

Secondary Generator:

Last Name:	First Name:	Title:	Email:
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Sponsor/Champion:

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

Benefit or Knowledge Gain for NCDOT:

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

Explain Anticipated Benefits:

As described earlier, NCDOT currently makes many decisions on interchange concepts early in project development in the absence of any quantitative knowledge on the safety implications of those decisions. This may result in designs that are less safe than they could be, resulting in more crashes, or in over-designs than mean wasted delays, costs, and impacts. Accomplishment of this research objective would mean more decisions on interchange design concept that get closer to the optimum.

What is the problem or issue needing investigation?

The NCDOT TIP prioritization process continues to produce many interchange improvement projects, showing that there are significant operational and safety problems at many NC interchanges and that potential cost-effective solutions exist for those problems. One difficulty faced throughout the early project development stages, however, is that teams do not have much information on the safety performance of rival interchange design concepts, leading to choices based on factors other than safety. Almost one hundred years after the invention of the cloverleaf interchange, we still have no idea whether, for a given traffic demand, it is safer or less safe than a standard diamond, and the same goes for one-loop designs, two-loop designs, and single-point interchanges. It is indeed ironic that the larger the project, the less current information is available to guide planners and designers to choose the safest feasible design. At a project site, would the extra cost and impacts for a loop ramp be justified later in terms of fewer crashes? In current practice, the sad answer is that we do not know.

Background:

The only high-quality (three-star or better) interchange CMFs contained in the Clearinghouse are for conversion of a standard diamond to a diverging diamond or to a roundabout interchange. Other safety information on interchanges is available, such as the ISAT developed by an NCHRP project some years ago, but generally concentrates on improving smaller aspects of the interchange rather than providing an overall CMF for the design concept.

The planning-level estimates of safety benefit (“safety benefit factors”) used in the SPOT prioritization process include only a handful of factors related to interchanges:

- Upgrade At-grade Intersection to Interchange or Grade Separation
- Improve Interchange
- Convert Grade Separation to Interchange
- Convert Grade Separation to Interchange to Relieve Existing Congested Interchange

It is apparent that these improvements are worded very generally and do not provide an indication of whether the type of interchange would affect the safety benefit.

An ongoing NCDOT research project will develop CMFs for converting a standard signalized intersection into a standard diamond interchange, and in turn there are many CMFs available for the conversion of a standard signalized intersection into other intersection designs. Thus, with completion of this project, teams would have at least some information on the conversion of many intersection designs to many interchange designs.

In April, staff from the Traffic Safety Unit and the GIS Unit completed an inventory of all interchanges in NC which is a great tool available to help the researchers complete this project. The inventory showed that there are perhaps 12 or so interchange designs across NC with large enough sample sizes to at least have a chance at CMF development.

This project should be limited to service interchanges. This is because the sample of system interchanges is smaller and the number of system interchange projects on the horizon is far smaller than for service interchanges.

Research Tasks:

The objective of this research is to develop a set of CMFs for the conversion of a standard diamond interchange into a number of other fairly common interchange designs. There are likely not enough available cases to use before-and-after data to develop the CMFs, so the CMFs will likely have to be derived with a cross-sectional method that compares the safety performance between the different interchange types. The project should aim for CMFs that will help with conceptual interchange design questions facing project teams early in project development, such as whether to use loop ramps or whether to signalize the ramp terminals, and not on later design details like curve radii, grades, median widths, etc.

Likely research tasks should include: 1) Literature review, 2) Assess sample sizes and data availability and determine scope, 3) Determine analysis methods, 4) Data collection, 5) Data analysis, 6) Validation of CMFs, and 7) Production of final report and other implementation assistance.

Products of the Research:

The final report from the research can be written for a narrow and technical audience that includes interchange experts in the Congestion Management Section, the Traffic Safety Unit, Roadway Design, and Feasibility Studies, plus the expert consultants that assist those entities. The research products should include a presentation that reaches the target audience. The research products should also include documentation sufficient to ensure that the CMFs produced are accepted into the Clearinghouse.

Possible IT Components:

IT would seem to have a minimal role in the research.

Implementation:

As noted above, the audience for the information to be produced during this project would be narrow and technical, so a single webinar informing these professionals of this new information should be sufficient in addition to the usual posting and circulating of the final report. The results would be implemented in NCDOT by the units mentioned above. In particular, Traffic Safety would use these results to provide better information for prospective TIP project alternatives and to provide the SPOT office with more reliable information at the prioritization level. We also expect the result to be included in the CMF Clearinghouse so other agencies across the world can benefit from the knowledge gained as well.

Additional Comments and Information:

This problem statement is co-sponsored by Daniel Carter, Traffic Safety Unit, 919-814-4949, dlcarter4@ncdot.gov.

Subcommittee Comments:

Research Idea Title:

Guidelines on Whether to Merge or Signalize Ramp Terminals on Urban and Suburban Arterials

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2023-020	2023	6/21/2021 12:00:00 AM

Research Idea Generator:

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

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Sponsor/Champion:

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Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Improved Worker or Public Safety

Explain Anticipated Benefits:

The final report from the research can be written for a narrow and technical audience that includes arterial experts in the Congestion Management Section, the Traffic Safety Unit, Roadway Design, and Feasibility Studies, plus the expert consultants that assist those entities. The research products should include a presentation that reaches the target audience.

What is the problem or issue needing investigation?

North Carolina's urban and suburban areas have many arterials with traffic merging onto the arterial from a ramp terminal. These merges often create difficulties for drivers, as the merging traffic may have to change lanes quickly to make another maneuver (such as a left turn) within a short distance or the merging traffic may have to contend with arterial traffic that wants to weave across its space to get to a driveway or side street. The easy options for designers in such cases are to install a stop sign or to signalize the ramp junction. Good tools exist to evaluate the operational advantages a merge usually enjoys over a stop sign or signal. However, there is no available information on the safety trade-off between a merge and a stop sign or signal at a ramp junction on an arterial. With a merge, the risks of sideswipe and lane-change crashes are obvious and pedestrians and bicyclists have elevated risks when trying to cross the ramp, but a signal likely introduces risks from rear-end crashes, especially on the arterial itself. In the absence of good safety information, project teams end up making decisions based on the perception of risk and operational information and may end up making poor decisions that lead to more crashes than there should be.

