# AOT Research 2025 External Research Program

The Agency of Transportation Research Section is pleased to pass along 7 Problem Statements for our 2025 External Research Program. We are distributing these statements to all entities on our Qualified Researcher List and are requesting responses from those interested in pursuing these projects. We are seeking Letters of Interest (details below) from researchers/research teams on individual Problem Statements, from which the AOT Champions and Research Section will select the party which they will work with to craft a Proposal.

Letters of Interest are due by February 12th, after which the AOT Champions and Research Section will identify the researcher/research team who they will ask to submit a 7–10 -page proposal by March 14th. AOT Champions will present the projects for selection to the Bureau Directors in early April.

Letters of Interest should be a maximum of two pages. They can include any of the following information: interest in the project, experience in the topic, capabilities to perform the research, expected methodology, rough estimate of timing (6 mo., 12 mo., 18 mo., 24 mo.), rough estimate of project budget (between $50,000 and $150,000), potential deliverables, and benefit to the Agency and beyond. We are unaware of the number of letters we will receive, so researchers are advised to make the pitches meaningful. There are 11 organizations currently on the 2025-2028 Qualified Researcher List.

Please submit individual Letters of Interest to Emily Parkany (emily.parkany@vermont.gov) by February 12, 2024.

# Problem Statement List:

## Contents

# In Situ Performance Monitoring of Bridge Closure Joints Constructed with Rapid-Setting Concrete

## Project Champion:

Fianna Barrows, Fianna.barrows@vermont.gov, Project Delivery Bureau/ Structures

## Title:

In Situ Performance Monitoring of Bridge Closure Joints Constructed with Rapid-Setting Concrete

## Problem Statement:

The Vermont Agency of Transportation (VTrans) has adopted rapid-setting concrete (RSC) for constructing connections between precast elements in Accelerated Bridge Construction (ABC), aligning with the current state of practice. While this approach accelerates construction and minimizes traffic disruption, it introduces uncertainties in the long-term performance of these connections. Current ABC designs by VTrans treat these connections as pinned, a conservative assumption for the strength limit state but potentially non-conservative for the durability limit state. The assumption of pinned behavior neglects the potential for fixity in these connections, which could lead to unintended stress concentrations, cracking, and reduced service life. Additionally, durability concerns have limited the adoption of bare decks in ABC projects, further highlighting gaps in the understanding of these connections' mechanical behavior. This project seeks to address these gaps by characterizing the mechanical and durability properties of RSC connections through advanced testing and analysis.

## Approach and Agency Resources:

To address the identified challenges, the project will focus on evaluating the performance of RSC bridge joints over time through periodic testing and model calibration. The updated approach includes the following steps:

1- Scheduled Live Load Testing:
- Conduct live load tests on selected bridges with RSC connections at scheduled intervals.
- These tests will evaluate the joints' structural behavior, including stiffness, strength, and crack development, under real-world conditions.
- Focus will be placed on assessing changes in performance over time to capture potential durability issues and long-term fixity effects.

2- Field Instrumentation and Monitoring:
- Deploy advanced instrumentation (e.g., strain gauges, displacement transducers, and crack sensors) to monitor critical parameters during live load tests.
- Record data on stress distribution, deflection, and crack progression to support model calibration and validate field performance.

3- Model Calibration via Trial and Error:
- Develop simplified analytical or numerical models of the RSC connections.
- Use trial-and-error techniques to calibrate these models based on test results, ensuring they accurately reflect observed behavior.
- Iteratively refine model parameters, such as joint stiffness and material properties, to align with field data.

To ensure project success, we will need to work with VTrans staff to identify suitable bridges constructed using RSC connections for scheduled live load testing. We will also need access to the bridges to instrument them and will need a vehicle for live load tests.

## Benefits and Implementation:

This research will provide the following tangible outcomes:

- Improved Design Guidelines: The findings will inform VTrans and other agencies about the mechanical behavior and durability of RSC connections, enabling updates to design practices that balance strength and durability considerations.
- Enhanced Durability: By identifying potential cracking mechanisms and addressing fixity issues, this project will contribute to the longevity and cost-effectiveness of ABC projects.

