# Clear Roads Research and Synthesis Proposals
# 2024

| # | Title | Est. Cost | Est. Duration | Project Summary | Presented by | Page |
|---|---|---|---|---|---|---|
| 1 | Update to Test Method 5 (Corrosion Effectiveness) | $150,000 | 18 months | Products that include a corrosion inhibitor must pass the Category specific limits of corrosion effectiveness, following Test Method 5 in the Clear Roads Guidance Document. This project will establish coupon MPY variation limits and corrosion effectiveness repeatability/reproducibility requirements that can be incorporated into Test Method 5. | Group 1<br>Jasmine Dondlinger, Nebraska DOT | 8 |
| 2 | Toxicity Standards for the Qualified Products List | $150,000 | 18 months | The goal of the project is to develop toxicity standards for the QPL to better evaluate and process deicers that are submitted to the QPL for evaluation. This will protect the Clear Roads states further ensuring that the deicers pass any toxicity standards that this research develops. | Group 1<br>Doug McBroom, Montana DOT | 11 |
| 3 | Synthesis – Predictive Methods to Update Road Report | | | This synthesis will conduct a survey of states to determine how they receive updates for road conditions if they have attempted automatic updates (successful or unsuccessful) providing next steps and obstacles to avoid when implementing, or updating, advanced traveler information systems. | Group 1<br>Doug McBroom, Montana DOT | 13 |
| 4 | The Use of Traction Control Materials for Snow and Ice Control | $125,000 | 18 months | This project will study the effectiveness of traction control materials such as clinoptilolite zeolites, for snow and ice control as an alternative to standard salt and brine applications. The project will also assess environmental impacts, such as air and water quality issues of traction control materials. | Group 2<br>Jessica Andrews, Utah DOT<br>Kevin Donovan, Illinois DOT<br>Group 1<br>Andrew Lawrence, Nevada DOT,<br>Doug McBroom, Montana DOT | 14 |

# Clear Roads Research and Synthesis Proposals
# 2024

| # | Title | Est. Cost | Est. Duration | Project Summary | Presented by | Page |
|---|---|---|---|---|---|---|
| 5 | Synthesis – Maximizing the Conspicuity of Maintenance Vehicles II | | | This synthesis will Revisit and update CR16-S3 and CR14-06 and improve conspicuity of maintenance equipment for reduction or elimination of collisions and accidents. | Group 2<br>Jeff Pifer,<br>West Virginia DOT | 16 |
| 6 | Synthesis – Application and Accuracy of Plow Up / Down Technology | | | Oftentimes, we use comparison studies to analyze and evaluate the effectiveness and efficiency of various wintertime technology. These studies usually contain many different uncontrollable variables largely affecting the results. Being able to accurately track difficult-to-track data, such as when plow blades are up or down, can provide one more control in data analysis. This synthesis will give states guidance on the different equipment options currently available for tracking plow up / down data as well as their respective accuracy and efficiency. Having another source of reliable, accurate data can open the door to more possible analysis studies. It will also generate ideas for utilizing this data in analyses of winter maintenance methods (such as plow blade comparison studies). | Group 2<br>Jessica Andrews,<br>Utah DOT<br>Patti Caswell,<br>Oregon DOT | 17 |
| 7 | Synthesis – Snow & Ice, 2030 – Be Ready for Change within the Snow & Ice Fighting Industry | | | As newer technologies emerge, and deicing material application methodologies evolve, while environmental degradation increases and contracted drivers become scarce, this synthesis would explore the latest innovations, trends and hurdles the Snow & Ice fighting industry is both blessed with and encumbered by. This synthesis is meant to highlight the most promising emerging trends and technologies and point to available implementation guidance (akin to 17-01). | Group 3<br>Mark Goldstein,<br>Massachusetts DOT | 18 |

# Clear Roads Research and Synthesis Proposals
# 2024

| # | Title | Est. Cost | Est. Duration | Project Summary | Presented by | Page |
|---|---|---|---|---|---|---|
| 8 | Synthesis – Update on Status of AVL/GPS for Winter Operations | | | The technology of AVL/GPS/Telematics has been very successful when it comes to tracking equipment, providing location, breadcrumbs, as well as information on excessive speed, harsh braking, erratic driving, and engine maintenance codes. There seems to be less success when it comes to information from the spreader controller on material usage. In some cases, it depends on the make, model, version, year of the controller for the systems to be able to track and report usage of the solid and liquid materials being dispensed. For agencies with a mix of controllers, finding a single AVL provider can be difficult. This synthesis will determine if there are systems that are able to track material usage on various spreader controllers accurately enough to track material usage for inventory purposes. | Group 3<br>Clay Adams, Kansas DOT | 22 |
| 9 | Winter Road Condition Requirements for Autonomous Vehicles | $100,000 | 15 months | The goal of this project is to understand the required road conditions for AVs to safely operate during the winter to allow state transportation agencies to make decisions regarding the management of their roadways and AV systems. | Group 4<br>Marcus Zimmerman, Alaska DOT&PF | 23 |

# Clear Roads Research and Synthesis Proposals
# 2024

| # | Title | Est. Cost | Est. Duration | Project Summary | Presented by | Page |
|---|---|---|---|---|---|---|
| 10 | Effective Pre-treatment Methods for Events Beginning as Rain | $150,000 | 18 months | States are experiencing shift in weather patterns that have resulted in more rain prior to freezing temperatures in a large portion of the country. There is plenty of research supporting the best treatment practices for snow and ice, but little to be said about rain that may precede the event. Rainfall poses many challenges to pretreatment and with little research to support effective pretreatment methods, many snow removal organizations are left questioning what effective pretreatment methods are. This project will determine the best treatment methods for winter weather events beginning as rain/freezing rain and inform snow removal organizations of those methods through informative products. | Group 4<br>AJ Younes, Virginia DOT<br>Randi Feltner, Kentucky TC<br>Matthew Heinze, Texas DOT | 25 |
| 11 | Correlation of Laboratory Chemical Tests with Field Performance | $150,000 | 24 months | The performance of deicing chemicals in actual usage on roads during various weather conditions is of great importance to highway maintenance managers. Evaluating chemicals in the field is difficult due to the many variables that cannot be controlled. This project will devise a scientific method to compare laboratory test results and characteristic measurements (e.g. gradation, viscosity) that can be performed at most state DOT test labs with performance evaluations in controlled or well-defined conditions on roadways. | Group 4<br>Michael Mattison, Nebraska DOT | 27 |