Background:

Examples of NC locations with merges on urban and suburban arterials that seem to cause drivers problems are common in Charlotte, Greensboro, and other cities. Just down the street from the Mobility and Safety offices in Garner is one such spot, where drivers making the merge from Greenfield Parkway onto eastbound Business US-70 who are destined for northbound Auburn-Knightdale Road must make three lane changes against often heavy traffic volumes at 55 mph or more in less than one thousand feet. Capital Boulevard north of downtown Raleigh features many merging ramps, including northbound and southbound north of Peace Street, northbound and southbound at I-440, southbound at Louisburg Road, and northbound at I-540, as well as at least a couple stop sign ramps and a couple signalized ramps.

Research Tasks:

The objective of this research is to develop guidelines for choosing between merges, stop signs, and signals on ramp terminals on urban and suburban arterials based on safety criteria. The researchers should collect and analyze crash and other data from as many such merge, stop sign, and signal sites at ramp junctions as possible to use as the basis for the guidelines.

Likely research tasks should include: 1) Literature review, 2) Assess sample sizes and data availability, 3) Determine analysis methods, 4) Data collection, 5) Data analysis, 6) Articulation and validation of the guidelines, and 7) Production of final report and other implementation assistance.

Products of the Research:

The final report from the research can be written for a narrow and technical audience that includes arterial experts in the Congestion Management Section, the Traffic Safety Unit, Roadway Design, and Feasibility Studies, plus the expert consultants that assist those entities. The research products should include a presentation that reaches the target audience.

Possible IT Components:

IT would seem to have a minimal role in the research.

Implementation:

As noted above, the audience for the information to be produced during this project would be narrow and technical, so a single webinar informing these professionals of this new information should be sufficient in addition to the usual posting and circulating of the final report. The results would be implemented in NCDOT by the units mentioned above. In particular, Traffic Safety would use these results to provide better information for prospective TIP project alternatives.

Additional Comments and Information:

This problem statement is co-sponsored by Daniel Carter, Traffic Safety Unit, 919-814-4949, dlcarter4@ncdot.gov.

Subcommittee Comments:

Research Idea Title:

Pushing the Envelope on Three-Phase Intersections

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2023-026	2023	6/22/2021 12:00:00 AM

Research Idea Generator:

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Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Improved Worker or Public Safety

Explain Anticipated Benefits:

As noted above, two-phase designs are ideal at many intersections on NC arterials, but at times project teams are unable to choose those designs. Therefore, three-phase designs could serve as a compromise by still delivering some safety, delay, progression, cost, and impact improvements compared to conventional four-phase intersections.

What is the problem or issue needing investigation?

At intersections along NC arterials, designs with two critical-phase signals are usually best. A two critical-phase signal generally provides better performance in terms of average delays of vehicles. Some of the intersections utilizing two critical-phase signals include reduced conflict intersections (RCIs) which are also superior due to safety and progression in particular, median u-turns (MUTs) due to safety and pedestrians and bicyclists, and continuous flow intersections (CFIs) due to capacity. However, during some projects we are unable to build two-phase intersections due to stakeholder objections, higher minor street demand, costs and impacts, or lack of precedent. In these cases, rather than just giving in and installing a sub-optimal conventional four-phase design, it is possible that we could compromise with a three-phase design. A three-phase design may provide some of the two-phase benefits, allow more direct movements (especially left turns from minor streets that stakeholders particularly desire), reduce costs and impacts, and alleviate some other public concerns. There are at least ten viable three-phase intersection designs available, but only three of them have seen any sizeable implementation or research attention.

Background:

The three fairly common or well-researched three-phase intersections include the offset intersection (subject of recent NCDOT research), a partial CFI with two left turn ramps, and a single quadrant. Less common three-phase designs that have been built or considered in NC include a CFI/MUT combo, a “thru-cut” that redirects minor street through movements, and a “reverse RCI” that redirects minor street through, and major street left turn movements. We are unaware of any three-phase designs built in NC that redirect major lefts (e.g., a “partial MUT”), redirect minor lefts, redirect left and through movements on one minor leg, or redirect one minor street through movement (e.g., a “seven-phase signal”). Note that the Virginia DOT is moving forward briskly with some projects to install thru-cut designs and has published some material on them.

The capacity and progression effects of the various three-phase designs are easy to see via macroscopic and microscopic traffic analysis methods with no research attention needed on those aspects during this project. The more pressing research needs are on potential motorist confusion and violations of movement restrictions, on public acceptance, and on pedestrian and bicyclist operations. Signing, marking, islands, and median designs could play an integral role in providing good operations of these designs.

Research Tasks:

The purpose of this project is to advance the state of the practice on three-phase designs—with emphasis on the seven newer designs—thereby allowing an increase confidence level to project teams during deployment of these project types, when given an opportunity to install them. It may be difficult for this study to provide guidelines on design choices for specific scenarios; however, we would like to remove some of the obvious objections people raise when one of these designs is proposed. As noted above, the more pressing research needs are on potential motorist confusion and violations of movement restrictions, on public acceptance, and on pedestrian and bicyclist operations.

Likely research tasks should include: 1) Literature review, 2) Driving simulator experiment to test driver confusion and ways to eliminate violations, 3) Field data collection to examine violations at existing sites, 4) Surveys to assess public and stakeholder acceptance, 5) Simulation, analysis of surrogate measures, or other ways at assess and improve pedestrian and bicyclist operations, 6) Production of final report and other implementation assistance containing recommendations on the implementation of three-phase designs.

Products of the Research:

The final report from the research can be written for a narrow and technical audience that includes intersection experts in the Congestion Management Section, the Traffic Signing and Delineation Unit, the Traffic Signal Design Section, Roadway Design, and Feasibility Studies, plus the expert consultants that assist those entities. The research products should include a presentation that reaches the target audience.