Increased Confidence in Bare Decks: The study will explore the feasibility of bare decks, reducing material use and long-term maintenance needs.

# Advancing Cost-Effective Bridge Monitoring Through AI-Powered Drive-By Sensing Systems

| Project Champion: |
| --- |
| Jennifer M. V. Fitch, jennifer.fitch@vermont.gov, Asset Management Bureau/Highway Division |
| **Title:** |
| Advancing Cost-Effective Bridge Monitoring Through AI-Powered Drive-By Sensing Systems |
| **Problem Statement:** |
| The structural health of Vermont's bridges is critical to ensuring public safety, efficient transportation, and economic stability. Traditional methods of Structural Health Monitoring (SHM), such as manual inspections and fixed sensor systems, are expensive, labor-intensive, and prone to missed damage due to limited coverage and infrequent assessments. These approaches often result in delayed identification of structural deficiencies, posing risks of catastrophic failure and increasing long-term maintenance costs. There is a pressing need for innovative, cost-effective solutions that provide continuous, real-time monitoring to address these challenges. This study seeks to answer key questions about how AI-driven, non-invasive drive-by sensing technology can revolutionize bridge health assessment, enabling early detection of damage, comprehensive coverage, and efficient resource allocation for maintenance and repair. This study seeks to validate and deploy an innovative Drive-By Sensing System integrated with Artificial Intelligence (AI). By equipping a standard vehicle with accelerometer sensors and using advanced machine learning techniques, this system offers a cost-effective and scalable alternative for continuous monitoring of Vermont's bridges. This approach eliminates the need for on-site sensor installations, minimizes disruptions, and enables comprehensive data collection over the entire bridge span during routine vehicular movement. |
| **Approach and Agency Resources:** |

This study will involve a pilot and demonstration project to evaluate the effectiveness of AI-driven drive-by sensing technology for bridge health monitoring. The Vermont Agency of Transportation (VTrans) will play a key role in facilitating access to bridge sites for field data collection and supporting potentially mounting sensors on a publicly owned vehicle to collect data from a representative sample of bridges. VTrans personnel may assist with identifying target bridges, provide ancillary support data collection, analysis, and modeling to evaluate the system's performance under various structural and environmental conditions. Additionally, the study will leverage existing agency resources, such as maintenance logs, inspection records, and GIS databases, to complement and validate the data gathered.

The study will include the following key tasks:

- Instrumenting one or two vehicles with off-the-shelf accelerometers to collect bridge vibration data during routine drives.
- Utilizing Real Time Kinematics integrated into Global Navigation Satellite System measurements (RTK GNSS) methods to achieve precise vehicle location and ensure accurate alignment of collected data with bridge sections.
- Tracking the conditions of a few target bridges over time to monitor structural changes and evaluate system effectiveness.
- Developing advanced AI models for processing collected data, with a focus on accurately detecting and classifying bridge damage states in real time.
- Studying the potential of integrating this method into connected and autonomous vehicles, paving the way for seamless, automated infrastructure monitoring at scale.

The anticipated outcomes include a validated drive-by sensing framework, and recommendations for strategies to enhance safety and maintenance efficiency across Vermont's bridge network.

## Benefits and Implementation:

This study offers significant benefits by introducing a cost-effective, scalable, and non-invasive approach to bridge monitoring. The AI-driven drive-by sensing system will enable early detection of structural deficiencies, reduce maintenance costs, and improve public safety by providing real-time insights into bridge health. Implementation of this method will streamline VTrans' infrastructure management processes by reducing reliance on labor-intensive inspections and fixed sensor installations.

The study outcomes will provide a practical roadmap for deploying the system across Vermont's bridge network, with actionable guidance on integration into existing workflows. Additionally, exploring integration with connected and autonomous vehicles will position VTrans at the forefront of innovative infrastructure management technologies, enhancing the state's transportation resilience and safety for years to come.