# Clear Roads Research and Synthesis Proposals
# 2024

| # | Title | Est. Cost | Est. Duration | Project Summary | Presented by | Page |
|---|---|---|---|---|---|---|
| 12 | Synthesis – Best Practices for Research Implementation | | | Significant quantities of quality research exist, but how much of it is used by agencies? This synthesis will explore winter maintenance-related technology and methods that could be used by office and field personnel (especially field personnel) to improve performance may not be visible to them or understood by them. A guidance document that describes the most successful methods for putting research into practice will enable agencies to improve their performance in winter maintenance operations using best practices with a proven track record. | Group 4<br>Michael Mattison, Nebraska DOT | 29 |
| 13 | Synthesis – Simulators for Training Snowplow Drivers | | | This synthesis will look at the current state of practice related to the use of simulators in winter maintenance training. How are simulators currently being used? Are they beneficial in providing advanced training prior to someone going out on the road? | Group 4<br>Paul Denkler, Missouri DOT | 30 |
| 14 | Salt Management Training for Non-DOT End Users | $100,000 | 15 months | The goal of this project is to create training unique to non-DOT salt end users. This could then be used to lessen the burden of explanation and guidance from DOTs, while also cutting down on overutilization of salting resources by all the others. The end goal is for the overuse of salt to stop everywhere, so why do it with just the DOTs? | Group 5<br>Scott Simons, Maryland SHA | 31 |

# Clear Roads Research and Synthesis Proposals
# 2024

| # | Title | Est. Cost | Est. Duration | Project Summary | Presented by | Page |
|---|---|---|---|---|---|---|
| 15 | Using GIS to Identify Highway Segments Sensitive to Deicing Materials – Phase II | $250,000 | 24 months | The geospatial tool, as developed for CR 20-05 Using GIS to Highlight Highway Segments Sensitive to Deicing Materials, requires a power user skill set and processing requirements beyond the average end user. Other issues with this form of the tool include, lack of computing power, access to national databases, and outdated software (ArcGIS 2.9). This project will provide a location for S&I Managers to go and use the tool for operational planning. Use the geospatial tool developed in CR 20-05 to display results on a map in an online environment. | Group 5<br>Joe Thompson, New York State DOT<br>Group 3<br>Mark Goldstein, Massachusetts DOT | 33 |
| 16 | Synthesis – Use and Performance of Fixed Automated Spray Technology (FAST) Systems and Non-Chloride De-Icers on Bridge Decks to Reduce Corrosion to Bridge Components | | | The current practice for VT AOT is to use chloride deicers on bridge decks along with the roadways. Sodium and Magnesium Chloride have caused corrosion to the bridge components, including steel and concrete. In the past, a Fixed Automated Spray Technology (FAST) system utilizing Acetates and / or Formates was used for deicing with reduced corrosion to the bridge decks. Many of these systems were removed due to difficulties in application methods and needed repairs. This synthesis will determine current practices related to the use of FAST systems and/or alternatives to chloride-based deicers. | Group 6<br>Todd Law, Vermont AOT | 35 |

# Clear Roads Research and Synthesis Proposals
# 2024

| # | Title | Est. Cost | Est. Duration | Project Summary | Presented by | Page |
|---|---|---|---|---|---|---|
| 17 | Quantitative and Nonproprietary Understanding of Pavement Surface Friction for Winter Road Maintenance Operations | $200,000 | 24 months | The goal of this project is to perform a comprehensive and quantitative investigation to provide a baseline understanding of how winter pavement surface friction is affected by key influencing factors. Many sensors for winter road maintenance assessment estimate the friction coefficient based on pavement surface condition and water/ice amount, overlooking the impact of salt type and quantity, as well as thermal factors identified in previous studies. This investigation will involve simulation of typical winter road surface conditions and salt application scenarios, under well-controlled laboratory settings. Various data obtainable through existing mobile equipment, including physical, thermal, chemical, and electrical information will be monitored and analyzed, aiming to uncover their cause-and-effect relationships with pavement surface friction. | Group 5<br>Mike Champman, Colorado DOT | 37 |

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# 2024 Research Proposal Form

**Proposer name:** Jasmine Dondlinger (QPL subcommittee)
**Organization:** Nebraska DOT

**Title of proposed research project:** Update to Test Method 5 (Corrosion Effectiveness)

**Topic Area (highlight one):**
**Planning/Methods** Equipment Materials Training Technology Safety

1) **Explain the specific problem or issue to address**.
Products that include a corrosion inhibitor must pass the Category specific limits of corrosion effectiveness, following Test Method 5 in the Clear Roads Guidance Document. This test involves immersing steel coupons (washers) in different flasks containing water, reagent grade NaCl, and product samples. Each flask contains three coupons. The coupons are measured and weighed before the test and after the test. The loss in mass due to corrosion is used to calculate a corrosion rate (MPY) for each coupon. The MPY of the three coupons in each flask are averaged. The Corrosion Percent Effectiveness is then calculated by subtracting the MPY due to water from both the sample and the NaCl, then dividing the corrected sample MPY by the corrected NaCl MPY and multiplying by 100%:

$$Percent\ Effectiveness\ = \frac{\{MPY\ (Sample) - MPY\ (Water)\}}{\{MPY\ (NaCl) - MPY\ (Water)\}} \times 100\%$$

Issue #1: The test method states "Typically, coupon variation may run plus or minus 3 MPY." This is referring to the variation between the three coupons in the same flask. However, this is not an actual variation limit requirement of the method.

Issue #2: The test method doesn't address variability within the lab or between labs. There are not currently any repeatability or reproducibility requirements.

Issue #3: Variability due to the MPY's of the water and NaCl can have a large impact on results. NDOT has had a typical MPY range of 4-7 for water and 55-75 for NaCl, but a lower water value doesn't necessarily happen with a comparably low NaCl value. Using those ranges, this table illustrates the potential **corrosion effectiveness** result variation for a sample with an MPY of 20.

| Sample MPY = 20 | | Water MPY | | |
|---|---|---|---|---|
| | | 4 | 5.5 | 7 |
| NaCl MPY | 55 | **31.4** | **29.3** | **27.1** |
| | 65 | **26.2** | **24.4** | **22.4** |
| | 75 | **22.5** | **20.9** | **19.1** |

In this example, if NDOT was performing the testing, the effectiveness of 31.4 would be repeated. Based on our historical data, the second analysis would likely be around 29.3, but

this table illustrates the potential for obtaining a result of 19.1. If variation limits were set, there would be greater confidence in reporting results.

2) **What is the goal of the project?**
To establish coupon MPY variation limits and corrosion effectiveness repeatability/reproducibility requirements that can be incorporated into Test Method 5.