Possible IT Components:

We anticipate a minimal IT role in this research.

Implementation:

As noted above, the audience for the information to be produced during this project would be narrow and technical, so a single webinar informing these professionals should be sufficient in addition to the usual posting and circulating of the final report. If the results are favorable for one or more of the designs, the champions of the research could in turn make some presentations to the field divisions, project managers, and their consultants informing them of these new options and encouraging their use.

Additional Comments and Information:

This problem statement is co-sponsored by Renee Roach, Traffic Signing and Delineation Unit, 919-814-5020, roach@ncdot.gov.

A recent presentation by the sponsor and a colleague showing ten candidate three-phase designs and ratings of the designs on va

Subcommittee Comments:

Research Idea Title:

Multi Modal Trip Reductions Rates in Local Municipalities

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
TR	2023-055	2023	6/25/2021 12:00:00 AM

Research Idea Generator:

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Secondary Generator:

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Sponsor/Champion:

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Benefit or Knowledge Gain for NCDOT:

Improved Models Performance/Traffic/Financial etc.

Explain Anticipated Benefits:

Knowledge gain should produce more accurate traffic studies and better predictions of needed roadway improvements.

What is the problem or issue needing investigation?

Accurate Trip Generation is necessary to properly project development traffic for impact analysis. Local municipalities and developers often desire to include trip reductions for multimodal travel. This potentially reduces traffic impacts for the development while achieving a planning vision for municipalities. However, we have little data to properly estimate or calculate these reductions. NCDOT is asked to accept estimates of reductions for bike, pedestrian, bus, or train travel without justification.

NCDOT, having the responsibility to review these studies, needs reasonably accurate trip reductions. Without this data, conservative rates are taken due to the lack of evidence. It would be helpful to have data to better illustrate and estimate actual multi-modal trip deductions. This would provide NCDOT with the assurance that the reductions are accurate, and that required traffic mitigation is appropriate.

This results in potentially under or over-estimating the traffic generated by a development, which creates inaccuracies in the projected need for improvements funded by these developments.

Background:

NCDOT reviews traffic studies provided by developers to estimate impacts and assess improvements to reduce the future public investment of addressing traffic issues. Developers and municipalities often desire that these studies take multi-modal reductions to reduce traffic impacts. We could use more data to help correctly estimate the traffic reductions that should be estimated for these developments.

These proposed rates often rise in downtown areas where pedestrian, bicycle, and bus traffic are likely to be more common. It seems logical and reasonable that closely spaced facilities with limited parking options and access to public transportation features will experience higher rates of multi-modal travel. It is difficult to answer questions on limits on these issues. If these rates were captured on a basis of access/distance to multi-modal facilities, distance and connections to other developments, more accurate impact studies could be delivered.

Research Tasks:

Measure and quantify multi-modal trip reductions. Research will need to measure existing sites for trip generation for multiple modes of travel for existing developments. Potential variables include distance from multi-modal travel hubs (such as bus stops), facility access such as bike lanes or greenway access, proximity and connections to other developments. Additionally, factors such as internal capture and pass-by trips should be considered as factors affecting these development rates. Multiple sites may need consideration to develop a useful rate of reduction.

Products of the Research:

The final report from the research can be written for a narrow and technical audience that includes in the Congestion Management Section, NCDOT Division Traffic Engineer and District Staff, Private Engineering Firms who develop the Traffic Impact Studies. The research products should include a presentation that reaches the target audience.

Possible IT Components:

Traffic Analysis

Implementation:

The audience for this information will be narrow and technical, so circulation of the final report should be sufficient to generate implementation.

Additional Comments and Information:**Subcommittee Comments:**

FY 2023

REQUEST FOR PROPOSALS

**PLANNING, PROGRAMMING,
POLICY & MULTIMODAL**

Research Idea Title:

Modeling the Effects Of Rail Noise Propagation on Pedestrians In North Carolina Railroad Environments

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
PL	2023-017	2023	6/20/2021 12:00:00 AM

Research Idea Generator:

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Benefit or Knowledge Gain for NCDOT:

Improved Models Performance/Traffic/Financial etc.;New or Improved Specifications;Improved Worker or Public Safety;Permitting or Regulatory Compliance;Other (Specify below)

Explain Anticipated Benefits:

The benefits of this research is to investigate how train noise travels from a moving train and the factors that impact its detection by humans including topography, geography, urban versus suburban environments, differences in train horn frequencies, differences in train noise of freight trains versus passenger trains, greater understanding of communities use of FRA permitted 'no train horn' zones and a comprehensive survey peoples' beliefs that trains are inherently loud, produce great amounts of vibration and provide plenty of advance warning. The benefits of these findings will be shared with highway and rail design engineers to 'design out' ease of access in rail environments as well as public education and public safety enforcement trespass awareness efforts.

What is the problem or issue needing investigation?

Over the last decade, the incidence of pedestrian strikes by train has increased in the United States resulting in injury, loss of life, as well as costly disruptions in sensitive transportation and logistics systems. Though trespass strike events are well documented, little research to date has investigated the relationship between sound propagation and its effect on rail trespass strikes. The history of efforts to control rail noise in the United States dates back to the early 1960s, and technological improvements in noise abatement have continued to enable trains to operate more quietly, thus avoiding immediate detection by individuals in the vicinity. Research has shown that roughness on the running surfaces of wheels and rails, is the root cause of rolling noise, and a variety of technological improvements such as dampening devices attached to the webs of wheels and the rails have been implemented to reduce this noise. Similarly, train rolling friction coefficients (friction coefficients are a key measurement of noise from vehicles) have fallen substantially with improvements in train wheel and track technology and are currently less than those of highway vehicles. For example, the coefficients for railroad steel wheels on steel rails is between 0.001-0.002, whereas the friction coefficient for car tires on asphalt is 0.02.