# Characterizing Changes at Selected Annual Exceedance Probability Streamflows for Climate-Change Scenarios in the Winooski River Watershed of Vermont

## Project Champion:

Jeff DeGraff, jeff.degraff@vermont.gov , Project Delivery Bureau/Structures & Hydraulics

## Title:

Characterizing Changes at Selected Annual Exceedance Probability Streamflows for Climate-Change Scenarios in the Winooski River Watershed of Vermont

## Problem Statement:

Current methods for calculating the 50%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% annual exceedance probability (AEP) for streamflow are based on the assumption of stationarity, meaning that the statistical distribution of past observations is free from trends and will remain constant in the future. This assumption allows the selected AEP to be calculated using historical stream flow data with the use of statistical methods. However, the stationarity assumption has been challenged by observed trends in streamflow records within the Winooski Watershed, including the potential impacts of climate change, as seen in events such as Tropical Storm Irene (2011), the Great Vermont Flood of 2023, and Tropical Storm Beryl (2024).

The Winooski River Watershed has the most populous and developed areas in Vermont that include Chittenden and Washington County. The watershed also has the highest overall concentration of Resilience Improvement Plan (RIP) priority structures and road segments; repeat damage locations; and Transportation Resilience Planning Tool (TRPT) high risk bridges, culverts, and road segments that is fully within the State of Vermont. For these reasons, predicting changes in peak streamflows calculated at 2050, 2075, and 2100, as a function of future climate and hydrological conditions which include but not limited to; temperature, precipitation, land use, surface water (lake, pond, reservoir storage, and etc.), groundwater, soil moisture, runoff, evapotranspiration, and snow and ice melt, will be beneficial for dam safety, and roadway infrastructure planning and design.

## Approach and Agency Resources:

Approach & Expected Outcomes

Develop, calibrate, and apply a deterministic, distributed parameter, physical-process-based watershed-modeling system to estimate future hydrological responses due to climate and land-cover changes within the Winooski River Watershed. The National Hydrologic Model (NHM) in conjunction with the Precipitation-Runoff Modeling System (PRMS) is expected to be used to help estimate future peak flow values at the selected AEPs within regulated and unregulated watersheds.

NOAA Atlas 15 will provide updated (non-stationary) estimates of precipitation frequency (depths and intensity) across the United States as a function of socioeconomic pathway scenarios (SSP2-4.5 and SSP2-8.5) from 2030-2100. The PRMS analysis is expected to incorporate similar socioeconomic pathways scenarios to be consistent with the NOAA Atlas 15 climate model assumptions. For more information regarding NOAA Atlas 15, please review the NOAA Atlas 15 Pilot Technical Report.

USGS is currently developing updated flow regression equations to estimate the 50%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% Annual Exceedance Probabilities (AEPs) for unregulated rivers in Vermont. These updated equations are expected to be available by Fall 2025. While the variables to be used in the new equations are not yet known, PRMS output variables such as mean annual precipitation, can be directly applied to the current or updated USGS regression equations to estimate future flows more precisely. For this study, provide output variables that can be directly used within the current and/or updated USGS regression equation.

The potential project report could include the following:

1. Title Page
2. Abstract
    a. Summary of study's purpose, methods, findings, conclusions
3. Introduction
    a. Background on the Winooski Watershed
    b. Purpose of Study
4. Study Area
    a. Description of geological extent
    b. Overview of the watershed's characteristics
5. Hydrologic Modeling
    a. Data Collection
        i. Sources of climate data
        ii. Historical streamflow records
    b. Modeling Techniques
        i. PRMS
        ii. Methodology for scaling climate inputs
    c. Model Calibration and Performance
    d. Climate Change Scenarios
    e. Model Runs with Future Climate Scenarios
        i. Estimating Instantaneous Peak Streamflows
6. Results
    a. Presentation of changes in the selected AEP streamflows
        i. Also, present changes in average daily stream flow
    b. Presentation of changes in soil moisture content
    c. Analysis of how these changes vary across different scenarios and time frames
    d. Maps or figures
    e. Discussion & Study Limitations
    f. Conclusions
7. Acknowledgements
8. References
9. Appendices

## Benefits and Implementation

Benefits and Implementation

VTrans currently sizes bridges and culverts on the assumption of stationarity in streamflows. This study will enable VTrans to adopt a future flow policy within the Winooski Watershed, directly impacting freeboard estimation, scour calculations, erosion force assessments along roadway embankments, and the design of scour countermeasures. By improving the sizing of bridges and culverts to enhance flood resilience, there would also be significant long-term economic and public safety benefits. Furthermore, the findings from this study could support broader policy changes at the state level.

