Clear Roads Research Proposals
2015

#	Title	Est. Cost	Est. Duration	Project Summary	Presented by	Page
1	Understanding the Relationship between Various Agency Resources, Focusing on Equipment Availability and Ability to Perform Winter Maintenance Operations (WMO).	$100,000	18 months	This project would develop tools that can help winter maintenance administrators optimally allocate resources and would demonstrate the level-of-service impact of not having mechanics, parts, or equipment.	David Frame, California DOT	4
2	Research Options for Bi-fuel and/or Blended Fuel Diesel/CNG for Snow Fighting Equipment.	$50,000	12 months	The goal of this project is to research options and solutions for a bi-fuel or blended fuel (diesel and CNG) for use in heavy-duty applications and equipment for snow removal on highway systems.	Kyle Lester, Colorado DOT	6
3	Pacific Northwest Snowfighters (PNS)	$30,000	3 years	The purpose of this project is to continue to support PNS with funding, which will be used to conduct quality assurance testing of QPL candidate products, develop new product testing protocols, develop new product specifications and categories, and conduct associated product category testing.	Ron Wright, Idaho TD	8
4	Comprehensive Study on Contracting Snow and Ice Response	$75,000	12 months	The goal of this project is to analyze and document state efforts to privatize snow and ice control.	Tim Peters, Illinois DOT	11
5	Tow Plow Safety Analysis	$75,000	12 months	The purpose of this project is to analyze and document the safety of tow plows and to document the best practices of the agencies using them.	Tim Peters, Illinois DOT	13
6	Synthesis of Best Practice for Material Application Methodology in Winter Operations	$100,000	12 months	This project would result in a comprehensive synthesis of best practices for anti-icing/deicing material application for varied weather events, road types, traffic considerations, and environmental concerns.	Paul Brown, Massachusetts DOT	15

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#	Title	Est. Cost	Est. Duration	Project Summary	Presented by	Page
7	Identifying Successful Practices for Staffing Winter Operations	$100,000	12 months	The goal of this project is to determine the optimum ratio of permanent to part-time staff to effectively perform winter operations. The project would also develop generic shift schedules for meeting various level of service and identify maximum shift lengths to help agencies standardize practices statewide and nationally. **Overview** **Questions**	Justin Droste, Michigan DOT	17
8	Determining the Best Method for Pre-treating Salt	$125,000	12 months	This project would identify and evaluate the range of different methods for mixing or pre-treating dry rock salt (including but not limited to stockpile injecting, onboard pre-wet, pre-wetting each truck load with spray bar, etc) to determine which method is most effective at delivering the best pre-treated product to the roadway.	Justin Droste, Michigan DOT	19
9	Assessing Snow Plow Weight and Function	$50,000	12 months	The purpose of this project is to develop a simple tool to analyze the loaded weights of snowplow trucks “on paper,” including all attachments and materials. The tool would support trade-off comparisons to help agencies make decisions about plow attachments and/or material carrying capacity, and provide guidelines for vehicle configurations based on desired LOS on certain types of roadways.	Tim Chojnacki, Missouri DOT	21
10	2015 Peer Exchange Funding	$45,000	12 months	This project would provide funding needed to put on the 2015 Winter Maintenance Peer Exchange in Minneapolis, Minnesota.	Patti Caswell, Oregon DOT	23

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#	Title	Est. Cost	Est. Duration	Project Summary	Presented by	Page
11	Understanding the Impact of Product Design Features on Winter Maintenance.	$100,000	12 months	The goal of this project is to evaluate certain design features, such as rumble strips and pavement markings, to determine their effects on winter maintenance and to recommend alternative designs where appropriate.	Patti Caswell, Oregon DOT	25
12	Assessing the Value of Residual Salt Left on the Road after Storm Events.	TBD	12 months	This project would attempt to determine the value (lb/ft) of the salt left over on the roadway after treating a storm event and how fast is it worn off by traffic.	Brandon Klenk, Utah DOT	27
13	Identification and Correction of Equipment Factors Causing Fatigue in Snow Plow Drivers	$200,000	24 months	This project would identify equipment factors causing snow plow driver fatigue, provide recommendations to reduce, eliminate or correct the equipment issues, develop cost/benefit data for each recommendation, and develop training materials	Allen Williams, Virginia DOT	29

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#	Title	Est. Cost	Est. Duration	Project Summary	Presented by	Page
14	Reducing Snow Plow Driver Fatigue by Modifying Human Behavior	$200,000	24 months	This project would confirm or reject the link between drivers' quality of rest and driver fatigue. If confirmed, the investigator would develop a series of training materials to help identify driver fatigue, improve driver rest, and relieve fatigue during operations.	Allen Williams, Virginia DOT	31
15	Basic Snow Fighting Video	$75,000	12 months	The purpose of this project is to develop a video and guidebook that explains the latest innovative approaches and tools available to winter maintenance professionals and provides resources for learning more about them. The materials will cover chemicals, pavement sensors, RWIS, plow blades, etc. and will reference the latest state and national research. The goal is to encourage agencies to move from a basic level of snow and ice control to higher level of service.	Jeff Pifer, West Virginia DOH	33
16	Salt Brine Primer	$75,000 to $100,000	12 months	The purpose of this project is to develop a booklet or "primer" on best management practices for utilizing salt brines for snow removal and ice control (SRIC).	Jeff Pifer, West Virginia DOH	35
17	Electric Plug and Socket Connectors for Truck Mounted Accessories (Wing Plows)	$50,000 to $80,000		This project would determine the number of different setups for wing plow lights that are used by Clear Roads members. It would also determine if there are options that show success in keeping the lights operating for more than a month during all storm events. The goal would be to find a setup that is able to operate for an entire snow season.	Cliff Spoonemore, Wyoming DOT	37

2015 Research Proposal Form

Proposer name:
Organization:

Title of proposed research synthesis or project:
Understanding the relationship between various agency's resources (focusing on equipment availability) and ability to perform winter maintenance operations (WMO).

Topic Area?: ~~Methods~~ Equipment ~~Materials~~ Training Technology Safety

1) **Explain the specific problem or issue**.
   State transportation agencies are tasked with keeping people and business moving by operating and improving transportation systems, which is vital to taxpayers and communities. Winter maintenance operations are crucial to fulfill such a mission. However, these activities rely on a series of physical and human resources, including availability of qualified mechanic workforce, parts, and shop facilities. The availability of these human resources and physical assets affects in return equipment up-time and productivity of winter maintenance operations (WMO).