Since 2015 I have watched approximately 63 video recordings from in-cab locomotive cameras of pedestrians struck by NCDOT Piedmont trains and Amtrak trains operating in NC. In addition, I conducted follow-up investigations, reviewed local law enforcement investigative reports, interviewed local investigators, railroad police agents and other rail industry stakeholders in keeping with the NCDOT BeRailSafe mission of mitigating rail tragedies in NC. The one recurring theme from investigators and the rare anecdotal feedback from victims' families is the universal belief that people walking on the tracks should hear or feel the train with adequate advance warning to avoid being struck.

A small minority of people enter the railroad to cause intentional harm to themselves. The vast majority do not. Most people use the railroad to walk to a pre-determined destination.

The video camera system onboard train locomotives display the train speed and the train horn status. After observing numerous videos of incidents while the train horn is sounding at 105 decibels and approach speeds between 50 and 79 M.P.H, the same or similar human behavior occurs. Most of the humans I observed were never aware of the train approach or made a realization far too late to take lifesaving action. Local law enforcement investigations indicate that most of the victims are not wearing earbuds or headphones. The video verifies the same human reaction regardless of the presence of earbuds: no awareness of a train approach or insufficient notice to react.

Even with the technological improvements that have been made, emergency response units, local enforcement agencies, elected officials, and the general public are largely unaware that walking on the railroad often involves individuals who are caught unaware, and are unable to hear an impending train before a strike occurs. In addition to noise reduction technologies that are being implemented, other external factors (i.e. topographic conditions, horn frequencies, train type, policy measure such as Federal Railroad Administration regulated No-Train Horn Highway Crossings i.e. 'quiet zones', etc.) may also play a role in why individuals are unable to hear approaching trains. Today, individuals have unlimited access to music, podcasts, and radio via cell phones and earbuds. Thus, individuals in the rail right-of-way who are listening to media through their earbuds may not be able to hear train horns or the sound of train rolling stock itself over the sound of these media.

Background:

NC/2019-08 Rail Network Trespass Statewide Severity Assessment and Predictive Modeling funded by NCDOT R&D was published in December 2020. Key findings from this 4-plus years of NC trespass research reveal astonishing counts and profiles of North Carolina's railroad trespassers.

The eleven trespass sites utilized static thermal cameras at known 'hot spot' railroad trespass sites that have a history of fatal railroad trespass events. 15,570 individual trespassers were identified during 721 observation days of which 652 days recorded trespasser activity. Scaled trespasser count data from these sites equal more than 12,200 annual trespassers at the Elon site and more than 11,600 annual trespassers in Mebane with 15,300 annual trespassers in Greensboro. The 2019 population of Mebane was 14,952. These trespassing are counts from one trespass site where many communities have dozens to 100's of known railroad trespassing locations.

Additional research findings revealed 1% of the trespassing events occurred with a train present in camera view, 35% traveled in pairs and involved family groups with children, strollers, bicycles, and walking dogs. The demographic research indicates higher incidence of railroad trespassing occurs in communities with greater densities of racial minorities, low-income housing, and less access to vehicles for personal transportation. These research findings reveal the magnitude of trespassing is much greater than Federal Railroad Administration reports.

Pedestrian trespass events often involve individuals who are caught off-guard and are unable to hear a train before a strike event occurs. Today, individuals have constant access to music, podcasts, and radio via cell phones and earbuds that may "drown out" the sound of trains as they approach. Additionally, technological improvements and policy measures that result in noise mitigation also play a role in trains being undetected by individuals on the railway. Research needs to be conducted to model how train noise propagates in various environments and how train noise is heard by individuals on the railroad right of way. Sounds produced by train horns, wheels, track, and other sound emitters need to be studied to determine how these noises may interact with pedestrians in rail environments as subject to external factors in the localized environment.

Research Tasks:

The objective of this applied research is the development of a model that demonstrates the decomposition of sound subject to a variety of factors including: (1) geographic and topographic conditions, (2) difference in horn frequencies by freight and commuter rail engines, (3) train type and its influence on noise propagation, (4) impact of policy, such as “quiet zones”, among other factors. The following research tasks are anticipated, although other and alternative proposed tasks are welcome for consideration:

1. Literature review of types of train noises propagated and factors that would influence the decomposition of noises emitted
2. Identification of a comprehensive set of factors that may affect train noise propagation that will be evaluated in this research
3. Development of a methodology for modeling noise propagation and decomposition subject to the localized environmental and other factors (identified in Task 2)
4. Creation of a model or simulation that demonstrates how propagated train noises are heard by individuals on the rail right-of-way subject to factors identified in Task 2 (see first sentence in this “Research Objectives and Tasks” box)
5. Production of a list of conditions that create high-risk environments for noise propagation to go undetected by individuals on the railroad right-of-way, based on the findings from the model or Simulation
6. Produce a report of the study’s findings

Products of the Research:

- A model that demonstrates how propagated train noises interact with external factors, such as vegetation/brush, buildings, etc., in the localized environment
- A prioritized list of high-risk environments resulting from the conditions that enable noise propagation to go undetected by individuals on the railroad right-of-way
- Scientific evidence to explain why individuals, who trespass on the railroad right-of-way, are caught “off-guard” by trains approaching
- Awareness, knowledge and guidance for highway and rail design engineers to ‘design out’ pedestrian ease of access to rail environments

Possible IT Components:

Modern, high-speed computers have enabled the development of microphone arrays that can pinpoint the sources of noise on trains as they pass by on a track. This technology is especially valuable for locating and modeling sources of noise propagation caused by trains. This study should employ state-of-the-art technology (i.e. decibel meters, video cameras etc.) and a data-driven approach to demonstrate how train noise propagation is dependent on a variety of factors (enumerated in “Research Objectives and Tasks”).

Implementation:

Based on the findings from this study, NCDOT will be able to pinpoint high-risk areas of train noise-detection. This information can be used to demonstrate where noise-related safety countermeasures can be implemented to obviate rail trespass strikes related to individuals being caught off-guard. BeRailSafe will implement the findings with public and public safety stakeholders through local, state, and national rail safety awareness networks. In addition, the research findings will be shared with highway and rail design engineers to ‘design out’ ease of access by pedestrians to rail environments.