3) **Describe the expected products/deliverables of the research.**
A literature review for corrosion test methods/specifications. This would ideally be primarily focused for deicers, but other methods/specification would be beneficial as it relates to corrosion of steel.
A survey of labs that perform corrosion testing to compare water and NaCl MPY values.
A round-robin test that would help establish appropriate variation limits and repeatability / reproducibility requirements.

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
    - Literature review – Test Method 5 is a modification of NACE TM0169/ASTM G31, but more corrosion test procedures would be beneficial to review, especially if there are variation limit requirements.
    - Survey – A survey of current labs that perform Test Method 5 and/or similar corrosion testing to determine what their historical values are when it comes to the water and NaCl MPY's. A survey could also indicate other variables that could contribute to variability such as coupon source.
    - Round-robin testing – Design and execute a round-robin test that would provide data to support establishing variation, repeatability, and reproducibility requirements.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
The Clear Roads QPL Subcommittee as the owners of the test method, as well as independent labs, DOT labs, vendors, and any other entities performing corrosion effectiveness testing of deicers.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
Having these requirements incorporated into Test Method 5 would:
    - Assist in improved cooperative testing between vendors and end users (DOT's),
    - Improve confidence in holding vendors accountable with the quality of their products,
    - Provide the QPL Committee with higher confidence in evaluating test results.

7) **How will you measure the success of this project?**
Appropriate repeatability/reproducibility and variation limits will be determined/established, and Test Method 5 will be updated to include these requirements.

8) **Estimated funding needed.** $150,000

9) **Estimated timeline for completing the research.** 18 months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
The Nebraska DOT performed a round-robin study with partner labs. Two Category 1 products were analyzed with coupons provided by NDOT as well as the participating lab's coupons to evaluate any variability due to coupon source. Due to the small sample size and number of participating labs, results were inconclusive.

# 2024 Research Proposal Form

**Proposer name:** Doug McBroom (QPL subcommittee)
**Organization:** Montana DOT

**Title of proposed research project:** Toxicity Standards for the Qualified Products List

**Topic Area (highlight one):**
Planning/Methods Equipment **Materials** Training Technology Safety

1) **Explain the specific problem or issue to address**.
Clear Roads Qualified Product List (QPL) is a list of winter material products that are evaluated to ensure users are purchasing safe and reliable products. To be placed on the list, a set of criteria is tested to ensure the product is safe to use. Currently the QPL requires toxicity tests for products to be considered by the QPL subcommittee, however, those tests are informational only. Products are evaluated and placed on the QPL, regardless of the results of the toxicity tests. Developing toxicity standards and limits are paramount for ensuring that deicers are safe to use for clear road states.

2) **What is the goal of the project?**
The goal of the project is to develop toxicity standards for the QPL to better evaluate and process deicers that are submitted on the QPL for evaluation. This will protect the Clear Roads state further ensuring that the deicers pass any toxicity standards that this research develops.

3) **Describe the expected products/deliverables of the research.**
   - Recommendations for an QPL Acceptance Standard for toxicity
   - Recommendations for Indicator Species
   - Final Report

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
   - An extensive literature review.
   - Testing methodologies (from the literature review) with indicator species
   - Recommendation memo to the QPL
   - Final Report

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
This would only be used by the QPL subcommittee.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
This would benefit the state DOT's ensuring that any deicer they use has been tested and will have passed any toxicity standard for the QPL.

7) **How will you measure the success of this project?**
Incorporation of standard methodology for a toxicity test and toxicity standards into the QPL testing regiment

8) **Estimated funding needed.** $150,000

9) **Estimated timeline for completing the research.** 18 months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
No.

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# 2024 Synthesis Proposal Form

**Requestor name:** Doug McBroom (Group 1)
**Organization:** Montana DOT

**Title of proposed synthesis project:** Predictive Methods to Update Road Report

**Topic area (highlight one):**
**Planning/Methods** Equipment Materials Training Technology Safety

1) **Explain the specific problem or issue to address**.
   Most snow and ice states have a traveler information system. The way that systems are updated could vary from state to state. In fact, with better forecasting, and Artificial Intelligence, some states have tried automatic updating of their traveler information system.

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
   This synthesis will conduct a survey of states to determine how they receive updates for road conditions, if they have attempted automatic updates (successful or unsuccessful) and compile a summary of the Clear Roads states' experiences.

3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems**?
   This synthesis will develop a framework for the community of practice within the Clear Roads states. It could provide next steps and obstacles to avoid when implementing, or updating, advanced traveler information systems.

4) **Are you aware of any similar or related information on this topic? If so, please list below.** Northwest Passage pooled fund and Wyoming DOT's use of SDX.

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# 2023 Research Proposal Form

**Proposer name:** Jessica Andrews, Keith Donovan, Andrew Lawrence, Doug McBroom (Group 2)
**Organization:** Utah, Illinois, Nevada Montana DOTs

**Title of proposed research project:** The Use of Traction Control Materials for Snow and Ice Control

**Topic Area (highlight one):**
Planning/Methods Equipment **Materials** Training Technology Safety

1) **Explain the specific problem or issue to address**.
Salt can be environmentally unfriendly and corrosive to vehicles, roadways, and surrounding features/assets when used for snow and ice control. It can also be less efficient or effective in certain weather conditions and temperatures. Traction materials also have environmental impacts such as air and water quality issues. Traction materials are also blown off the road by traffic sometimes in as little as 3 to 4 passes which then need to be reapplied. There has been little research by Clear Roads investigating traction materials' effectiveness and impact on roadway surfaces.

2) **What is the goal of the project?**
To study the effectiveness of various traction control materials for snow and ice control as an alternative to standard salt and brine applications in specific conditions, as well as assessing its environmental impacts.

3) **Describe the expected products/deliverables of the research.**
A report detailing the results of the testing of various traction control materials and their effectiveness for traction control, snow and ice removal, optimal placement guidelines, whether it is an effective replacement for chloride products and can help alleviate environmental concerns regarding chloride deicer use, as well as any impacts regarding air and water quality.

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
- The researcher would conduct a comprehensive literature search on traction control materials that have been used or could be available for departments of transportation for traction control.
- The research would survey the states to determine what is currently being used for traction control materials and the cost, as well as survey industry to determine what is available and the cost.
- From the survey and literature review the research will identify and obtain various products for testing.
- The research will conduct a series of tests through the winter season to compare the effectiveness of these products. These products will be analyzed for any environmental impacts compared to traditional winter materials.