   To date, there is a lack of knowledge and understanding on how decisions on one of the upstream elements of this chain may affect WMOs. Winter maintenance administrators need tools that can help them manage the link between equipment uptime and productivity, explain the impact of decisions on the other chain links, and show what is the impact of not having mechanics or parts, or equipment on the level of service in WMO.

2) **What is the goal of the project?**
   The goals of the project are to: (a) identify existing practices and additionally available techniques that can be used by agencies to optimally allocate resources to various links of the winter maintenance operation chain; (b) develop a decision-making process that can be used by WMO administrators to implement the identified practices/techniques; (c) compile the research results in an easy-to-implement guide toolkit.

3) **Describe the expected products/deliverables of the research?**
   (a) A catalog of practices and techniques, including their review and analysis.
   (b) A decision-making process narrated through a case study that can be used by WMO administrators to implement the identified practices/techniques.
   (c) A guidebook that synthesizes the above deliverables into an easy-to-implement training document, which is supported by Powerpoint presentations or video recorded webinar presentations.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
   - Survey domestic agencies and review international practices (and literature) to identify existing practices and additionally available techniques
   - Develop conceptual decision-making process
   - Identify case study for calibration and validation of process
   - Apply conceptual decision-making process to case study
   - Compile and publish the guide toolkit, including the printed Guidebook and supporting material (either Powerpoint or video presentations)

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
WMO administrators, including fleet managers, shop managers, and resource 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**.
The information gained from successful completion of this project will help WMO operators argue for appropriate allocation of resources to various links of the parts/mechanics/equipment/shop/operation chain.

During the question and answer part of a session at the 2014 TRB Annual Meeting (where preliminary results of the WSDOT study were presented), there was a wide consensus among attendees that often resources needed for WMO operations may be overlooked only at one of the chain links and still affect the overall agency's WMO effectiveness. This may potentially create budget misalignment scenarios where WMO operations are not as effective as they could be.

7) How will you measure the success of this project?
If states adopt the decision making process to allocate resources to improve equipment availability and level of service of WMO and if the Guidebook that this project produces is adopted.

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

9) **Estimated timeline for completing the research.**
- Six (6) months _____
- Twelve (12) months _____
- Eighteen (18) months __X___
- Other: _____ months

10) Are you aware of any similar or related research on this topic? If so, please list below.

WSDOT recently completed a pilot case study on a related topic, which aimed at analyzing the impact of building failures on WSDOT operations. As part of that study, a simple exercise was performed to analyze how failures of a major mechanic shop facility in Seattle could affect WSDOT Roadway Snow and Ice Control (RSIC) Operations. The results of that study were published in both a WSDOT report, a paper presented at the 2014 TRB Annual Meeting and an article published on the 2014 Transportation Research Record. However, that study was focused on the building chain link and did not include parts and mechanics in the analysis.

CLEAR ROADS
research for winter highway maintenance

2015 Research Proposal Form

Proposer name: David Wieder, Bill Pentek
Organization: Colorado Department of Transportation

Title of proposed research synthesis or project:
Research options for bi-fuel and/or blended fuel diesel/CNG for snow fighting type equipment including but not limited to class 7 and class 8 plow trucks, loaders up to 5 yards capacity, motor graders and snow blowers.

Topic Area: Methods **Equipment** Materials Training **Technology** Safety

1) **Explain the specific problem or issue**.
We need to look at opportunities for bi fuel/blended fuel diesel engines in a heavy duty application. Currently there is not a bi fuel option only dedicated CNG or Diesel.

2) **What is the goal of the project?** Research options and solutions for a bi fuel or blended fuel (diesel and CNG) for use in heavy duty applications and equipment for snow removal on highway systems.

3) **Describe the expected products/deliverables of the research?**
Information on types of equipment with bi-fuel or alternate fuel systems available.
Information on any aftermarket retrofits available.
Determine timeframes that this technology may be developed and available.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
Conduct a literature and product search. This would most likely be an international search.
Collaborate all the different types of systems and equipment available in a matrix and describe the pros and cons of each system. This can include prototypes.
Provide fuel consumption comparisons between diesel only applications, blended fuel applications and bi fuel applications.

5) Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.
The intended audience will be upper and executive management at DOT's and municipalities. The deliverable will be a presentation including executive summary and recommendations for these types of fuel systems.

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.** Utilizing CNG as a bi fuel or blended fuel or other alternate fuels should lower emissions, decrease wear to the current emission controls currently on diesel engines. The use of CNG or other alternate fuels could help reduce emissions and help green government, as well as saving money.

7) **How will you measure the success of this project?**
The success will be measured by the material supplied and presented at the completion of the research of systems and equipment available. Further success will be adoption of alternate fuel technology in snow fighting fleets, reducing emissions and reducing fuel costs enabling DOT's to put those savings toward roads.

8) Estimated funding needed. ?

This synthesis shouldn't cost more than $50,000

9) **Estimated timeline for completing the research.**
   - Six (6) months _____
   - Twelve (12) months ___X__
   - Eighteen (18) months _____
   - Other: _____ months

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

2015 Research Proposal Form

Proposer name: Ron Wright
Organization: Idaho Transportation Department

Title of proposed research synthesis or project: Pacific Northwest Snowfighters (PNS)

Topic Area?: Methods **X** Equipment X Materials **X** Training Technology Safety

1) **Explain the specific problem or issue**.

The Pacific Northwest Snowfighters (PNS) is widely recognized as the premier deicer material research, testing, and product approval entity in North America. Many states and provinces rely on the PNS Specifications and Qualified Products List (QPL) as standards for accepting products for bid on contracts, and compliance of products to standardized material specification. Additionally, PNS is the visible and recognized clearinghouse for questions regarding deicer characteristics, and a primary sponsor of research into deicer performance for both agencies and manufacturers.

Clear Roads has previously sponsored the PNS with funding to conduct quality assurance testing of QPL candidate products, develop new product testing protocols, develop new product specifications and categories, and conduct associated product category testing. The PNS is the conduit by which new and innovative research test methods can be implemented into the current product purchasing of agencies.