Additional Comments and Information:

8 June 2021 on the CSX railroad bridge over US 64 in Apex, 18 year old Ava Sory lost her life with an Amtrak train, while her 17 year old companion narrowly escaped death, literally by inches. The images of their faces when they realized the train was upo

Subcommittee Comments:

Research Idea Title:

Guidance to Planning Organizations on How to Update Travel Demand Models to Consider Connected and Automated Vehicles and Their Impacts

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
PL	2023-074	2023	6/25/2021 12:00:00 AM

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Benefit or Knowledge Gain for NCDOT:

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

Explain Anticipated Benefits:

As described above, NCDOT needs accurate traffic forecasts to make the best possible project decisions, and they are likely not currently getting accurate enough information without consideration of CAVs. Forecasting future traffic was difficult without CAVs (see NCHRP Report 934 for example), and CAVs have compounded the difficulties. Nonetheless, NCDOT needs to make the attempt in many cases. Even if the research eventually provides project teams with some idea of the range of future travel demand that is plausible the effort will have been worthwhile. Just one freeway widening project team that correctly chooses six lanes instead of eight lanes, and thereby NCDOT tens of millions of dollars, will repay the research costs many times over. Improved accuracy of travel demand models through the addition of CAVs also provides benefits in the variety of other uses of the models, such as long range transportation planning decisions, transportation conformity, site impact analyses, project prioritization evaluations, etc.

What is the problem or issue needing investigation?

Within the past couple years, the author of this statement worked on two relevant freeway widening projects. Both were widening existing four-lane freeways on the fringes of growing urban areas that could no longer handle the increasing traffic demand with any decent quality of service. One of the big questions for each project team was whether the freeway should be widened to six lanes or eight lanes. In each case, the difference in cost and impacts between six lanes and eight lanes added up to tens of millions of dollars (in a large urban project the cost difference between six and eight lanes could be hundreds of millions of dollars). The traffic forecasts in both cases showed, after appropriate traffic analysis, that in the design year of 2040 a six-lane cross-section might work adequately, but it was a close call and if the forecast was slightly too low six lanes would likely not be sufficient much of the time.

In both cases described above, the traffic forecasts providing the main quantitative input to the traffic analysts did not consider connected and automated vehicles (CAVs). Essentially, the forecasts assumed that the vehicle fleets present during model calibration in the 2010s would be the same as the vehicle fleets of 2040. However, many projections show that by 2040 CAVs will be a significant presence on US roadways, and this is likely especially true in prosperous and growing urban areas like the two project sites described above. When design years are advanced to 2045 and then 2050 it is even more likely that CAVs will be a large percentage of the vehicle fleet. In addition, we know from a library of recent research that CAVs will significantly affect both supply and demand sides of transportation, more specifically land-use, people choosing to travel who do not travel much now, empty-vehicle trips, freight movements, temporal trip patterns, mode choices, route choices, highway capacities, and in many other ways. In both cases described above the forecasts used to make important and costly decisions ignored a likely large segment of travelers that behave quite differently from those included in the model.

When asked why the forecasts in the cases described above ignored CAVs, the forecasters had a ready answer, in that their main input, the travel demand models maintained by the planning organizations (POs), did not consider CAVs. In turn, when the POs were asked why they had not updated their travel demand models to consider CAVs, they provided three reasons. First, they said that they did not have the staff or consultants available to conduct a major model update. Second, they said that they are not at all certain about how CAVs will affect travel in the target year. Some CAV-related factors seem to push demand up, for example, while other factors seem to push demand down. Third, the POs said that they do not have guidance on how to adjust their models for CAVs. They do not have examples that they can mimic, and the available literature does not provide a recipe for making those adjustments. There is not much that research can do to overcome the first of those problems, but this research is aimed at providing guidance on how POs can overcome the second and third of those problems.

Background:

The literature on CAVs and their impacts is extensive. However, there is no document available to provide specific guidance to POs on how they should adapt their long-range models for CAVs and their impacts. A search of research underway at the national level did not show any projects like this one.

The most important piece of literature along these lines is NCHRP Report 896 from 2018. Report 896 acknowledged the importance of CAVs to future transportation planning and provided a framework for how agencies can start to adjust. Report 896 stopped well short of providing the specific guidance being called for in this research though. Report 896 did not recommend particular variables, at particular levels, or in particular combinations. Report 896 did not provide any examples of anyone actually modifying a model and demonstrating results.

On the other hand, there is literature available describing efforts to modify travel demand models. Bardaka, et al. ("Regional Impacts of Autonomous Vehicles on Transportation Network Demand: A Case Study of the Triangle Region, NC," presented at the TRB Annual Meeting in January 2020) modified the regional travel demand model for the Raleigh area for several CAV scenarios for example. They showed that modifying a travel demand model is technically possible and does not require a large effort. However, the Bardaka, et al. team tested an arbitrary and limited set of scenarios, so their results also do not provide complete guidance to POs. This proposed research aims to combine the efforts of NCHRP Report 896 and the Bardaka, et al. team to run systematic and helpful sets of scenarios through real models.

Another aspect of the voluminous research on CAVs that warrants attention is the recent progress on the highway capacity effects of CAVs. Many efforts have been made in recent years along these lines, but the most impactful is likely the pooled fund study being led by Oregon DOT. The research team in that project is developing Highway Capacity Manual adjustment factors for various levels of CAV penetration and has already made several presentations to the TRB Highway Capacity and Quality of Service Committee. The highway capacity effects of CAVs are not settled science, but they seem further along than many other aspects.