The Vermont Agency of Natural Resources' Watershed Management Program is currently seeking funding for a project to investigate the geoclimatic drivers of drought and low streamflows in Vermont, determine how climate change may impact low streamflows and aquatic habitat in the future, and develop a suite of tools for estimating low-flow conditions to inform management and mitigation now and into the future. Complimentary studies to assess geoclimatic drivers of both extreme high and low flow conditions would help the State achieve more comprehensive resiliency in the face of future flooding and drought.

Relationship to Current Projects

The Vermont Agency of Natural Resources' Watershed Management Program is currently involved with and/or aware of several current efforts in the Winooski Watershed that would all benefit from the incorporation of future flood flows and AEPs under different climate projections. These include:

- ANR currently utilizes USGS StreamStats regression equations that estimate channel bankfull width/depth/area throughout Vermont based on climate and watershed characteristics. The proposed hydrologic model and results of a study on hanging flood flows, AEPs and future climate could be used to determine future channel conditions using these regression equations and even their ultimate applicability moving forward.
- FEMA is currently updating the Flood Insurance Rate Maps in Vermont, including the Winooski River Watershed, and USGS is also developing a HEC-RAS model for much of the Winooski mainstem and the North Branch. The results of this study would inform the applicability of both products considering non-stationarity and future climate scenarios.
- UVM has been developing the VT Data - Topographically Defined Floodplains for the Lake Champlain Basin (probHAND 2022), available on the VT Open Geodata Portal. The results of a study regarding future flows under different climate projections could enhance that work.
- UVM is also working on an AI model to help identify likely flood damage and opportunities for floodplain restoration and mitigation. Again, future flows would be most relevant and valuable.
- Vermont ANR will be developing model flood hazard bylaws for municipalities. Having future discharges and timelines estimated would be helpful by way of helping to refine and specify development standards to avoid and minimize future damage from flooding.
- Barre City is pursuing a 2D hydraulic model to determine local flooding extents. The future discharge data may be of considerable interest.
- At a recent meeting of municipal officials in Winooski Watershed there was a strong interest in a watershed wide model that could clearly identify and help prioritize actions for mitigation and floodplain restoration across the watershed. The data that USGS could develop would be very valuable.
- Future discharges and timelines could inform Vermont's transportation standards, the transportation resilience tool and mitigation funding priorities.

# Evaluation of Cement-Based Pavement Markings

## Project Champion:

Philip Peloquin, phil.peloquin@vermont.gov , Construction and Materials Bureau/Material Testing & Certifications Section

## Title:

Evaluation of Cement Based Pavement Markings

## Problem Statement:

There are several critical challenges faced by pavement markings, these challenges can be attributed to environmental factors, traffic, and winter maintenance practices. These challenges significantly affect the visibility of pavement markings. Improved performance of pavement markings can result in better visibility of these markings with the potential to save lives on Vermont's roadways.

Vermont's climate, which includes cold winters, snow, ice, and freeze-thaw cycles, places significant strain on pavement markings. The repeated freeze-thaw process can cause materials to crack, peel, or fade more quickly.

High traffic volumes, especially with heavy vehicles like trucks, can accelerate wear on pavement markings. The constant friction from tires can lead to the abrasion of marking materials, reducing their visibility and retroreflectivity.

Winter maintenance practices including plowing and the use of deicing chemicals can significantly impact the longevity and effectiveness of pavement markings. These practices, while essential for safety and road usability, can contribute to the deterioration of pavement marking materials over time with mechanical abrasion and wear resulting from plowing activities and chemical degradation, fading, striping, and surface damage resulting from the use of deicing agents.

The consequences of these challenges are:

**Safety Risks**; As retroreflectivity decreases, drivers have a harder time seeing the road markings, which can increase the likelihood of accidents, particularly in low-light conditions.

**Cost Implications**; Frequent replacement of pavement markings incurs significant costs for transportation agencies, including materials, labor, equipment, and administrative cost associated with planning this additional work. Additionally, the need for more frequent road work disrupts traffic flow and which may be an indirect economic cost.

**Public Disruption**; Increased maintenance and construction activities can cause traffic congestion, delays, and driver frustration, which negatively impacts the traveling public.

In addition to these challenges the FHWA has set minimum retroreflectivity standards establishing minimum levels of retroreflectivity that must be maintained for road markings to ensure adequate visibility for drivers. This means that pavement markings must perform for longer periods without significant degradation of their reflective properties, especially during night-time driving or in poor weather conditions.

## Approach and Agency Resources:

We anticipate that the research will include a product literature review, product installation at various Vermont locations, performance evaluation using four ASTM standards, a life cycle cost analysis, and a plan for continued monitoring and evaluation after project end.

Product Literature Review: Gathering and reviewing available product literature, including user manuals, technical specifications, product brochures, installation guidelines, installation costs and any other relevant documents provided by the manufacturer.

Product Installation: Installation of the Enduramark product across various configurations as recommended by the manufacturer at various locations as recommended by Agency SMEs which may include different environmental conditions, operations settings, or user scenarios.

Performance Evaluation: Evaluation of the installation using industry-standard test methods:

ASTM D913 Standard Practice for Evaluating Degree of Pavement Marking Line Wear

ASTM E1710 Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer

ASTM E2177 Standard Method for Measuring the Coefficient of Retroreflected Luminance (RL) of Pavement Markings using the Bucket Method in a Condition of Wet Recover

ASTM E2832 Standard Method for Measuring the Coefficient of Retroreflected Luminance of Pavement Markings in a

standard Condition of Continuous Wetting (RL-2). Including but not limited to durability and retroreflectivity.

Life Cycle Cost Analysis: Evaluate the total cost of ownership of the installation over life of the installation or research project. Evaluation to consider not only initial investment but also all associated cost that occur during the operational phase. The evaluation should provide a comprehensive view of the financial implications involved in the installation and its continuous upkeep, highlighting potential cost savings or challenges. It is understood that a comprehensive life cycle cost analysis may extend beyond the duration of this proposed research project, additional work plans will be developed to continue the evaluation of the installation beyond the proposed research project's time frame.

## Benefits and Implementation:

The goal of this research is to provide foundational information that may result in the adoption of cement-based pavement markings as a standard material. As a standard material cement-based pavement markings would be an acceptable option for construction and maintenance activities. This innovative solution has the potential to address key challenges such as safety risks, cost implications, and public disruption.

# Efficacy of Transportation Investments with Wildlife Accommodations

## Project Champion:

Chris Slesar: Chris.Slesar@vermont.gov , Environmental Resources Coordinator, Project Delivery Bureau Environmental Section

## Title:

Efficacy of transportation investments with wildlife accommodations in Vermont

## Problem Statement:

Road networks can fragment wildlife populations, leading to biological consequences such as poor genetic exchange, disruption of movement patterns, and declines in species abundance and distribution; all affecting the resilience and health of wildlife populations. Wildlife crossings are a great way to accommodate for terrestrial animal movement, allowing connection between habitat blocks while mitigating the consequences of the fragmentation caused by imperviable transportation networks. The creation of safe crossings decreases wildlife-vehicle collisions and increases the safety of roadways for both humans and wildlife.

VTrans has invested in wildlife friendly improvements such as the installation of ledges and particular substrates for easier passage. Much of the focus has been on the identification of structures (e.g. culverts, bridges, underpasses) most important to wildlife and the construction of improvements to those structures when under already needed repair.

VTrans in conjunction with The University of Vermont developed a tool called the Terrestrial Passage Screening Tool (TPST) to determine what structures should include wildlife accommodations. This one-of-a-kind tool ranks pre-existing structures on a scale of 0-5843 on their capacity to pass wildlife [5843 was the number of assessed structures when the tool was developed]. The TPST has been an incredibly helpful resource for VTrans biologists in determining where to install wildlife accommodations across the state of Vermont.

However, there are additional tools that VTrans can employ to form more strategic decisions by building on the foundations of the TPST. The data for the TPST has not been updated from its original development, so it can only truly give a static picture of the current landscape and does not take into consideration how structure replacements designed for wildlife connectivity, hydraulics, and climate change impact wildlife movement patterns.

This research will further the development of the TPST, addressing structures where wildlife accommodations have already been installed, and quantify the added wildlife benefits for these structures. There is a need to understand and quantify whether infrastructure investment in wildlife results in improvements to wildlife passage. Additionally, are there particular improvements that may be more effective than others given the characteristics of the structure and surrounding landscape? Can this information be leveraged to quantify and better understand the value of improvements to the full complement of structures across the network?

## Approach and Agency Resources:

Further research is needed of how structures can be designed to accommodate for wildlife movement patterns, and if the current methodology in determining when, where, and how to install the crossings is having a positive impact on wildlife. We suggest conducting research to inspect the impact of these structures by analyzing our pre and post construction data of several VTrans projects with and without wildlife accommodation installed throughout the state of Vermont. Assessing the success of these wildlife crossings may include both field and modeling-based research. The modeling-based research can utilize programs such as Circutscape to model how wildlife movement changes with the installation of different structures. The field component of this research will employ technology such as Reconyx game cameras, tracking pads, and hair traps to assess the usability of our structures by terrestrial wildlife.

Agency resources that are available for this project include reconyx game cameras. Potential monitored in-agency projects include the Waterbury I-89 CULV project, the Searsburg culvert-to-bridge project, and the Route 12 Worcester-Elmore project. Reviewing our past successes focused on wildlife movement will gauge the effectiveness of these structures. We encourage the inclusion of projects without wildlife passages or monitoring to better understand the impact of wildlife infrastructure.

This project can build on the existing Terrestrial Passage Screening tool found here: https://vtrans.vermont.gov/sites/aot/files/Research/2021_Symposium/2021_UVM_wildlife_connectivity_research_final_report_Drasher_Murdoch.pdf. We suggest that the proposed research project will allow the TPST to become an easily updatable, dynamic tool able to be updated as new crossing structures are developed. The ranking of structures should be dynamic as structures are replaced with different attributes than the original such as length, width, bankfull width, and height. We would like to answer how changing structures characteristics impacts connectivity. This research corresponds with Vermont Biofinder, Vermont Conservation Design, and The Staying Connected Initiative, all of which focus on connecting large swaths of land throughout the northeast to allow for wildlife movement throughout the region. By understanding how we can effectively create wildlife accommodations throughout the state, we can gauge the ability for wildlife to travel throughout the region. We expect Vermont Fish and Wildlife Department, and The Nature Conservancy, to help guide the research.

The outcomes of this project should result in better practices in determining where and when to install wildlife accommodations throughout the Vermont transportation network. It will allow for a systematic, statewide model that guides decisions on how wildlife infrastructure should be installed throughout the state of Vermont, expanding past the 5843 structures already mapped by the TPST, and can gauge wildlife movement throughout the state by understanding what works and what does not.

## Benefits and Implementation:

By gauging wildlife movement throughout the state and how wildlife use VTrans structures, the state could save money on wildlife infrastructure. This research will take a static tool and make it dynamic. The static nature of the TPST means that over time the tool will become obsolete. By actively changing the nature of the tool, we can create an easily updatable tool that is able to be used without an expiration date. This can not only further our understanding of how structures impact wildlife movement, but can give us a better picture of movement throughout the state; further enhancing our review and decision-making capabilities. This research project could also have monetary value to the state as well. By understanding what type of structures are effective at passing wildlife, VTrans can streamline the need and design for wildlife accommodations, making sure the only structures that are installed are structures that will be effective at passing wildlife. Additionally, with the knowledge of what will be effective, we can decrease mortality on the roadways, increasing the safety for all travelers, human or not, within our state.

We would like the final outcome of our research to be a tool that can quantify the benefit to wildlife prior to the installation of a structure. The creation of a dashboard similar to the Flood Resiliency Dashboard (found here): https://roadfloodresilience.vermont.gov/?_gl=1*1etocrg*_ga*Nzg5Njc1NTMwLjE2NzE0Njg1MDI.*_ga_V9WQH77KLW*MTczNTkwNzYxMS40My4wLjE3MzU5MDc2MTkuMC4wLjA.#/map

The dashboard should be able to compare various proposed dimensions of a new structure (length, height, bankfull-width, etc.) during the resource ID and scoping phase of the project to determine how the different dimensions of a new structure could impact wildlife movement. This could help VTrans biologists and engineers determine where to and where to not install wildlife crossing structures across the Vermont transportation Network; only installing structures in places there will be a net positive impact on wildlife, and skipping the installation of wildlife infrastructure on structures that will have no effect on wildlife movement. This will work well with the already designed Terrestrial Passage Screening tool on the Vermont Biofinder Tool: https://anrmaps.vermont.gov/websites/BioFinder4/?_gl=1*1wbz73k*_ga*Nzg5Njc1NTMwLjE2NzE0Njg1MDI.*_ga_V9WQH77KLW*MTczMDIxMDk4MC4yNi4wLjE3MzAyMTA5ODkuMC4wLjA

# Assessment of Data and Modeling Tools for AOT Policy and Planning Needs Present and Future

| Project Champion: |
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| Collin Smythe, collin.smythe@vermont.gov ,Systems Planning Coordinator, VTrans Policy, Planning and Research Bureau |
| **Title:** |
| Assessment of Data and Modeling Tools for AOT Policy and Planning Needs Present and Future |
| **Problem Statement:** |
| The purpose of this research project is to evaluate policy and planning-related transportation models and datasets both currently in use in Vermont as well as in anticipation of future needs across AOT and other state agencies over the next decade. AOT is responsible for developing a wide range of transportation plans and policies as well as supporting the planning and policy analysis efforts of other state agencies, regional and local governments, and the state legislature. The agency utilizes several different models, tools, and datasets to answer a wide variety of transportation related questions for both real-time highway systems information and broader policy analysis and long-range planning purposes. Some of the major issues include questions related to work zone management, detour identification, reducing emissions of greenhouse gases and other air pollutants, electric vehicle adoption rates and associated electric grid and charging issues, the movement of freight, rail and transit systems, aviation, long range planning initiatives, road networks and vehicle miles traveled (VMT), and a host of land use, housing, and equity questions. Given the wide range of policy and planning topics and initiatives for which AOT requires data and information, it would be beneficial to have a comprehensive inventory of the tools and datasets currently utilized within the agency to help evaluate where efficiencies might be gained. It is also critical to understand the potential future data and modeling needs of AOT and how those needs might evolve in the rapidly changing transportation technology and planning landscape. As AOT moves into the future there will be a changing suite of questions and challenges related to things like the evolving nature of goods movement driven by e-commerce, implications of increasing levels of vehicle automation, transportation funding challenges, and improving transit service to diverse and dispersed populations. In confronting those challenges it will be important to keep pace with new transportation planning and analysis technologies driven by novel data collection methods, artificial intelligence and machine learning, and advanced computing methods as well as understanding the limitations, anticipated needs, and available options to address them. The analysis completed through this project will be a starting point to keep track of and to build upon knowledge around new technologies, modeling tools, and datasets that will enable AOT staff to be more innovative in improving or streamlining processes and data for current needs and to determine if there are better ways to meet those needs in a different manner moving into the future. |
| **Approach and Agency Resources:** |

Work will focus on the tools and datasets used throughout AOT for the development of transportation studies and plans and in support of transportation-related policy decisions. The first component will be the inventorying of currently utilized tools, models, and datasets followed by an evaluation of gaps and limitations in the current suite of tools and datasets being used to address existing needs. This will be followed by an exploration of potential future needs and the evolving methods, tools, or datasets to address those needs. The scope of the research should include a wide range of contemporary transportation decision making contexts from informing long range transportation plans to evolving questions about EV adoption and infrastructure, highway systems information, GHG mitigation, goods movement, equity, road pricing, transportation demand management, land use, and resilience. The research will then identify data, methods and tools through a review of published studies and current practice that can address the current gaps and the anticipated planning needs over the next decade. The research should also consider the resources that will be needed to implement and maintain data sets and modeling tools and consider the needs of key stakeholders in Vermont, including staff at AOT and the other state agencies that AOT cooperates with to collaboratively address interagency planning and policy objectives. This will require evaluating technical planning materials and how they are used in Vermont and meeting with key stakeholders to understand current challenges and expected needs.

## Benefits and Implementation:

This research will be used as a basis for understanding and visualizing interconnections between models, tools, and datasets currently utilized by AOT for policy analysis and planning studies, with the goal of identifying efficiencies to be found where a current or future product could be leveraged to meet multiple needs. The gap analysis and investigation into potential future needs can then be used to help plan for future efforts or areas of focus and be supplemented with the information from exploration into the newly available and up-and-coming methods and tools that might also be used to fill data and information needs and gaps.

# Acoustic Resonance Technologies for Monitoring Concrete Early Age Strength Development In-Situ

| Project Champion: |
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| Jim Wild, jim.wild@vermont.gov , Construction Section/Highways Bureau |
| **Title:** |
| Acoustic resonance technologies for monitoring concrete early age strength development in-situ |
| **Problem Statement:** |
| Construction and maintenance projects for critical transportation infrastructure often face stringent time constraints. Construction schedules on these projects are often directly influenced by the rate of strength gain of structural concrete in the field. It is imperative that contractors and engineers have access to representative in-situ concrete strength data as soon as possible to expedite and maintain schedules. However, the traditional testing methods for assessing the strength gain of concrete, such as compression test (ASTM C39) and maturity methods (ASTM C1074), rely heavily on casting, curing, and testing cylinders in a laboratory setting, which is time-consuming, labor-intensive, and may not accurately represent in-situ conditions. This is especially a case for the monitoring of early strength gain of concrete in rapid construction and repair projects to determine optimal traffic opening time. Therefore, there is a critical need for a more representative and practical in-situ solution to monitor the strength gain of cementitious mixes directly in the field, without the need for destructive testing like coring, to provide real-time feedback, enabling contractors and engineers to make timely, data-driven decisions and reduce construction delays |
| **Approach and Agency Resources:** |

We anticipate that this project may include the following components. Field testing does not have to be related to Vermont projects, but we are looking for a plan that optimizes what can be learned from laboratory and field tests so that VT AOT has confidence with using acoustic resonance or similar technologies, in the field, with rapid construction and repair projects.

Comprehensive Literature Review: Conduct an extensive review of existing studies, current practices, and established standards related to acoustical resonance methods for property monitoring of cementitious materials.

Understanding the Working Mechanisms: Investigate the fundamental working mechanisms of acoustic resonance in detecting and correlating the strength gain of concrete.

Elucidating the Link Between Cement Hydration and Acoustic Parameters: Obtain comprehensive insights into the relationship between hydration, microstructural evolution, strength gain, and acoustic signatures of cementitious mixes.

Laboratory Validation Benchmarked Against the Maturity Method: The correlations between acoustic data and concrete strength development will be validated against the maturity method (ASTM C1074) and strength tests (ASTM C39) to assess the reliability and accuracy of acoustic resonance in early strength gain of concrete ensuring its practical applications in future projects.

Analyzing the Influential Factors on Reliability and Accuracy: Investigate the effects of factors such as temperature, humidity, material composition, curing conditions, concrete mix design, and structural defects on the reliability and accuracy.

Field Testing: Deploying the acoustic resonance monitoring technology on real-world construction projects is essential to validate its practicality, accuracy, and robustness under actual environmental and operational conditions.

## Benefits and Implementation:

If the research produces favorable results, the benefits will be actual in-situ concrete strength determinations within minutes for the contractor and project staff to make decisions on planned construction activities. The time savings could result in 4-12 plus hours which would provide the contractor with an extra working shift and ultimately benefit the taxpayers by having the structure open on time or earlier. A further potential benefit is more accurate determination of in-situ concrete strengths when compared to traditional methods relying on representative cylinders being stored in representative conditions. If successful, this research may allow for direct measurements of in place concrete, giving a higher confidence level in the early strength values as variables with cylinder storage and representation are eliminated.