Without a steady and reliable source of funding to continue the core mission, and to have a Pooled Fund Project assigned to it, the PNS could lose the ability to keep the specifications and the QPL viable as a standard for other states and provinces to rely upon. The PNS would begin to function solely as an unaffiliated association of States and Provinces.

2) **What is the goal of the project?**

The objective of this research is to support the continued work and knowledge of PNS in the realm of deicer product performance and characteristics. As a Pooled Fund effort, under the auspices of Clear Roads, research can be championed to identify environmentally benign alternatives to chlorides, best practices for deicer applications, innovations in corrosion inhibitor products, deicer enhancement products, and many other aspects of deicer technology.

As a sub-set of Clear Roads, PNS can also continue to produce updates to the QPL, field questions on deicer products, and provide deicer testing specifications via an independent web site, and with a link within the Clear Roads site.

3) Describe the expected products/deliverables of the research?

This project will provide:

- Continuous analysis of needs within the realm of deicer technology and research.
- Technical and Knowledgeable review of ongoing deicer research.
- Identification of research entities equipped to perform deicer research, and their relative capabilities.
- Analysis of “best fit” products for any given region or climate.

- Continuously updated Product QPL, defining product categories, and updating testing specifications.
- Central clearinghouse for deicer related questions and concerns.
- Website updates and maintenance.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**

Continuous development of new products from end user defined needs promotes the asset of establishing product classifications for new and existing products based upon chemical and performance characteristics. Integral to this is the standardization of test methods to measure the products compliance to a baseline that is documented and made public for all users, manufacturers and public entities.

The project will maintain the consistent evaluation of products for the QPL, evaluate new test methods for implementation of products into proper classifications, and develop standards to promote independent evaluation of products.

- Prepare and/or review deicer material research problem statements.
- Determine timelines and budgets of approved research.
- Review proposals and recommend research entities to the larger group.
- Serve as the Technical Advisory Committee on deicer research.
- Review research updates and prepare status reports for the larger group.
- Troubleshoot research challenges and work closely with research entities.
- Review draft final reports and address shortcomings or inconsistencies.
- Provide comments to larger group on the research outcome, and recommend approval or rejection of final reports.
- Evaluate the need for further research and provide recommendations.

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

- All users of deicer products.
- Through the research analysis, testing, and comparison of deicer products so that winter maintenance managers can make educated decisions on which products are most suited to their specific needs.

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**.

To determine best-fit products for any given climate or geographical location, assess product specific environmental impacts, compare performance, and provide specific product characteristics and blends.

Provide an essential conduit between manufacturers capabilities and end user needs.

Provide a common basis for products to be prequalified and examined for deicing properties and classification.

Reduce the risk of purchasing products with unknown issues that could result in negative impacts for a failure to perform during a winter event.

7) **How will you measure the success of this project?**

Currently the PNS QPL is growing in the number of agencies requirements not only including DOT's but extending to County, Local and Private Groups.

8) **Estimated funding needed.**
TBD- Estimate $30,000 including the cost of website maintenance for three years. (Dependent upon website maintenance and upgrade requirements.)

9) **Estimated timeline for completing the research.**
- Six (6) months _____
- Twelve (12) months _____
- Eighteen (18) months _____
- Other: __36___ months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**

2015 Research Proposal Form

Proposer name: Tim Peters
Organization: Illinois Department of Transportation

Title of proposed research synthesis or project:
Comprehensive Study on Contracting Snow and Ice Response

Topic Area: **Methods** Equipment Materials Training Technology **Safety**

1) **Explain the specific problem or issue.**
   A number of state DOTs have outsourced some or all snow and ice response to private contractors. The purpose of this study is to document the costs, benefits, issues and concerns associated with using private contractors to preform snow and ice control functions.

2) **What is the goal of the project?**
   The goal of this project is to analyze and document state efforts to privatize snow and ice control.

3) **Describe the expected products/deliverables of the research?**

The expected products are:

- A listing of states that are currently contracting snow and ice functions to the private sector.
- An analysis of costs and cost trends associated with contracting snow and ice functions.
- In addition to costs, the research should document privatized function and the report should consider contracting approaches (pay per season vs. pay per hour).

The report should attempt to answer questions including:

- What types of response are contractors best suited for?
- Are there areas where contractors are more viable? i.e. rural vs. urban.
- What types of contracting methods, quality control measures, and incentives have been used in privatized snow and ice functions?
- Does the magnitude of a storm have any effect on contracted responses? (Are private contractors more or less effective large and small events)
- Are there any specific lessons learned from the winter of 2014-2015 where large snow falls hit in the northeast, where contracted snow and ice operations by states and municipalities is common?
- Are there any quantifiable differences in the safety record of contractors vs. public sector crews operating in similar conditions and similar areas?

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**

- Develop a survey form or other approach to gathering data
- Gather data (including follow-up with users)
- Data analysis
- Report development
- Final presentation

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
   State DOTs and other operators of large highway assets (turn pike and toll high way authorities).

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 research can help state DOT's who may decide to contract for snow and ice operations.

7) **How will you measure the success of this project?**
The measure of success will be based on the level of completeness of information on contracting and if best practices and standards for contracting snow and ice operations can be identified.

8) **Estimated funding needed.**
$75,000

9) **Estimated timeline for completing the research.**
- Six (6) months _____
- **Twelve (12) months __X___**
- Eighteen (18) months _____
- Other: _____ months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
This has been a topic of discussion, but I am not aware of specific published research.

2015 Research Proposal Form

Proposer name: Tim Peters
Organization: Illinois Department of Transportation

Title of proposed research synthesis or project: Tow Plow Safety Analysis

Topic Area?: Methods **Equipment** Materials Training Technology **Safety**

1) Explain the specific problem or issue.

   Tow plows are a relatively new approach to clearing highways. The purpose of this project is to analyze their safety and to document the best practices used by agencies using them.

2) What is the goal of the project?

The goal of this project is to analyze and document the safety of tow plows and to compare it to other methods of accomplishing the same thing, (i.e. two trucks, or wing plows). How many accidents per lane mile plowed do tow plows have relative to other approaches to plowing?

3) Describe the expected products/deliverables of the research?

The expected products are:
A comparison of accidents per lane mile between conventional plowing methods and the tow plow.
A listing of safety practices related to the tow plow (lighting modifications, shadow vehicles, public service ad campaigns)

4) List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?