Research Tasks:

The objective of this research is to provide guidance to POs on how they should update and exercise their travel demand models to include CAVs and their effects. The guidance from this research needs to be specific such that PO staff or consultants working from this document can produce updated travel demand models and forecasters working from those models can produce helpful project-level forecasts or ranges. The research team will produce at least two examples of successful applications in actual PO travel demand models; that is, the researchers will pick at least two working models, update them for a realistic set of CAV scenarios, run them, demonstrate the results, and discuss how well the examples went. Note that this project is scoped to look at tour-based and four-step travel demand models but not activity-based models, which currently require significant upfront costs and maintenance.

Likely research tasks should include: 1) Literature review, 2) Assemble preliminary list of CAV factors and levels to be tested, and a summary of how each of these factors likely affects the supply and/or demand sides of transportation, 3) Draft directions on how typical demand models should be updated, 4) Choose at least two test models, 5) Alter test models to be able to run CAV scenarios, 6) Run the chosen CAV scenarios through the updated models, 7) Critically examine the results from Task 6, and 8) Produce a final report/guidance document and other implementation assistance.

Products of the Research:

The final report from the research will have a narrow and technical audience. The key to research success will be that PO staff working on tour-based or four-step travel demand models can use the research report to update their models and run the best set of CAV scenarios through their model to provide forecasters and traffic engineers with the information they need to make informed project decisions. Planners and forecasters working in areas without travel demand models will also be able to use the results to help in their work. The research will also provide guidance on which projects need to make the effort to include CAVs in the forecast and which do not.

Possible IT Components:

IT might have to approve the researchers for access to certain NCDOT databases such as in ATLAS. Otherwise, IT would seem to have a minimal role in the research.

Implementation:

Several levels of webinars might be needed to implement the results. NCDOT planners, traffic engineers, and project managers (and their consultants) might be targeted with a shorter webinar emphasizing that the capability to update travel demand models and forecasts for CAVs exists. Meanwhile, a detailed webinar or series with technical step-by-step guidance and plenty of time for questions and discussion could be provided to PO staff and consultants who work on travel demand models.

Additional Comments and Information:

This problem statement is co-sponsored by Jamal Alavi, PE, CPM, Director, Transportation Planning Division, 919-707-0901, jalavi@ncdot.gov.

Subcommittee Comments:

Research Idea Title:

Equity Analysis for Long Range Transportation Planning

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
PL	2023-078	2023	6/25/2021 12:00:00 AM

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Benefit or Knowledge Gain for NCDOT:

Increase Operational Efficiency/Time Savings;Cost Savings;Improved Models Performance/Traffic/Financial etc.;New or Improved Specifications;Permitting or Regulatory Compliance;Other (Specify below)

Explain Anticipated Benefits:

The benefits of addressing equity in long range transportation planning are great to a community in terms of impacts to economy, quality of life, and addressing other areas of past inequality. Benefits of addressing equity well in early planning propagate through the project development process. By identifying issues early, engaging all populations, and conducting equity analysis during the earliest planning phase, benefits are realized throughout project prioritization, development, and implementation. It helps ensure that inequality in transportation investment and decision-making do not occur, starting early in the planning process, where the ideas for many project proposals are generated and the prioritization for projects begins. Benefits are gained in the quality of project proposals that are developed, in that equity is considered and accounted for appropriately. Additional benefits may be realized in cost savings and time savings in project development and delivery, as equity analysis results in early identification of affected people and issues, so that they can be addressed appropriately and project proposals can be better scoped early, resulting in less project delays, less rework, and more predictable cost estimates.

What is the problem or issue needing investigation?

The importance of Transportation Equity is highlighted in the following excerpt from FHWA's publication 'The Transportation Planning Process Briefing Book- Key Issues for Transportation Decisionmakers, Officials, and Staff' (A Publication of the Transportation Planning Capacity Building Program, FHWA-HEP-18-015).

"Transportation equity refers to the way in which the needs of all transportation system users are reflected in the transportation planning and decision-making process. In particular, transportation equity focuses on the needs of those traditionally underserved by existing transportation systems, such as low-income and minority households, older adults, and individuals with disabilities. Transportation equity means that transportation decisions deliver equitable benefits to a variety of users and that any associated burdens are avoided, minimized, or mitigated so as not to disproportionately impact disadvantaged populations.

USDOT and modal administration regulations and guidance outline specific program requirements as well as best practices for achieving more equitable outcomes.

Considering equity early and often through methods such as public participation and data collection and analysis improves the planning process's ability to adequately respond to the needs of the community it serves. It may also improve project delivery by preventing costly and time-consuming delays that could arise from previously unrecognized conflicts as projects move from planning into implementation."

The scope of this proposal is develop data collection/ usage and methodology for considering/incorporating, analyzing, measuring, coordinating on, and reporting equity in long range transportation planning. This proposal builds on the literature review, equity definition, gap analysis, data identified and other interim deliverables of RP2022-17: Including Equity in Benefit-Cost Analysis.

The unique types of planning conducted in NC will need to be considered (state required Comprehensive Transportation Plans), as well as other types of long range plans such as Metropolitan Transportation Plans, corridor plans, statewide plans, subarea plans, etc. The focus is to consider existing available guidance, complete needed areas identified through gap analysis, and develop specific guidance/ methodology/ tools needed for implementation in North Carolina. Specific examples of questions to be answered include the following.

- How can equity best be addressed during development of vision, goals and objectives, and performance measures for a long range transportation plan?
- What are best practices for addressing equity during implementation of complete streets in development of proposals?
- How can purpose and need / identified need development be influenced by and reflect equity?
- What methodology can be applied to ensure equity is appropriately addressed during project proposal development/ alternatives analysis during long range transportation planning?
- What coordination with stakeholders and public engagement efforts are key, related to equity in the long range transportation planning process?
- How can equity analysis in long range transportation planning be measured and evaluated (specific performance measures and evaluation tools)?
- What are documentation best practices for equity analysis in long range transportation planning?

This research project would need to be conducted with a strong component of outreach and coordination with affected stakeholders, including NCDOT Transportation Planning Division, NCDOT modal divisions, other NCDOT units, FHWA, MPOs, RPOs, transit agencies, community representatives, and others.