- The researcher would then compile the test data to make conclusions as to the effectiveness of these products.
- The researcher should evaluate the weather and road conditions in which the identified traction control materials would provide the most benefit.
- Evaluation of the suitability of the various materials evaluated to be placed by typically available winter highway maintenance equipment.
- Evaluate feasibility and market conditions for the identified traction control materials.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
The intended audience would be Clear Roads members and other interested wintertime maintenance staff.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
This would help put another tool in the belt of wintertime maintenance personnel to use as an alternative to the standard salt and brine applications, as well as optimal conditions in which to use them. This could also be a good alternative for areas where excess salinity is a concern. Additionally, this will help departments of transportation understand the environmental impacts of these types of materials.

7) **How will you measure the success of this project?**
Success will be measured by obtaining information needed to determine if these types of materials could be a viable alternative to traditional winter maintenance materials.

8) **Estimated funding needed.** $125,000

9) **Estimated timeline for completing the research.** 18 months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
No.

CLEAR ROADS
research for winter highway maintenance

# 2024 Synthesis Proposal Form

**Requestor name:** Jeff Pifer (Group 2)
**Organization:** West Virginia DOT

**Title of proposed synthesis project:** Maximizing the Conspicuity of Maintenance Vehicles II

**Topic area (highlight one):**
Planning/Methods Equipment Materials Training Technology **Safety**

1) **Explain the specific problem or issue to address**.
Revisit and update CR16-S3 and CR14-06 with current state-of-the-art research and practices.

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
Research, literature, state and contractor practices, and sample policies, procedures, and specifications.

3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems**?
Improve conspicuity of maintenance equipment for reduction or elimination of collisions and accidents.

4) **Are you aware of any similar or related information on this topic? If so, please list below.**
   - CR 14-06 Use Of Equipment Lighting During Snowplow Operations
   - CR 16-S3 Maintenance Vehicle Conspicuity
   - Michigan DOT study on green led strobe lighting.
   - Ohio DOT study on green led strobe lighting.
   - An older study by Dupont (I think) about color conspicuity.

# 2024 Synthesis Proposal Form

**Requestor name:** Jessica Andrews and Patti Caswell (Group 2)
**Organization:** Utah and Oregon DOTs

**Title of proposed synthesis project:** Application and Accuracy of Plow Up / Down Technology

**Topic area (highlight one):**
Planning/Methods **Equipment** Materials Training Technology Safety

1) **Explain the specific problem or issue to address**.
Oftentimes, we use comparison studies to analyze and evaluate the effectiveness and efficiency of various wintertime technology. These studies usually contain many different uncontrollable variables largely affecting the results. Being able to accurately track difficult-to-track data, such as when plow blades are up or down, can provide one more control in data analysis. Many states struggle with functional, accurate plow sensors. Whether a plow is up or down can be a significant factor in determining tort liability (yes, the truck was in the area, but it was not plowing and therefore couldn't have damaged your car by throwing abrasives). Plow sensors can be installed in different locations and using different technologies (a switch v. pressure, e.g.).

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
We are looking to compile literature, state practices, existing studies or reviews on ways plow up / down data is or can be utilized as well as different existing methods of collecting plow up / down data and their accuracy, reliability, and longevity.

3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems?**
This will give states guidance on the different equipment options currently available for tracking plow up / down data as well as their respective accuracy and efficiency. Having another source of reliable, accurate data can open the door to more possible analysis studies. It will also generate ideas for utilizing this data in analyses of winter maintenance methods (such as plow blade comparison studies).

4) **Are you aware of any similar or related information on this topic? If so, please list below.**
No.

# 2024 Synthesis Proposal Form

**Requestor name:** Mark Goldstein (Group 3)
**Organization:** Massachusetts DOT

**Title of proposed synthesis project:** Snow & Ice, 2030 – Be Ready for Change within the Snow & Ice Fighting Industry

**Topic area (highlight one):**
**Planning/Methods** **Equipment** **Materials** **Training** **Technology** **Safety**
All of these "topic areas" may apply to this synthesis.

1) **Explain the specific problem or issue to address**.
   As newer technologies emerge, and deicing material application methodologies evolve, while environmental degradation increases and contracted drivers become scarce, this synthesis would explore the latest innovations, trends and hurdles the Snow & Ice fighting industry is both blessed with and encumbered by.

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
   There are tremendous repositories of winter operations information and data. AASHTO, SICOP, Clear Roads, Aurora, etc. are great sources of information that examine and showcase the latest snow and ice fighting advances. Aspects include policies & procedures, deicing material types and methodologies, vehicle and material application tracking capabilities (GPS/AVL), connected vehicle technologies (Automaker vehicles reporting ABS/Windshield wiper deployment, MDSS, etc.), road weather information systems, modern building (i.e., Salt Shed and depot) designs and location strategies, route optimization, efficient equipment configurations (wings/tow plows), focus on sidewalk clearing, Complete Streets programs, etc. Other modern advances such as 511 Traveler Information websites and roadside messaging support the dissemination of information to the motoring public. Variable speed limits and roadside messaging regarding plows operating or icy conditions on the roadway ahead are important newer capabilities. Modern navigation platforms also provide important information, with much of it relying on motorists' observations and incident reports (stalled vehicle or crash ahead, etc.).

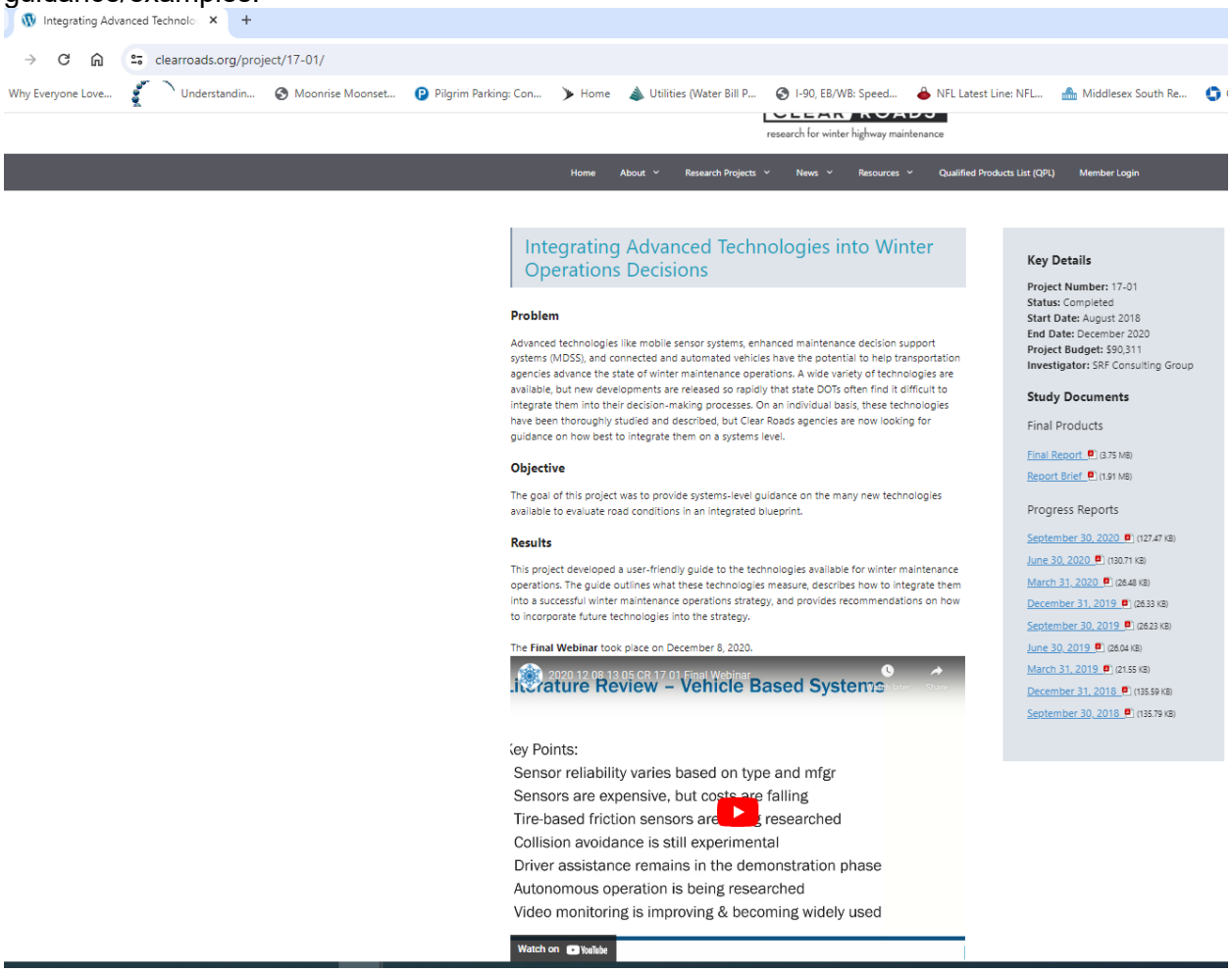
3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems**?
   Snow & Ice programs need to embrace and leverage change. They must be as efficient as possible and serve as the main defenders of the roadways during Snow & Ice season while acting as stewards of their Departmental or Agency budgets and simultaneously trying to

defend their constituents' environments. This is a difficult balance to maintain. This is especially true in an era of shrinking budgets, escalating infrastructure responsibilities, and global climate flux. This synthesis is meant to highlight the most promising emerging trends and technologies and point to available implementation guidance (akin to 17-01).

4) **Are you aware of any similar or related information on this topic? If so, please list below.**
Clear Roads 17-1 sought recommendations on how to implement some newer technologies (Mobile sensor systems, MDSS). https://www.clearroads.org/project/17-01/

Here's Greg hosting that project's final webinar.
https://youtu.be/Dkr7kVDXt0Y

This could be a partner synthesis that captures the latest advances and integration guidance/examples.




Greg filled me in on a February Webinar and related paper: Becoming a Tech-Savvy DOT of Tomorrow: https://nap.nationalacademies.org/catalog/27293/becoming-a-tech-savvy-dot-of-tomorrow

It is a look at potentially disruptive (Behavior-changing/marketplace altering/new-and-improved way of doing things or business). It suggests a playbook for DOTs to keep themselves aware of emerging technologies and how they can best leverage them to improve their transportation systems:




***Figure II-1. Steps for adapting to disruptive technologies.***

Additionality, I did a brief search for other related research (broad):

Simulating future climate change impacts on snow- and ice ...

IOPscience
https://iopscience.iop.org › article

by HE Greaves · 2023 ·

A review of ice and snow risk mitigation and control ...

ScienceDirect
https://www.sciencedirect.com › science › article › pii

by L Matejicka · 2022 · Cited by 15 — The lack of adequate countermeasures usually leads to economically-damaging bridge closures that bridge owners try to minimise through weather

Climate change impacts on future snow, ice and rain runoff ...

ScienceDirect
https://www.sciencedirect.com › science › article › pii

by S Etter · 2017 · Cited by 57 — Catchments with a low degree of glacierization will switch from **snow**-dominated to rain-dominated altering the runoff seasonality towards more **winter** runoff

[How New Technologies Can Improve Ice and Snow ...]

[Earth Development]
https://earthdevelopmentinc.com ›

# 2024 Synthesis Proposal Form

**Requestor name:** Clay Adams (Group 3)
**Organization:** Kansas DOT

**Title of proposed synthesis project:** Update on Status of AVL/GPS for Winter Operations

**Topic area (highlight one):**

Planning/Methods **Equipment** Materials Training **Technology** Safety

1) **Explain the specific problem or issue to address**.
The technology of AVL/GPS/Telematics has been very successful when it comes to tracking equipment, providing location, breadcrumbs, as well as information on excessive speed, harsh braking, erratic driving, and engine maintenance codes. There seems to be less success when it comes to information from the spreader controller on material usage. In some cases, it depends on the make, model, version, year of the controller for the systems to be able to track and report usage of the solid and liquid materials being dispensed. For agencies with a mix of controllers, finding a single AVL provider can be difficult.

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
To generate a survey and compile the information on the various AVL systems currently being used by the Clear Roads membership. The information to be gathered would be items such as what providers are able to produce data on what controllers. What information is able to be tracked, application rates of various materials, both solids and liquids. What level of accuracy is the material usage. Depending in the calibration of the spreader, Is the data accurate enough for inventory purposes.

3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems**?
It would be a great help to the field staff If there are systems that are able to track material usage on various spreader controllers accurately enough to track material usage for inventory purposes. The ability to also track real time application rates would also help management address situations where maybe more material is being applied than justified.

4) **Are you aware of any similar or related information on this topic? If so, please list below.**
   - 14-01 Synthesis on GPS/AVL Equipment Used for Winter Maintenance
     - Seems like there have been a lot of changes in the industry since then.
   - 16-01 Utilization of AVL/GPS Technology: Case Studies
     - A more in-depth look at how the technology is used.
   - 20-04 Expanded Use of AVL/GPS Technology
     - Can technology used for winter also be moved to / used in summer maintenance vehicles?
   - 21-06 Calculating Plow Cycle Times from AVL Data

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# 2024 Research (or Synthesis) Proposal Form

**Proposer name:** Marcus Zimmerman (Group 4)
**Organization:** Alaska DOT&PF

**Title of proposed research project:** Winter Road Condition Requirements for Autonomous Vehicles

**Topic Area (highlight one):**
Planning/Methods Equipment Materials Training **Technology** **Safety**

1) **Explain the specific problem or issue to address**.
Autonomous Vehicles (AV) rely on visible lane markings for navigation, but what happens if lane lines are obscured by snow and / or ice? Per a November 2023 Center for Transportation Studies article describing a study by the University of Minnesota, testing this very idea at the MnROAD facility… "When snow partially or fully impeded lane line visibility, it significantly reduced lane detection. This would make autonomous control very challenging even with light snow cover."

2) **What is the goal of the project?**
The goal of this project is to understand the required road conditions for AVs to safely operate during the winter to allow state transportation agencies to make decisions regarding the management of their roadways and AV systems.

3) **Describe the expected products/deliverables of the research.**
The expected deliverables would be a report with PowerPoint presentation on the findings. The findings would include…
   - Description (tutorial) of how AV systems work.
   - A list of sensor types and data available from AVs that transportation agencies can use.
   - Best Management Practices for maintaining roads to allow for safe operation of AVs.

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
   - A review of relevant literature from domestic and international research efforts as well as trade publications detailing system architecture and operations.
   - Survey and follow up interviews with users and manufacturers of AV equipment technology.
   - Develop of a primer on the topic of AV technology addressing…
     - Autonomous vehicle system architecture and operations.
     - Sensors and data available from AV systems.
     - Best Management Practices for maintaining roads to allow for AV operations.

- Final report and webinar

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
Anyone dealing with winter road maintenance. Presentation with tutorial of how the AV systems work. Best practices for maintaining roads to allow for safe operations of AVs. What data is possibly available from the AVs that transportations agencies could use.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
This research will help AK DOT&PF evaluate its winter maintenance practices ensuring we are meeting or exceeding the requirements for AVs to operate on our roadways. I think other states would use this information in the same way.

7) **How will you measure the success of this project?**
If the Clear Roads member states have access to a primer document to refer to as needed in order to make decisions at the intersection of winter maintenance and AV technology.

8) **Estimated funding needed.** $100,000

9) **Estimated timeline for completing the research.** 15 months.

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
A few sample references include…
    - National Academies of Sciences, Engineering, and Medicine. 2024. Connected and Autonomous Vehicle Technology: Determining the Impact on State DOT Maintenance Programs. Washington, DC: The National Academies Press. https://doi.org/10.17226/27625
    - Influence of Autonomous and Partially Autonomous Vehicles on Minnesota Roads
        - CTS article (November 2023).
        - Project page.
        - Final Report.
        - Technical Summary.
    - ROADVIEW – autonomous vehicles in extreme weather
    - Do We Need a Change in Road Winter Maintenance to Accommodate for Automated Vehicles? A State-of-the-Art Literature Review Considering Automated Vehicle Technology's Usage of Road Infrastructure During Winter (Abstract) (Report)
    - Implications of automated vehicles for physical road environment: A comprehensive review
    - CR 21-05 Evaluation of Electric Vehicle Technologies and Alternative Fuels for Winter Operations [Intended only as an example of how to approach this topic]

# 2024 Research Proposal Form

**Proposer name:** A.J. Younes (Group 4), Randi Feltner, Matthew Heinze
**Organization:** VDOT, KYTC, TXDOT

**Title of proposed research project:** Effective Pre-treatment Methods for Events Beginning as Rain

**Topic Area (highlight one):**
Planning/Methods Equipment **Materials** Training Technology Safety

1) **Explain the specific problem or issue to address**.
   States are experiencing shift in weather patterns that have resulted in more rain prior to freezing temperatures in a large portion of the country. Kentucky, Virginia, and Texas are just a few examples of these states, but much of the country has been affected by this shift. There is plenty of research supporting the best treatment practices for snow and ice, but little to be said about rain that may precede the event. Rainfall poses many challenges to pretreatment and with little research to support effective pretreatment methods, many snow removal organizations are left questioning what effective pretreatment methods are. The lack of research to support treatment decisions made for these types of events pose challenges to how agencies communicate their plans to the public. There is a need for scientific research to be done that establishes applications rates, treatments, and methods that best combat winter weather events that begin with rain or freezing rain.

2) **What is the goal of the project?**
   To determine the best treatment methods for winter weather events beginning as rain/freezing rain and inform snow removal organizations of those methods through informative products.

3) **Describe the expected products/deliverables of the research.**
   Guidance that could be supplied to snow removal organizations that recommends the best methods for pretreating winter weather events that begin with rain. A version of this guidance could be tailored to agency leadership, and another could be designed for practical use by field forces.

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
   Literature review, review of practices, lab evaluation, and field evaluation.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**

Maintenance field staff and agency leadership. The products would be used to inform agencies of the best pretreatment methods for winter weather events that begin with rain.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
These products would be used to inform the organization of the recommended treatment options for winter storms beginning as rain. DOTs would benefit from this research as it will influence and support the treatment methods they may utilize for these types of storms. Being able to best treat transportation systems during mixed precipitation events significantly improves winter maintenance operation and the safety of the travelling public. Along with the impacts on the travelling public, transportation agencies will benefit from being able to use materials in a more cost-effective fashion once they understand the best practices rooted in research for these types of events.

7) **How will you measure the success of this project?**
By the successful creation of informational products.

8) **Estimated funding needed.** Up to approximately $150,000

9) **Estimated timeline for completing the research.** 18 months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
WTB#22 Anti-icing2 (wisc.edu) 2005

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# 2024 Research Proposal Form

**Proposer name:** Michael Mattison (Group 4)
**Organization:** Nebraska DOT

**Title of proposed research project:** Correlation of Laboratory Chemical Tests with Field Performance

**Topic Area (highlight one):**
**Planning/Methods** Equipment **Materials** Training Technology Safety

1) **Explain the specific problem or issue to address**.
The performance of deicing chemicals in actual usage on roads during various weather conditions is of great importance to highway maintenance managers. Evaluating chemicals in the field is difficult due to the many variables that cannot be controlled. Further, new chemicals or combinations of chemicals are often evaluated subjectively by users to determine their effectiveness. An economical and repeatable method to determine the performance potential of chemicals in various environments is needed.

2) **What is the goal of the project?**
Devise a scientific method to compare laboratory test results and characteristic measurements (e.g. gradation, viscosity) that can be performed at most state DOT test labs with performance evaluations in controlled or well-defined conditions on roadways. Make comparisons for several common deicing products to verify the methodology and establish a library of test correlations with field performance. If needed, develop new laboratory and/or field test specifications for the comparisons.

3) **Describe the expected products/deliverables of the research.**
Develop a detailed methodology and model for measuring field performance of common deicing chemicals and comparing with standard lab tests. Catalog the results and create a library of comparisons indicating how lab results correlate with field performance. Provide a guidance document for use of the method and the library.

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
   - Perform a literature search for related work.
   - Develop a scientific method to evaluate field performance.

- Create a theoretical model of how measurable deicing chemical properties correlate with field performance under various conditions including precipitation type, temperature, traffic and others.
- Collect data to test the model.
- Analyze data from lab tests and field performance measurements.
- Revise the model as needed for best correlations.
- Write a report that details the methodology and how it can be reproduced.
- Create a library of tested chemicals and correlation with field performance.
- Write guidance document for winter maintenance practitioners and laboratories.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
   - Laboratory managers for state DOTs and other agencies
   - Maintenance practitioners in state DOTs and other agencies

   Laboratory managers may need some training on how to use the developed protocols to perform tests correctly. Maintenance practitioners, including managers, engineers, and operators will need to know how to use the guidance documents to best use chemicals based on test results and expected road-weather conditions. Training will be needed for any personnel involved with data collection to perform correlations.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
   The users guide will aid maintenance practitioners in using the most effective materials at the optimum application rate to achieve the desired Level Of Service for the expected road-weather conditions.

7) **How will you measure the success of this project?**
   A successful outcome will provide a cookbook (library of chemicals, tests, and conditions) that is simple enough for maintenance managers to use effectively. Theory, test protocols and methodology will be documented clearly with sufficient details for lab managers and maintenance managers and engineers to duplicate the results and apply to other chemicals.

8) **Estimated funding needed.** $150,000

9) **Estimated timeline for completing the research.** 24 months.

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
    No.

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# 2024 Synthesis Proposal Form

**Requestor name:** Michael T Mattison (Group 4)
**Organization:** Nebraska DOT

**Title of proposed synthesis project:** Best Practices for Research Implementation

**Topic area (highlight one):**
**Planning/Methods** Equipment Materials Training Technology Safety

1) **Explain the specific problem or issue to address.**
   Significant quantities of quality research exist, but how much of it is used by agencies? Technology and methods that could be used by office and field personnel (especially field personnel) to improve performance may not be visible to them or understood by them.

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
   What research projects and training materials have been adopted by practitioners in government agencies responsible for winter maintenance? How were the projects shared and promoted with the people responsible for implementing them? What is the most effective way of gaining acceptance for new ideas and science-based practices?

3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems**?
   Agencies will learn how to implement research more quickly and effectively to get greater value from research. A guidance document that describes the most successful methods for putting research into practice will enable agencies to improve their performance in winter maintenance operations using best practices with a proven track record.

4) **Are you aware of any similar or related information on this topic? If so, please list below.**
   I am not aware of other information on this topic.

# 2024 Synthesis Proposal Form

**Requestor name:** Paul Denkler (Group 4)
**Organization:** Missouri DOT

**Title of proposed synthesis project:** Simulators for Training Snowplow Drivers

**Topic area (highlight one):**
Planning/Methods Equipment Materials **Training** Technology Safety

1) **Explain the specific problem or issue to address**.
How are simulators currently being used? Are they beneficial in providing advanced training prior to someone going out on the road?

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
State of practice – who (what states) are currently using them?
- Are they being used for more than just snowplow training?
- Training for all fleet classes?

How are they being incorporated into driver training programs?
Are there future influences on CDL test?

3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems**?
- By the sharing of best practices with other state DOTs.
- Using all available resources to improve the safety of our drivers and the traveling public.
- Information could be used as a starting point for DOT wanting to consider the use of simulators as part of their driver training program.

4) **Are you aware of any similar or related information on this topic? If so, please list below.**
No Boundaries pool fund group just sent out a survey this week asking for feedback on this exact topic.

# 2024 Research Proposal Form

**Proposer name:** Scott K. Simons (Group 5)
**Organization:** Maryland SHA

**Title of proposed research project:** Salt Management Training for Non-DOT End Users

**Topic Area (highlight one):**
Planning/Methods Equipment Materials **Training** Technology Safety

1) **Explain the specific problem or issue to address**.
   Recently, our Maryland Department of Environment (MDE) has set out to create a training program/curriculum for non-DOT users. The MDE has recognized SHA's salt reduction efforts and publicly claimed that SHA isn't a concern for over utilization of salt resources. However, SHA in the eyes of the media and public are the ultimate contributors. Kind of the "Big Brother" effect.

   MDE has been trying to use our internal BMPs to create a non-DOT user training, but quickly realized, that what we do things on such a large scale (resources, types of equipment, access to technology, etc.) won't be able to create a one size fits all training. SHA's internal training may cover a few things pertinent to non-DOT users, but it's only 40 percent or less.

   MD thinks a training of this sort would help lessen that "Big Brother" label, show a good faith effort as the "Big Brother", and shape the narrative to include everyone's responsibility for smart and sensible salting.

   This could then be used to lessen the burden of explanation and guidance from DOTs, while also cutting down on overutilization of salting resources by all the others. The end goal is for the abuse to stop everywhere, so why do it with just the DOTs?

2) **What is the goal of the project?**
   To create training unique to non-DOT salt end users.

3) **Describe the expected products/deliverables of the research.**
   A training or series of trainings outlining the following:
   - Scientific properties of salt and salt alternatives, including liquids
   - Multiple methods of treatment using salt and salt alternatives, including liquids
   - Usage rates based on temperatures, environmental regulations, types of equipment, etc.
   - Impacts on infrastructure.
   - Impacts on health.
   - Fiscal impacts
   - Other

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
    - Consult Clear Roads TAC for possible DOT BMPs/training that may be applicable to this effort.
    - Consult Department of the Environment Offices of other states for ideas/training that may be applicable to this effort.
    - Consult non-DOT end users on situations/needs unique to smaller snow removal/salt use operations.
    - Compile the findings for presentation to the Clear Roads Project Team.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
Non-DOT salt end users.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
MD thinks a training of this sort would help lessen that "Big Brother" label, show a good faith effort as the "Big Brother", and shape the narrative to include everyone responsible for smart and sensible salting.

7) **How will you measure the success of this project?**
If the product ends up used by multiple DOTs it should be considered a success.

8) **Estimated funding needed.** $100,000

9) **Estimated timeline for completing the research.** 15 months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
CR 16-06 Training Video for the Implementation of Liquid-Only Plow Routes

# 2024 Research Proposal Form

**Proposer name:** Joe Thompson (Group 5) / Mark Goldstein (Group 3)
**Organization:** New York State DOT / Massachusetts DOT

**Title of proposed research project:** Using GIS to Identify Highway Segments Sensitive to Deicing Materials – Phase II

**Topic Area (highlight one):**
Planning/Methods Equipment Materials Training **Technology** Safety

1) **Explain the specific problem or issue to address**.
The geospatial tool, as developed for CR 20-05 Using GIS to Highlight Highway Segments Sensitive to Deicing Materials, requires a power user skill set and processing requirements beyond the average end user. Other issues with this form of the tool include, lack of computing power, access to national databases, and outdated software (ArcGIS 2.9).

2) **What is the goal of the project?**
To provide a location for S&I Managers to go and use the tool for operational planning. Use the geospatial tool developed in CR 20-05 to display results on a map in an online environment.

3) **Describe the expected products/deliverables of the research.**
The tool would be adapted, so it can be hosted in a central location and accessed as an online application. Migration to an on-line application has five major benefits:
   - It eliminates the need for individual distribution and installation of the tool software.
   - It ensures a common version is used by all users.
   - Upgrades are made to a single installation.
   - Custom, optimized user interfaces can be developed to make the tool simpler and more accessible to a wider user base.
   - Datasets can be curated to ensure that all analyses use the most current and consistent data.

4) **List the specific research tasks that would form the scope of work. (What steps will the researcher need to take to develop the deliverables?)**
   - Review files / deliverables from CR 20-05.
   - Develop outline for online tool.
   - Build an online tool.
   - Beta testing of online tool.
   - Finalize and post / host tool.
   - Final report and webinar.
   - Post project contract – will need a maintenance contract to host and maintain tool.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
State DOT snow and ice managers.

6) **How will they be used to impact your organization? How would they benefit DOTs? Describe how the research recommendations can be used to improve the winter maintenance operations of state transportation systems**.
Agencies would be in a better position to have a spatial awareness of vulnerabilities to their highway networks.

7) **How will you measure the success of this project?**
Site traffic and practical use.

8) **Estimated funding needed:** $250,000.

9) **Estimated timeline for completing the research:** 24 months.

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
No.

# 2024 Synthesis Proposal Form

**Requestor name:** Todd Law (Group 5)
**Organization:** Vermont Agency of Transportation

**Title of proposed synthesis project:** Synthesis: Use and Performance of Fixed Automated Spray Technology (FAST) Systems and Non-Chloride De-Icers on Bridge Decks to Reduce Corrosion to Bridge Components.

**Topic area (highlight one):**
Planning/Methods **Equipment** **Materials** Training Technology Safety

1) **Explain the specific problem or issue to address**.
The current practice for VT AOT is to use chloride deicers on bridge decks along with the roadways. Sodium and Magnesium Chloride have caused corrosion to the bridge components, including steel and concrete. In the past, a Fixed Automated Spray Technology (FAST) system utilizing Acetates and / or Formates was used for deicing with reduced corrosion to the bridge decks. Many of these systems were removed due to difficulties in application methods and needed repairs.

2) **What information do you want the synthesis to compile (literature, state practices, sample policies or specifications, etc.)?**
   - Literature search to identify manufacturers of FAST systems.
     - Collect information from FAST system manufacturers – product reviews to include system specifications, performance specifications, and material use.
   - Survey DOTs to determine current practice related to the use of FAST systems and / or alternatives to chloride-based deicers.
   - Case studies to include agency experiences with FAST systems.
     - How / where were they used?
     - What materials did the FAST systems apply.
     - Performance as compared to traditional methods of material application.
     - Reliability / durability of the FAST systems?
     - Were these FAST systems worth the cost of purchase, installation, maintenance / repair?

3) **How will the synthesis report be used to improve the winter maintenance operations of state transportation systems**?
Bridges can be significantly impacted by winter weather - as depicted by signs stating that bridges may freeze before the roadway. They are an expensive asset and chloride-based deicers cause significant damage to bridge components. Having an automated system that is reliable and cost-effective, along with being less corrosive, provides multiple benefits to the DOTs.

4) **Are you aware of any similar or related information on this topic? If so, please list below.**
CR 21-03 Efficacy, Cost, and Impacts of Non-Chloride Deicers

# 2024 Research Proposal Form

**Proposer name:** Xianming Shi and Yong Deng
**Organization:** Washington State University
**Championed by:** Mike Chapman, Colorado DOT

**Title of proposed research project:** Quantitative and Nonproprietary Understanding of Pavement Surface Friction for Winter Road Maintenance Operations

**Topic Area (highlight one):**

**Planning/Methods** Equipment Materials Training Technology Safety

1) **Explain the specific problem or issue to address**.
Road surface friction is of utmost importance in winter road maintenance (WRM) operations, particularly as it is directly influenced by the application of salt to combat ice and snow accumulation. Maintaining the optimal salinity level on roads is a critical measure to mitigate the adverse impacts of salt on infrastructure and ecosystems. Consequently, the ability to detect pavement surface friction in a timely and accurate manner holds significant importance to traffic safety, environmental stewardship, and infrastructure preservation. Without this ability, current WRM practices tend to error on the over-application side.

   Currently, on-vehicle sensors are emerging as the preferred choice for the rapid and continuous assessment of pavement surface friction due to their superior production efficiency, adaptability, reduced traffic disruption, and lower risks to operators. However, there still exists a significant gap in the current practices. First, many sensors for WRM assessment estimate the friction coefficient based on pavement surface condition and water/ice amount, thus overlooking the impact of salt type and quantity, as well as thermal factors identified in previous studies. Second, commercial sensors lack transparent algorithms, making it challenging to calibrate them for varying scenarios of pavement surface conditions in winter.

2) **What is the goal of the project?**
The goal of this project is to perform a comprehensive and quantitative investigation to provide a baseline understanding of how winter pavement surface friction is affected by the key influencing factors. This investigation will involve simulation of typical winter road surface conditions and salt application scenarios, under well-controlled laboratory settings. Various data obtainable through existing mobile equipment, including physical, thermal, chemical, and electrical information will be monitored and analyzed, aiming to uncover their cause-and-effect relationships with pavement surface friction. To establish predictive models for quantifying pavement surface friction, advanced data mining techniques such as machine learning will be employed to process the collected data and construct the models. This initiative is poised to significantly advance the fundamental understanding of winter road surface friction in relation to road conditions, the environment, and WRM practices.

Additionally, it will enable the application of nondestructive testing and data mining techniques in the effective monitoring and management of pavement surface conditions, ultimately contributing to the implementation of targeted mitigation strategies and the optimized allocation of resources for WRM program.

3) **Are you aware of any similar or related research on this topic? If so, please list below.**
We are not aware of any related information on this topic.

4) **Estimated project budget / duration?**
$200,000 and 24 months.