Develop a survey form or other approach to gathering data
Gather data (including follow-up with users
Data analysis
Report development
Final presentation

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

State DOTs who are using tow plows and those considering tow plows.

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 research will impact my organization make a decision on purchasing a tow plow. The research could identify best practices that would help improve safety

7) How will you measure the success of this project?

The measure of success will be based on the level of completeness of information on tow plows and practices among users.

8) Estimated funding needed.

$75,000

9) Estimated timeline for completing the research.
   - **Six (6) months _____**
   - **Twelve (12) months __X___**
   - **Eighteen (18) months _____**
   - **Other: _____ months**

10) Are you aware of any similar or related research on this topic? If so, please list below.

Individual states have analyzed tow plows in advance of their purchase on a cost benefit basis. I am not aware of an analysis that looked at their relative safety or comprehensive documentation of best practices related to tow plow use.

2015 Research Proposal Form

Proposer name: Paul Brown
Organization: MassDOT

Title of proposed research synthesis or project:
Synthesis of Best Practice for Material Application Methodology in Winter Operations

Topic Area: **Methods** Equipment **Materials** Training Technology Safety

1) **Explain the specific problem or issue**.
   A standard for anti-icing/deicing material application rates is needed, which recognizes current best practice, to include: efficient operations, environmental considerations, effectiveness, expense, and ease of operation. (the 5 “E”s)

2) **What is the goal of the project?**
   To research, evaluate, and deliver best practices in snow and ice fighting methodology based upon current practice and innovative solutions currently being developed.

3) **Describe the expected products/deliverables of the research?**
   A synthesis which will accurately and comprehensively describe the current state of practice and selected innovation and best practice for anti-icing/deicing material application for varied weather events, road types, traffic considerations, and environmental concerns.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
   A review of past and present research on this subject, investigation of recent trends and innovative practices being developed, and in depth interviews with industry experts in this field of study.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
   Highway maintenance agencies involved in winter operations delivery. No specific training is recommended. The synthesis in book form will be available to managers for review and guidance.

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 synthesis will provide a useful tool to winter ops managers to improve or adjust material application methodology and material selection.

7) **How will you measure the success of this project?**
   The end product should be a comprehensive and easy to understand synthesis of best practices in material application methodology based upon a well-researched and thoroughly disseminated review of current practice in this area. Widely held recognition of this synthesis as the definitive source of information on best practices for material applications across the 5 “E”s will be the ultimate gauge of success. (Similar to NCHRP Report 577 in the field material impacts to the environment)

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

9) **Estimated timeline for completing the research.**
   - Six (6) months _____
   - Twelve (12) months __X___
   - Eighteen (18) months _____
   - Other: _____ months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
   1) The Manual of Practice for an Effective Anti-icing Program – 1996
   2) NCHRP Report 526: Snow and Ice Control: Guidelines for Materials and Methods – 2004
   3) NCHRP Synthesis 344: Winter Highway Operations – 2005
   4) NCHRP Report 577: Guidelines for the Selection of Snow and Ice Control Materials to Mitigate Environmental Impacts – 2007
   5) Maine Winter Roads: Salt, Safety, Environment and Cost – A Report by the Margaret Chase Smith Policy Center – The University of Maine – 2010
   6) Performance Rating of De-icing Chemicals for Winter Operations – Barbara M. Gerbino-Bevins – University of Nebraska-Lincoln – 2011
   7) NCHRP Synthesis 449: Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment – 2013
   8) Establishing Effective Salt and Anti-icing Application Rates; A Clear Roads Study - 2015

2015 Research Proposal Form

Proposer name: Justin Droste
Organization: Michigan Dept of Transportation
E-mail address: drostej@michigan.gov

Title of proposed research synthesis or project:
Identifying successful practices for staffing winter operations

Topic Area (circle one): **Methods** Equipment Materials Training Technology

1) Explain the specific problem or issue.
Most winter agencies utilize permanent and temporary workers to perform winter maintenance. What is the appropriate ratio for winter staffing and what are the costs associated with each type of worker? (training, accidents, benefits, unions, salaries, effect on summer programs, etc). Other issues include shift schedules, overtime, and continuous working hours which causes fatigue and safety concerns.

2) List the proposed research objectives.
- Provide information on different classifications of operators, and associate costs per class across various parameters..
-Determine an optimum ratio of permanent to part time staff required to effectively perform winter operations to meet various levels of service.
-Determine generic shift schedules required to meet various levels of service (# of shifts, start/ stop times, overtime, etc).
- Utilize previous research on driver fatigue and shifts lengths to determine a universal standard for agencies to use as it pertains to maximum continuous working hours.

3) List the tasks that would form the scope of work.
- Literature search
- Survey other agencies (states, countries).
- Create a report and presentation for sharing the information on staffing costs, and optimum staffing levels per LOS.
- Provide a universal standard, based on sound research, for implementing a universal maximum continuous shift length for operators for clear roads to endorse.

4) Describe the expected outcomes or products/deliverables of the research? Who is the intended audience for the products/deliverables?

-A better understanding of costs associated with using full time and permanent workers will help aide managers to more effectively set the operations. Providing a maximum shift length recommendation will help supervisors and managers realize what limits are acceptable, and backed by clear roads.

5) How would the products/deliverables be implemented? How would they benefit DOTs?

-Findings can be utilized by state agencies to promote regional/ district levels to influence/ improve staffing practices and provide consistency statewide. A recognized maximum shift length (continuous

work hours) could help state agencies instrument policies in their state which are universal across the nation.

6) Estimated funding needed. $____100,000_____

7) Estimated timeline for completing the research.

- **Six (6) months _____**
- **Twelve (12) months _X____**
- **Eighteen (18) months _____**
- **Other: _____ months**

8) Are you aware of any similar or related research on this topic? If so, please list below.
The driver fatigue study, and true costs associate with winter maintenance project should be beneficial.

Submit proposal to:
Colleen Bos at colleen.bos@ctcandassociates.com
Call (608) 577-4805 or e-mail with questions.

2015 Research Proposal Form

Proposer name: Justin Droste
Organization: Michigan Dept of Transportation
E-mail address: drostej@michigan.gov

Title of proposed research synthesis or project:
Determining the best methods for Pre-wetting Salt

Topic Area (circle one): **Methods** Equipment Materials Training Technology

1) Explain the specific problem or issue.
There are currently many methods to mix or pre-treat dry rock salt (including but not limited to stockpile injecting, onboard pre-wet, prewetting each truck load with spray bar, other). Which method is most effective in delivering the best pre-treated product to the roadway. What are positives and negatives of each method? What are the most accepted methods for pre-wetting salt?

2) List the proposed research objectives.
- Identify all current practices for pre-treating salt.
-Picture inventory of equipment used.
- Evaluate each method to test various sample moisture content/ composition to judge uniformity and optimal composition.

3) List the tasks that would form the scope of work.
- Literature search
- Survey other agencies (states, countries).-field/ lab test methods and results.
- Create a report/ graphics summarizing results and recommendations and associated costs to implement each practice.

4) Describe the expected outcomes or products/deliverables of the research? Who is the intended audience for the products/deliverables?

-Expect to receive a field guide/ manual, for supervisors and management to use in developing treatments plans for garages.

5) How would the products/deliverables be implemented? How would they benefit DOTs?

-These informational guides can be used for training purposes, and provide substance for decision makers to implement a BMP for pre-wetting salt. This could allow regions/ districts, or statewide operations to become more uniform, and be confident that they are optimizing effectiveness.

6) Estimated funding needed. $____100,000_____

7) Estimated timeline for completing the research.

- **Six (6) months _____**
- **Twelve (12) months** _X____
- **Eighteen (18) months _____**
- **Other: _____ months**

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

Submit proposal to:
Colleen Bos at colleen.bos@ctcandassociates.com
Call (608) 577-4805 or e-mail with questions.

2015 Research Proposal Form

Proposer name: Tim Chojnacki
Organization: Missouri DOT

Title of proposed research synthesis or project:

Topic Area?: Methods **Equipment** Materials Training Technology Safety

1) **Explain the specific problem or issue**.
In an effort make snowplow trucks as versatile as possible, owners have expanded the types of materials carried on and the number of various plow attachments on their snow plow trucks. This versatility comes at a cost with regard to additional weight of the truck. It is possible to exceed the gross vehicle weight rating (GVWR) of a plow truck when it is loaded with snow and ice chemicals. In order to operate below the GVWR, provisions must be made so the operators can easily tell how much material to load. The question becomes, is it more advantageous to carry a full load of chemicals, or have the various attachments available?

SNOW PLOW TRUCK

Photo courtesy of the North Dakota Department of Transportation

2) **What is the goal of the project?**
The goal of this project would be to explore this issue with equipment manufacturers, operators and owners to see if there are any best practices available for quickly assessing the weight of plow trucks (barring weighing every truck). Owners could analyze the options "on paper" before ordering new trucks to ensure they have selected the best configuration for their application. Owners could also analyze existing fleet to determine appropriate use.

3) **Describe the expected products/deliverables of the research?**
The expected outcomes would be a simple tool to analyze loaded weights of snow plow trucks, some trade-off comparisons for owners to use to make decisions about plow attachments and/or material carrying capacity and guidelines for vehicle configurations based on desired LOS on certain types of roadways.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
   1) Literature search
   2) Possible survey of manufacturers and owners
   3) Share or develop a tool for owners to use to assess existing and new equipment.
   4) Recommend guidelines for owners

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
   Fleet managers and Operations managers would benefit from having this type of data available. The information will be used to help make purchasing decisions for vehicles and attachments. Training should be minor, however, assumptions and Inputs will need to be addressed and communicated with the audience.

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 deliverables would give DOTs a tool for analysis of their fleet and recommendations on truck configuration. It will improve our operations by helping us ensure we are using the right equipment configuration for the facilities we operate on.

7) **How will you measure the success of this project?**
   The success of this project will be determined by the number of states or agencies that use the deliverables.

8) **Estimated funding needed.**
   $50,000

9) **Estimated timeline for completing the research.**
   - Six (6) months _____
   - Twelve (12) months __X___
   - Eighteen (18) months _____
   - Other: _____ 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

2015 Research Proposal Form

Proposer name: Patti Caswell
Organization: Oregon Department of Transportation

Title of proposed research synthesis or project: Peer Exchange Support

Topic Area?: Methods Equipment Materials **Training** Technology Safety

1) **Explain the specific problem or issue**.
Clear Roads supports attendance of member states at the Fall biennial peer exchange.

2) **What is the goal of the project?**
To promote attendance at the Peer Exchange to enable sharing of research results and hear how other states have been implementing Clear Roads research, and learn of new research ideas that may be promoted through Clear Roads.

3) **Describe the expected products/deliverables of the research?**
List of research ideas from Peer Exchange breakout sessions with popularity ranking.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
Clear Roads uses the results of the breakout sessions to aid in developing research ideas to pursue.

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**.
Clear Roads will hear success stories, and problems states have experienced in implementing research that has emanated from Clear Roads. This will help shape future projects with consideration for implementation issues.

7) **How will you measure the success of this project?**

8) **Estimated funding needed.**
$45,000

9) **Estimated timeline for completing the research.**
- Six (6) months _____
- Twelve (12) months __X___
- Eighteen (18) months _____
- Other: _____ 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

2015 Research Proposal Form

Proposer name: Patti Caswell
Organization: Oregon DOT

Title of proposed research synthesis or project: Understanding the Impact of Product Design Features on Winter Maintenance

Topic Area?: **Methods** **Equipment** Materials Training Technology Safety

1) **Explain the specific problem or issue**.
Project design features should be maintainable in all seasons, however some design features either are difficult to maintain or conflict with current winter maintenance strategies.

2) **What is the goal of the project?**
The goal of this project would be to evaluate certain design features such as rumble strips and pavement markings, to determine necessary winter maintenance effects and to recommend alternative designs. For example—if durable striping is necessary what are the winter maintenance challenges (certain plow blade required to minimize damage?) and the ability to meet winter Level of service. If rumble strips are recommended/required in a snow zone based on traffic safety, is there a design alternative or equipment that should be considered to improve winter maintainability?

3) **Describe the expected products/deliverables of the research?**
List of certain design features and preferred alternatives, design modifications, or equipment/equipment modifications that would improve maintainability.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
Evaluate current design standards for a few highway features such as pavement markings and rumble strips. Field test maintenance of features and assess: impacts to features (e.g., pavement markings diminished), type of equipment that has least impact to feature and evaluate winter maintenance results (e.g., great job keeping pavement marking intact, but lousy job clearing snow). Develop recommendations for design and equipment to improve maintainability of certain features.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
DOT maintenance crews/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**.
Would benefit DOTs by improving design to consider winter maintenance and performance of material/design in winter maintenance, and maintainability of highway features for safety.

7) **How will you measure the success of this project?**
At least two design features are evaluated and recommendations made are implementable.

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

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

- Six (6) months _____
- **Twelve (12) months x**
- Eighteen (18) months _____
- Other: _____ months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
Similar concept proposed in 2013 peer exchange around the AASHTO Green Book—expand green book to consider ease of maintenance as part of sustainability—designs should be practical to maintain in all seasons.

CLEAR ROADS
research for winter highway maintenance

2015 Research Proposal Form

Proposer name: Brandon Klenk
Organization: UDOT

Title of proposed research synthesis or project: Assessing the Value of Residual Salt Left on the Road after Storm Events

Topic Area?: **Methods** Equipment **Materials** Training Technology Safety

1) **Explain the specific problem or issue.** Is there value in the residual salt left on the roadway after a storm event?

2) **What is the goal of the project?** To see if there is benefit in pretreatment activities of residual salt.

3) **Describe the expected products/deliverables of the research?** What is the value (lb/ft) of the salt left over on the roadway after treating a storm event and how fast is it worn off by traffic.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?** Measure salt left on road after storm event. Measure how fast it's worn off the road due to traffic.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.** Maintenance stations pretreatment programs. No training would be needed just charts for information.

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**. If there is value in the left over salt, it could reduce the amount of material used in pretreatment for storm events occurring in close proximity. Would be able to save money in both time and material usage.

7) **How will you measure the success of this project?** If it's determined there is value in the residual salt and if so, usable charts that can be used to determine pretreatment strategies.

8) **Estimated funding needed. ??**

9) **Estimated timeline for completing the research.**
   - Six (6) months _____
   - Twelve (12) months __X___
   - Eighteen (18) months _____
   - Other: _____ 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

2015 Research Proposal Form

Proposer name: Allen Williams
Organization: VDOT

Title of proposed research synthesis or project:
Identification and Correction of Equipment Factors Causing Fatigue in Snow Plow Drivers

Topic Area: Methods **Equipment** Materials Training Technology **Safety**

1) **Explain the specific problem or issue.**
Snow plow drivers experience a number of factors which cause them to fatigue during winter operations. Fatigued drivers are at greater risk for crashes, less productive and make less than desirable decisions.

2) What is the goal of the project?
The project will identify equipment factors causing fatigue and make recommendations to reduce, eliminate or correct those factors.

3) Describe the expected products/deliverables of the research?
The final product would be a series of identified equipment factors causing snow plow driver fatigue and provide recommendations to reduce, eliminate or correct the equipment issues. The investigator should develop a cost/benefit for each recommendation. Depending on the recommendation, the investigator may need to develop training or instructional materials.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
Building on the research completed in the project Environmental Factors Causing Fatigue in Snow Plow Drivers, Virginia Tech Transportation Institute (VTTI) (2014):
   a. Conduct a national and international Literature Review of the subject,
   b. Evaluate the survey data from the previous research project and assess the need for additional surveys or interviews to identify potential equipment issues,
   c. Investigate the degree to which each of the factors cause fatigue during winter operations,
   d. Determine recommendations to address the issues identified,
   e. Develop cost/benefit data for each recommendation,
   f. Develop the training and/or instructional materials for each recommendation.

5) **Who is the intended audience for the products/deliverables?**
Identify training needed and describe the use of products/deliverables. DOT Agency Management, field managers, field supervisors and equipment 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**.
The recommendations from this project when implemented would reduce the fatigue experienced by snow plow drivers during winter operations. Reducing the fatigue in drivers has shown to reduce accidents, improve production and improve decision making.

7) **How will you measure the success of this project?**
When implemented DOT's should show a decrease in accidents during winter operations, realize a decrease in operational time for comparable winter weather events and find fewer situations where bad decisions caused problems during winter operations.

8) **Estimated funding needed.**
$200,000

9) **Estimated timeline for completing the research.**
- **-** Six (6) months _____
- Twelve (12) months _____
- Eighteen (18) months _____
- **- Other: _24__ months**

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
Environmental Factors Causing Fatigue in Snow Plow Drivers VTTI (2014)

CLEAR ROADS
research for winter highway maintenance

2015 Research Proposal Form

Proposer name: Allen Williams
Organization: VDOT

Title of proposed research synthesis or project: Reducing Snow Plow Driver Fatigue by Modifying Human Behavior

Topic Area: Methods Equipment Materials Training Technology **Safety**

1) **Explain the specific problem or issue**. In the previous study on Snow Plow Driver Fatigue, the investigator found there was a probable link between drivers' quality of rest and fatigue during snow operations. Driver fatigue can be a major cause of accidents and low production.

2) **What is the goal of the project?** This project would confirm or reject the link between drivers' quality of rest and driver fatigue. If confirmed, the investigator would develop a series of training materials for managers and drivers to help improve the quality of rest for drivers as well as practices managers can use during operations to identify and relieve the fatigue in drivers.

3) **Describe the expected products/deliverables of the research?** The investigator would provide a report first confirming or rejecting the link between drivers' quality of rest and driver fatigue during winter operations based upon field research with a statically significant sample of snow plow operators. The investigator would develop training guides, DVD's and classroom training materials for managers and drivers to improve drivers' behavior to get better quality of rest before and during winter operations, identify fatigue during operations and techniques/practices to relieve fatigue during operations.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
    a. Investigator shall build off of the work by Virginia Tech Transportation Institute to perform a literature search nationally and internationally,
    b. Investigator shall conduct field research of a statically significant number of snow plow drivers to confirm or reject the link between driver rest and driver fatigue. Provide a detailed report of the findings from the field research,
    c. If confirmed, the investigator shall develop training materials to reduce driver fatigue, identify driver fatigue and develop techniques/practices to relieve fatigue during operations.

5) **Who is the intended audience for the products/deliverables?** Identify training needed and describe the use of products/deliverables. DOT field management, snow plow drivers and senior management in setting practices to provide drivers the greatest opportunities for quality rest.

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 findings of this research and subsequent training materials will provide DOTs with the resources to reduce fatigue in snow plow drivers during winter operations. Field managers and drivers will have the ability to identify fatigue during operations and

have the tools alleviate the fatigue. This will reduce accidents caused by driver fatigue and increase productivity as drivers will be more alert thus making better decisions.

7) **How will you measure the success of this project?** A reduction in the number of accidents involving snow plow drivers during winter operations and increased productivity during operations.

8) **Estimated funding needed. $200,000**

9) **Estimated timeline for completing the research.**
   - Six (6) months _____
   - Twelve (12) months _____
   - Eighteen (18) months _____
   - Other: ___24 months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
Environmental Factors Causing Fatigue in Snow Plow Drivers – VTTI (2014)

2015 Research Proposal Form

Proposer name: Jeff Pifer
Organization: West Virginia DOT

Title of proposed research synthesis or project: Basic Snow Fighting

Topic Area?: Methods **Equipment** Materials Training Technology **Safety**

1) Explain the specific problem or issue.

There are many new and innovative approaches and tools available to winter maintenance professionals. A simple comprehensive video and guidebook that explains these tools and provides references to past Clear Roads Projects, TRB reports, state research reports, APWA articles for agencies that want to improve their level of service. This information is widely scattered.

2) What is the goal of the project?

The goal of this project is to develop a video and guidebook that highlights existing resources explaining the tools that can help agencies move from a basic level of snow and ice control to higher level of service. The emphasis of this project is basic technologies including the use of salt brine for anti-icing and deicing applications.

3) Describe the expected products/deliverables of the research?

The products are a video 10-15 minutes in length and a guidebook.

The technologies covered include:

Chemicals, Liquid chemicals (heavy emphasis on salt brine), Pavement Temperature Sensors, Pavement Specific Weather Forecasts, RWIS, Advanced Plows and Plow Blades, and other techniques and equipment as determined by the project TAC. The focus should be on moving from basic snow and ice operations to more advanced technologies and techniques.

The guidebook will describe these snow fighting tools and describe their advantages over basic snow fighting techniques. It will provide references to past Clear Roads Projects, TRB reports, state research reports, Aurora research on RWIS, and APWA and other magazine articles for agencies that wish to explore these techniques in detail. Among the projects they should highlight is the Clear Roads Cost Benefit Analysis Toolkit, which agencies can use to analyze these tools.

The emphasis of this project is not new research, it is highlighting best practices, cataloging and organizing existing information, and presenting it a logical tiered format with a video that can stimulate an interest and a guidebook that can link agencies to key references and resources to allow them to make good decisions.

4) List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?

Perform a literature and resource search for primary chemicals, liquid chemicals (heavy emphasis on salt brine), pavement temperature sensors, pavement specific weather forecasts, RWIS, advanced plows and plow blades, and other techniques and equipment as determined by the project TAC.

Develop a guidebook that provides a basic summary of the technologies and a list of additional resources, and information necessary to implement these technologies. The list of resources should be organized in a manner that it highlights basic items first and moves to more detailed studies and then theoretical research. The focus should be on helping agencies moving from a basic level of service to a higher level of service.

Finally the team would develop a video to showcase this work and help to market the guidebook to winter maintenance professional and organizations.

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

State DOTs and local units of government responsible for snow and ice control.

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 research will impact agencies snow and ice control by providing a single reference that can help them integrate new technologies and move to a higher level of service.

7) How will you measure the success of this project?

The measure of success will be based on the level of completeness of information and the acceptance and use of the guide by agencies.

8) Estimated funding needed.

$75,000

9) Estimated timeline for completing the research.
- **Six (6) months _____**
- **Twelve (12) months __X___**
- **Eighteen (18) months _____**
- **Other: _____ months**

10) Are you aware of any similar or related research on this topic? If so, please list below.

This project should highlight existing research and resources. It is focused on cataloging and marketing existing research.

2015 Research Proposal Form

Proposer name: Jeff Pifer
Organization: WVDOH

Title of proposed research synthesis or project: Salt Brine Primer

Topic Area: **Methods** Equipment **Materials** Training Technology Safety

1) **Explain the specific problem or issue**.
Salt brine best management practices.

2) **What is the goal of the project?**
Review the current practice among various agencies utilizing salt brines for snow removal and ice control (SRIC), compile the data, and produce a set of best management practices.

3) **Describe the expected products/deliverables of the research?**
A thorough primer "booklet" of best management practices for the use of salt brines for SRIC.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
Survey agencies utilizing salt brine, perform follow up interviews as needed, review and compile data, generate final salt brine BMP's booklet.

5) **Who is the intended audience for the products/deliverables? Identify training needed and describe the use of products/deliverables.**
Any agency currently utilizing or wanting to start utilizing salt brine for SRIC. BMP's booklet would be available for distribution to interested agencies.

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**.
Some agencies have a depth of knowledge with salt brines; others are still on the fence or new to the game. This research would provide a baseline for all agencies utilizing or interested in utilizing salt brine.

7) **How will you measure the success of this project?**
A product that provides for the confident use and management of salt brines for SRIC operations.

8) **Estimated funding needed.**
$75,000-$100,000

9) **Estimated timeline for completing the research.**
   - Six (6) months _____
   - **Twelve (12) months __X___**
   - Eighteen (18) months _____
   - Other: _____ months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
PennDOT has been working on a salt brine research project.

2015 Research Proposal Form

Proposer name: Cliff Spoonemore
Organization: WYDOT

Title of proposed research synthesis or project: Electric Plug and Socket Connectors for Truck Mounted Accessories (Wing Plows)

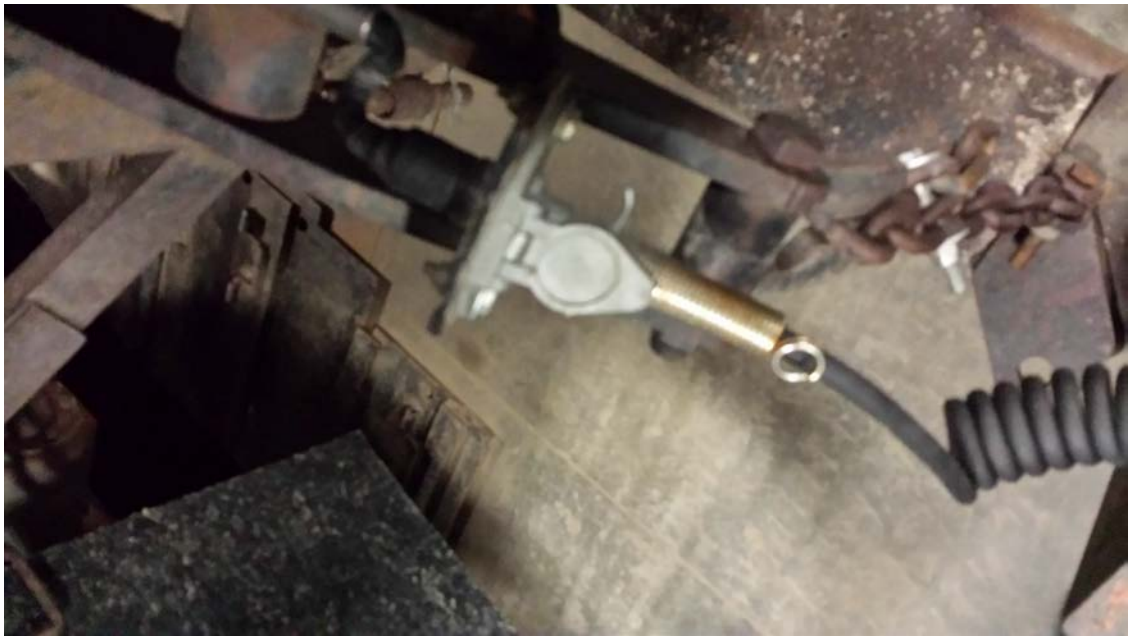
Topic Area?: Methods **Equipment** Materials Training Technology Safety

1) **Explain the specific problem or issue**.
Wing Plow lights have to be plugged into the truck. The connecting wiring harness (plug and socket) starts out solid but after the first 12 hour shift the connection begins to loosen up. This allows chemicals, abrasives and road material to enter the connection and begin to break it down. Mechanical/operator, environmental, or corrosion are issues that can cause light failure. The question is can or has the industry developed a connection that can survive the plowing environment for more than a month. Shop mechanics have more than enough repairs to handle without this small reoccurring electrical issue happening on a regular (monthly or sooner) basis.

2) **What is the goal of the project?**
A synthesis to determine the number of different setups that are used by Clear Roads members. Also determine if anyone or several options are showing success in keeping the lights operating for more than a month during all storm events. Find a set up that can operate for an entire snow season.

3) **Describe the expected products/deliverables of the research?**
The result could be a universal solution for all states to follow. The first deliverable would be a white paper type report on what the extent of the problem is and what solutions are being used by each state. This may lead to a future problem statement for additional research or a problem statement for the industry to develop a solution.

4) **List the specific research tasks that would form the scope of work, ie. What steps will the researcher need to take to develop the deliverables?**
A literature search to see if other environments are experiencing the same issue, ie, farmers with their equipment failing because of dirt and dust entering the connection. The Department of Defense (Navy) with the pounding from storms and salt water on connections exposed to the weather. This literature search may develop a catalog of weather resistant connections.



A collection of different types of connections from each Clear Road member state. With a brief explanation of the Pros and Cons of each connection. Each Clear Road state would have to provide a Point of Contact for the Principle Investigator (PI) to call upon to gain more knowledge of their specific connection.

This may not be limited to the connection assembly, but also any add on or fabrication done by the individual shops to protect the connection from the weather or the environment.

The PI would then organize the collected information into a Popular Mechanics type document listing the top 10 best connections. Listing Pros & Cons for each, purchase cost, installation cost, how long it is expected to last, and installation/replacement time, and any other interesting facts of the connection.

A suggested list of measureable items to be used in a Cost/Benefit analysis. A possible equation for the analysis.

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

This information would be for the State Equipment Supervisors or chief mechanics/operators that need to repair the equipment. Try to find the best connection that will last the longest in the winter weather environment. Mechanics do not mine repairing items that go bad but this product needs to last more than a month. The product should last a full season. This research is not intended to find a 10 year or life of the truck connection. Just one that will stay in service for at least a snow season (~ 6 months).

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**.
One can hope that there is a solution exists even if it is a very expensive electrical connection. A cost benefit analysis that shows a positive (greater than 1) rate of return may make this solution viable. The extra expense may far out weight the down time of just one truck at a single shop let alone the affect on an entire fleet. This would not only eliminate down time for electrical connections but it will also free up the mechanic to complete other repairs to keep a truck on the road.

7) **How will you measure the success of this project?**
This will depend on the granularity of the accounting or tracking system used by each State for vehicle maintenance. This will also be a part of the recommendations from the PI on how to collect the data and what data for a cost benefit analysis. It could be as simple as less vehicle down time in the shop over an entire snow season. Rather than a major cost savings traceable by software.

8) **Estimated funding needed.**
$50K - $80K if it was just a simple synthesis the cost would be the lower side. There could be more research time in the literature search and then the collection of the pictures and explanations from each state. Collating and evaluating each of those samples will take some time. The cost benefit analysis equation and items list for the analysis will take some time.

9) **Estimated timeline for completing the research.**
- Six (6) months _____
- Twelve (12) months __X___
- Eighteen (18) months _____
- Other: _____ months

10) **Are you aware of any similar or related research on this topic? If so, please list below.**
Recreational Vehicle websites - did not see any specifications

The above connection was caught under the wing plow. Not much you can do about this as it is operator protections that need to be improved. You can see some corrosion also.

Above: Add on wire protection tube. On the left is the plug and socket connector and it becomes loose after just one 12 hour shift. The plug and socket connections at both ends are replaced on average once every month. The receiving end seems to last longer. These are metal connections.

Whelen Lights mounted to a Shop fabricated bracket. These lights also become loose over time. Maybe just a matter of vehicle inspection. Then you cross the line of when is an operator allowed to work as a mechanic. If tightening these lights down is a mechanic's job then the truck is in the shop for repair and not on the road. Should this minor repair be completed by the operator, the truck is still down for a period of time and not in service.