Background:

Current practices seek to use available guidance, data, and methods to consider equity appropriately in long range transportation planning. However, with specific research, and development of more specific methodology and performance measures, the handling of this topic could be enhanced. This would benefit of the communities of NC, as well as result in efficiency in the project delivery process by having earlier identification of issues and engagement of interested/ affected parties.

Research Tasks:

Research tasks are likely to include:

- 1- Review of Interim Deliverables from RP2022-17
- 2- Problem Identification
- 3- Outline/ scope specific Guidance/ Best Practices and Tools to be developed
- 4- Develop Guidance/ Best Practices and Tools to Address Equity Analysis in Long Range Transportation Planning

These steps, as typical with research projects, will be done in coordination with the affected stakeholders mentioned above. Beyond the steering committee, outreach such as stakeholder interviews may be necessary. There is, and will continue to be, variance that must be accounted for in guidance and recommendations in how long range transportation plans are conducted and the resultant products. This variance is due to the different planning products, the size and nature of communities across NC, and other factors.

Products of the Research:

- Documentation of Problem Identification (drawing on RP2022-17 for documentation of Literature Review, Gap Analysis, etc.)
- Draft Outline/ scope specific Guidance/ Best Practices and Tools to be developed
- Develop Guidance/ Best Practices and Tools to Address Equity Analysis in Long Range Transportation Planning:
 - equity in vision, goals and objectives, and performance measures development
 - equity during implementation of complete streets in development of proposals
 - equity in purpose and need / identified need
 - equity analysis methodology for project proposal development/ alternatives analysis
 - equity related stakeholder coordination and public engagement efforts considerations
 - equity specific performance measures and evaluation tools
 - equity documentation best practices
- Communication/ Outreach Material(s) (The focus of this research proposal is not to develop the training or the materials for it, as the submitters thought that would make the scope too broad. However, some brief materials can easily be produced from this initial work that could be useful in early outreach, such as a brochure-style overview.)

Possible IT Components:

There is a possibility that one or more of the tools developed as part of this project to address equity evaluation may have an IT component. Tools already exist for travel demand modeling (TransCAD) and for mapping GIS data (statewide geodatabase, ATLAS) related to equity. So it is anticipated that the methodology developed for equity analysis will need to use outputs from these tools, and be compatible and utilize these existing tools to the maximum extent practicable. In that sense, there may not end up being a 'new' IT tool or component, but methodology and use of existing tools (or additions).

Implementation:

Implementation components will need to include standardization of practice by inclusion of accepted proposals in the TPD Procedure Manual. One challenge is that NCDOT may choose to follow these practices on all long range planning studies for which they are the project lead (such as CTP outside of MPO areas, and other studies) by including it in their Procedures Manual and communicating to staff the new policy. But NCDOT TPD does not have the authority to compel other partners to follow new best practices on other types of long range transportation planning studies for which NCDOT is a partner and not the lead agency, such as MPOs leading Metropolitan Transportation Plans. Therefore, implementation hinges on the planning partners realizing the benefits of the practices and the resources needed to conduct them not being overly burdensome. Outreach efforts and education/ training are key to implementation. NCDOT TPD will lead the training and outreach for implementation.

Additional Comments and Information:

This research project will need to consider the TCRP RESEARCH REPORT 214- Equity Analysis in Regional Transportation Planning Processes (2020) and the 'Transportation Equity Scorecard' (<https://rip.trb.org/view/1635483>) to the extent appropriate, as well

Subcommittee Comments:

FY 2023

REQUEST FOR PROPOSALS

**STRUCTURES, CONSTRUCTION
& GEOTECHNICAL**

Research Idea Title:

Impact Damage Evaluation of Prestressed Girders

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
ST	2023-019	2023	6/21/2021 12:00:00 AM

Research Idea Generator:

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Secondary Generator:

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Benefit or Knowledge Gain for NCDOT:

Improved Material Structure/Pavement/Performance;New or Improved Specifications;Other (Specify below)

Explain Anticipated Benefits:

Assist SMU and Division engineers determine whether the observed and anticipated damage can be sufficiently repaired, or the damaged girder needs to be replaced, especially on new bridges which are expected to be in service for 75 to 100 years.

What is the problem or issue needing investigation?

Impact damage evaluation of prestressed girders, which may not be obvious or clearly visible during a typical damage inspection.

Background:

Over the last couple of years there have been several instances of impact damage to bridges in NC. The impact damage is typically caused by non-permit over-height vehicles, such as trucks hauling construction equipment or dump trucks with the bed in a raised position on active construction sites. After such events, a damage inspection is typically performed to evaluate the extent of damage to bridge girders.

For steel beams and girders, the damage often manifests as distortion, gouges or tearing/fracture in the bottom flange or web and the connecting cross-frames or diaphragms. In general, the damage is clearly visible, except for possibly hairline cracks or fractures.

For prestressed concrete girders, the damage often manifests as spalls and/or severed prestressing strands. However, there are instances where cracks are either barely visible or close due to pre compression of the member. In addition, typical concrete bridges have only one or two diaphragm locations per span, which may increase their susceptibility to longitudinal cracking at the top flange to web interface. In such situations there is concern with overlooking damage that may not be visible externally or the damage may be internal, such as debonding of the strands.

Finite element modeling and analysis is typically used to predict damage and determine critical impact points for vehicle crash testing of bridge barrier rails. This research proposes to employ similar finite element techniques to inform the Structures Management Unit's (SMU) engineers and bridge inspectors on critical impact points, and clues to possible internal damage and its extent. This information will assist the engineers determine whether the damage can be repaired, or the damaged girder needs to be replaced.

Research Tasks:

1. Literature review.
2. Develop a finite element model of a prestressed concrete bridge or a sufficiently approximate model with essential elements such as the deck, girders, diaphragms, bearings, etc.
3. Develop methodology to simulate intensity of various types of impacts by construction equipment, hauling trucks, etc.
4. Parametric study to predict severity of external and internal damage based on location, type and intensity of impact.
5. Compare damage simulations with observations from several real-life case studies.
6. Prepare final report with recommendations for damage inspection based on the location along the span, impact intensity, and anticipated severity of impact damage.

Products of the Research:

- Guidance for an approach to prestressed concrete bridge damage inspections based on location along the span, impact intensity, and anticipated severity of impact damage.
- Finite element prestressed concrete bridge model, which may be adapted and used in future impact evaluations.

Possible IT Components:

N/A

Implementation:

New or updated damage inspection and evaluation policy.

Additional Comments and Information:

Subcommittee Comments:

Research Idea Title:

Methods for Concrete Crack Sealant

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
ST	2023-027	2023	6/23/2021 12:00:00 AM

Research Idea Generator:

Last Name:	First Name:	Title:	Email:
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Sponsor/Champion:

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Benefit or Knowledge Gain for NCDOT:

Cost Savings;Improved Material Structure/Pavement/Performance;New or Improved Specifications

Explain Anticipated Benefits:

Improve service life of NCDOT concrete structures by using concrete crack sealing materials/methods that are more durable, cost effective, and/or easier to install, compared to current practices.

What is the problem or issue needing investigation?

NCDOT is looking for cost effective and practical materials/methods for sealing concrete cracks outside of the current practice of specifying the use of either silane or epoxy resin injection methods.

Background:

NCDOT currently uses silane to seal concrete with fine cracks. Silane is typically only used on to fill gravity fed cracks. Epoxy resin injection is used to seal larger cracks and cracks that are on vertical or overhead surfaces. Epoxy resin injection is often problematic to install in the field and harder to inspect/test the application to verify the Contractor has met the specifications. Disruptions in the supply chains to both silane and epoxy resin can present difficulties in obtaining the materials and can result in cost increases to projects. Having alternative materials and methods to seal concrete cracks can provide both cost effective benefits as well as material durability compared to the use of silane and epoxy resin injection.

Research Tasks:

- Perform a literature review of relevant research (including review of NCDOT specifications/policy as well as other state's).
- Review materials/methods commonly available (for both bridge and building industry) for sealing concrete cracks within the common ranges of which silane and/or epoxy resin injection is specified and select best candidates based on cost effectiveness, ease of installation and durability.
- Investigate the installation methods, durability of selected materials/methods, and testing/sampling requirements for concrete crack sealing on horizontal, vertical, and overhead surfaces.
- Test the installation, durability, and testing/sampling requirements of the materials/methods on horizontal, vertical, and overhead surfaces and document performance.
- Provide guidance for usage and material/method specifications.

Products of the Research:

- Report material/method performance from test evaluations.
- Document performance with respect to conditions of crack openings.
- Document candidate crack sealing material/method performance against silane and epoxy resin injection for cost, installation, durability, and testing/sampling requirements.
- Recommendations on for when to use each selected material/method.
- Performance based material/method specifications with inspector testing/sampling requirements.

Possible IT Components:

N/A

Implementation:

The findings and recommendations of the research can be used in the Structure Management's Asset Management Manual guidelines for preservation activities on concrete structures and the specifications can be used for project contract lettings.

Additional Comments and Information:

Subcommittee Comments:

Research Idea Title:

Measurement While Drilling: Identify Optimum Equipment for Use on Department Drill Rigs and Measured Data Utilization in Improved Site Characterization and Design

SubCommittee:	Research Idea #:	Fiscal Year:	Created Date:
ST	2023-032	2023	6/24/2021 12:00:00 AM

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Secondary Generator:

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Sponsor/Champion:

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Benefit or Knowledge Gain for NCDOT:

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

Explain Anticipated Benefits:

Cost savings by better site characterization and improved foundation designs. We will have better definition of formational soil and density boundaries, correlation with scourability, and drilling/coring improved efficiency (which improved sample return). New specifications potentially because foundation installation will be in better defined materials.

What is the problem or issue needing investigation?

The Department utilizes mechanical drill rigs in our field subsurface investigations. Known Measurement While Drilling (MWD) sensors for geotechnical use were developed for hydraulically driven rigs, although some adaptors have been developed. We would like to know what the optimum equipment is to be used with our existing rigs, and then develop correlations with measurements to soil and rock parameters used in design.

Background:

Measurement While Drilling (MWD) has been used in the oil industry and foundation construction industry for years and has developed over time. MWD as a geotechnical site characterization tool is a more recent development, starting in the early 2010's. It is one of FHWA's EDC/A-GaME (Advanced Geotechnical Methods in Exploration) underutilized subsurface exploration tools. Some presentations are attached for additional information. Monitored drilling for geotechnical work has been used to increase drilling efficiencies, particularly with core recovery, sink hole exploration and identifying formational/density boundaries, etc. There is an established ISO for MWD use in Europe. More recently in the US, research is being done to use measurements obtained to correlate to soil and rock properties used in design.

Research Tasks:

Review MWD products available, determine which are compatible with the Departments mechanical drill rigs.

Review existing research and summarize potential design parameters and other items that can be developed using MWD collected data. Increased efficiency of drilling, boundaries of formational units, scour potential at stream crossings and foundation design parameters as examples.

After consultation with NCDOT research team, purchase for the Department the most compatible and agreed upon products.

Products will need to be installed by our Equipment Unit unless the drill company (Central Mine Equipment Co.) agrees to do installation at acceptable cost.

In conjunction with Geotechnical Engineering Unit staff, review functions of installed devices to verify we are getting correct and usable data.

Provide training of Unit staff how to incorporate MWD data into geotechnical design.

Products of the Research:

Optimum equipment installed on one of our drill rigs.

Laptop/tablet to function with data collection in field.

Drilling & coring process efficiencies identified.

Scour potential correlation identified.

Design parameters that can be correlated and developed.

Possible IT Components:

Software for use in data collection and reporting. Tablet/laptop to be used in data collection and either reporting data or transferring data to office computers.

Implementation:

Equipment to be installed while research is proceeding. Design information including scourability, if successful, to be incorporated into Unit design. Explore adding capability to additional rigs.

Additional Comments and Information: