**CR 19-04: Technical Requirements and Considerations for Automated Snowplow Route Optimization**

**CONTRACTING LANGUAGE TEMPLATE**

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# Introduction

Planning for snow and ice control (SIC) activities on the roadways before, during, and after winter weather events involves complicated decisions about staging and routing of the winter maintenance vehicles that are responsible for plowing and spreading chemicals and abrasives. DOTs and other transportation agencies are increasingly exploring automated methods for snowplow route optimization as a means for increasing the efficiency of these operations. Route optimization projects have been demonstrated to produce significant savings for transportation agencies when they result in the implementation of new routes.

The purpose of this document is to provide DOTs with a flexible template to assist with the development of RFPs for automated snowplow route optimization. The language suggested here is intended to ensure that DOTs and consultants/software vendors have a shared understanding of the scope of work that the DOT requires and to maximize the likelihood that the project will result in safe, feasible, implementation-ready routes. The accompanying Guidance Document provides a more in-depth description of the technical requirements for route optimization and the key decisions DOTs should consider when developing an optimization scope.

This document is organized to reflect the scope section of a hypothetical RFP and contains the following sections:

1. Project Description
   1. Optimization Purpose
   2. Optimization Scope
      1. Geographic Extent
      2. Optimization Scenarios
2. Data Needs and Sources
   1. GIS Road Network
   2. Winter Maintenance Fleet and Equipment
   3. Winter Maintenance Facility Locations and Service Territory Boundaries
   4. Existing Winter Maintenance Routes
   5. Winter Maintenance Operational Practices
3. Project Tasks
   1. Task 1. Project Launch Meeting
   2. Task 2. Data Acquisition and Preparation
   3. Task 3. Draft Route Optimization
   4. Task 4. DOT Route Review
   5. Task 5. Route Revisions
   6. Task 6. Comparison of Baseline and Optimized Routes
   7. Task 6. Final Report

Throughout this document, suggested contract language is shown in an inset text box:

This RFP is being issued by the {state DOT} for the purpose of developing optimized winter maintenance routes.

Curly brackets {} denote information that will vary by project and will need to be completed by the issuing DOT.

# Project Description

The project description provides an overview of the optimization project, covering essential points including the purpose of the optimization, how many scenarios are to be conducted, what structural component of the DOT’s winter maintenance plans should be included in the optimization, and the geographic area that the optimization will cover. The project description frequently includes an overview of the DOT’s winter maintenance goals and responsibilities. Providing access to the DOT’s winter maintenance plan or other policy documents that guide winter maintenance practice will give respondents to the RFP the opportunity to tailor their proposal to the DOT’s practices.

1. This RFP is being issued by the {state DOT} for the purpose of contracting for winter maintenance route optimization services.

## Optimization Purpose

The optimization purpose indicates whether cost-minimizing or service-time-minimizing routes will be sought. Software requirements are also provided regardless of the purpose chosen.

1.a. The purpose of this project is to develop new winter maintenance routes that minimize winter maintenance costs while successfully achieving the DOT’s winter maintenance performance targets. The optimized routes must be consistent with the DOT’s winter maintenance practices described below and in its Winter Maintenance Plan.

*OR*

1.a. The purpose of this project is to develop new winter maintenance routes that minimize winter maintenance service time using the currently available winter maintenance fleet. The optimized routes must be consistent with the DOT’s winter maintenance practices described below and in its Winter Maintenance Plan.

*OR*

1.a. The purpose of this project is to develop new winter maintenance routes that are consistent with the DOT’s winter maintenance practices described below and in its Winter Maintenance Plan. Optimized routes for {describe region} should minimize winter maintenance costs while successfully achieving the DOT’s winter maintenance performance targets. Optimized routes for {describe region} should minimize winter maintenance service time using the currently available winter maintenance fleet.

*AND*

1.a. continued: Minimum expectations for the optimization software used for this project are that it is capable of addressing the following elements of winter maintenance operations {include applicable features}:

* capacitated routing for material spreading,
* mixed winter maintenance fleets consisting of vehicles with differing material capacities and plow configurations,
* constraints on the winter maintenance vehicles that are compatible with differing road types,
* lane-specific routing, and
* turning behavior prohibitions and penalties.

The DOT’s Winter Maintenance Plan {and other relevant documents} can be accessed at {URL *OR* in Appendix X of this RFP}. Respondents are strongly encouraged to review these resources to identify any winter maintenance practices that may require modification to standard winter maintenance optimization approaches and highlight their capacity to address any identified issues in their proposal.

## Optimization Scope

The optimization scope details the geographic extent of the project and the optimization scenarios to be conducted. As described in the Guidance Document, the optimization scenarios that should be conducted depends on which components of winter maintenance operations can realistically be altered to improve winter maintenance efficiency.

### Geographic Extent

The optimization project can be conducted statewide or in a smaller pilot region.

1.b.i. This project shall cover all roadways maintained by the state. The state is responsible for winter maintenance on {##} lane miles. Existing routes utilize {##} winter maintenance vehicles routed from {##} winter maintenance garages.

*OR*

1.b.i. This project shall cover all roadways maintained by the state in {##} service territories located in {description of pilot territory locations}. In this region, the DOT is responsible for winter maintenance on {##} lane miles. Existing routes utilize {##} winter maintenance vehicles routed from {##} winter maintenance garages.

### Optimization Scenarios

The optimization scenarios specified in the RFP should describe the winter maintenance treatment type (plowing vs spreading) and weather severity combinations for which routes should be developed as well as whether facility locations, service territory boundaries, and fleet allocations should be included in the optimization. The scenario elements are presented separately below but should be combined into a set of comprehensive scenario descriptions.

1.b.ii. The consultant shall produce optimized routes for {XX} separate winter maintenance scenarios. These scenarios should create routes for:

*Treatment Type/Weather Severity*:

* Plowing only, with vehicles speeds used during typical winter weather
* Plowing only, with vehicles speeds used during severe winter weather
* Material spreading replicating the current material(s) applied, with vehicle speeds and material spreading rates used during typical winter weather
* Material spreading replicating the current material(s) applied, with vehicle speeds and material spreading rates used during severe winter weather
* Material spreading using an alternative material type, with vehicle speeds and material spreading rates used during severe winter weather
* Material spreading using an alternative material type, with vehicle speeds and material spreading rates used during severe winter weather

*Structural Components of winter maintenance – Facility Locations*:

* All winter maintenance facility locations shall be considered fixed in their current locations.
* A total of {# of locations} preselected locations for {winter maintenance facilities *OR* winter maintenance garages *OR* salt sheds *OR* a subset of facility locations} should be tested for improved efficiency in conjunction with the winter maintenance route optimization.
* The locations of {all winter maintenance facilities *OR* all winter maintenance garages *OR* all salt sheds *OR* a subset of facility locations} should be optimized in conjunction with the winter maintenance routes. All {described the locations that should be considered for new facilities, e.g.: all undeveloped land or all land in the state-owned right of way} should be considered for new facilities.

*Structural Components of Winter Maintenance – Service Territory Boundaries*:

* All service territory boundaries shall be considered fixed in their current locations.
* All service territory boundaries shall be optimized in conjunction with the winter maintenance routes.

*Structural Components of Winter Maintenance – Fleet Allocation*:

* The winter maintenance fleet allocation shall be considered fixed in its current configuration.
* The winter maintenance fleet allocation shall be optimized in conjunction with the winter maintenance routes.

# Data Needs and Sources

This section of the RFP should describe the data that will be provided by the DOT, the quality control and modifications that the consultant will be expected to provide for this data, and data that the consultant must collect as part of the project. If feasible, providing a sample of the GIS road network, winter maintenance fleet table, facility locations, and services territory boundaries will allow consultants to better assess the extent of the data preparation required for the project and more narrowly tailor their project budgets. Ideally, this data would be made available through an open-access portal for the respondent to download and review.

2. The availability and format of the data that is anticipated to be used for this project are described here. If additional data beyond what is presented here is required, the consultant should describe what other data is needed as well as how they would obtain this information.

## GIS Road Network

The RFP should provide a description of the existing road network if a sample or a link to the network GIS can not be provided. In either case, requirements for attributes of the improved road network should also be provided.

2.a. The DOT will provide a GIS road network for {all roads *OR* all state-maintained roads} in the {state *OR* pilot region} in {software file type, e.g., ESRI ArcGIS shapefile} format. The road network includes the following features {select applicable features *OR* omit if sample road network data provided}:

* Representation of individual travel and turn lanes as separate links
* Local roads that may be traversed by winter maintenance vehicles
* Median crossovers that can be utilized by winter maintenance vehicles
* Off-network areas requiring service by the winter maintenance vehicles included in the optimization
* Link attributes for each road segment documenting:
  + Functional classification and/or winter maintenance priority level
  + Winter maintenance vehicle travel speeds
  + Winter maintenance material spreading rates
  + Any restrictions on the winter maintenance vehicles compatible with each road/lane
  + Any restrictions on the material that can be applied
  + Any deviations from standard cycle time thresholds to account for known hazard areas
  + Pavement width

The consultant shall review the road network for completeness and accuracy and modify the GIS as necessary to include {select applicable features that are not included in the DOT’s GIS files}:

* Representation of individual travel and turn lanes as separate links
* Local roads that may be traversed by winter maintenance vehicles
* Median crossovers that can be utilized by winter maintenance vehicles
* Off-network areas requiring service by the winter maintenance vehicles included in the optimization
* Link attributes for each road segment documenting:
  + Functional classification and/or winter maintenance priority level
  + Winter maintenance vehicle travel speeds
  + Winter maintenance material spread rates
  + Any restrictions on the winter maintenance vehicles compatible with each road/lane
  + Any restrictions on the material that can be applied
  + Any deviations from standard cycle time thresholds to account for known hazard areas
  + Pavement width

*OR*

2.a. The consultant shall be responsible for acquiring a routable road network suitable for winter maintenance routing that includes all roadways that are the responsibility of {state DOT} for winter maintenance within the geographic extent of the project. The consultant shall review and modify the road network as necessary to include the following features:

* Representation of individual travel and turn lanes as separate links
* Local roads that may be traversed by winter maintenance vehicles
* Median crossovers that can be utilized by winter maintenance vehicles
* Off-network areas requiring service by the winter maintenance vehicles included in the optimization
* Link attributes for each road segment documenting:
  + Functional classification and/or winter maintenance priority level
  + Winter maintenance vehicle travel speeds
  + Winter maintenance material spread rates
  + Any restrictions on the winter maintenance vehicles compatible with each road/lane
  + Any restrictions on the material that can be applied
  + Any deviations from standard cycle time thresholds to account for known hazard areas
  + Pavement width

## Winter Maintenance Fleet and Equipment

The RFP should provide a description of the winter maintenance fleet and equipment table that is required if a sample is not provided.

2.b. The DOT will provide a tabulation of the winter maintenance vehicles available for routing. For each vehicle in the winter maintenance fleet, the following information will be recorded {omit if providing sample fleet table}:

* The maximum distance the vehicle can travel before refueling
* The vehicle’s material capacity for solids, liquids, or both
* The vehicle's compatibility with and access to tow plows or dedicated left-side plows that alter the number of lanes or the type of lane the vehicle can treat in a single pass (if used by the DOT) as well as how many of the plows are available
* The vehicle’s home depot or garage

The fleet tabulation will be provided in {file format, e.g. .doc or .csv} format.

*OR*

2.b. The Consultant shall coordinate with DOT supervisors to develop a tabulation of winter maintenance vehicles available for routing. For each vehicle in the winter maintenance fleet, the following information will be recorded:

* The maximum distance the vehicle can travel before refueling
* The vehicle’s material capacity for solids, liquids, or both
* The vehicle's compatibility with and access to tow plows or dedicated left-side plows that alter the number of lanes or the type of lane the vehicle can treat in a single pass (if used by the DOT) as well as how many of the plow are available
* The vehicle’s home depot or garage

## Winter Maintenance Facility Locations and Service Territory Boundaries

The RFP should provide a description of the winter maintenance facility locations where routes will begin/end and the service territory boundaries that are required if a sample is not provided. If the project includes vehicle reallocation, the maximum number of winter maintenance vehicles that can be based at each facility and the material storage capacity of the facilities may also be required.

2.c. The DOT will provide GIS files with the locations of all winter maintenance facilities {if vehicle reallocation is included in the optimization also add: the maximum number of vehicles that can be housed at each facility, each facility's material storage capacity,} and service territory boundaries in {software file type, e.g., ESRI ArcGIS shapefile} format.

*OR*

2.c. The DOT will provide {the address *OR* the latitude and longitude} of all winter maintenance facilities {if vehicle reallocation is included in the optimization also add: the maximum number of vehicles that can be housed at each facility, each facility's material storage capacity,} and service territory boundaries in {software file type, e.g., .doc} format.

*OR*

2.c. The consultant shall work with DOT staff to document the location of all winter maintenance facilities {if vehicle reallocation is included in the optimization also add: the maximum number of vehicles that can be housed at each facility, each facility's material storage capacity,} and service territory boundaries.

## Existing Winter Maintenance Routes

The RFP should provide a description of how information about the existing winter maintenance routes is recorded. Existing routes can be in a GIS or as turn-by-turn directions that are converted into GIS or replicated as in the optimization software. GIS versions of existing routes are preferred and will generally lead to lower project costs.

2.d. The DOT will provide a GIS of existing winter maintenance routes, including the winter maintenance vehicle travel speeds and route completion times in {file format} to support comparisons between existing routes and the optimized routes created for this project.

*OR*

2.d. The DOT will provide a text file of turn-by-turn directions for each existing route with identification of the territory or facility associated with the route. Vehicle travel speeds and route completion times will be included to support comparisons between existing routes and the optimized routes created for this project.

*OR*

2.d. The consultant shall work with DOT staff to document existing winter maintenance routes, including the winter maintenance vehicle travel speeds and route completion times, and shall create a GIS version of these routes to support comparisons between existing routes and the optimized routes created for this project.

## Winter Maintenance Operational Practices

The RFP should provide a description of the existing winter maintenance operational practices as described below.

2.e. The consultant shall review the DOT’s winter maintenance plan and work with DOT operations staff to document the following elements of winter maintenance operations so that they can be incorporated in the optimization {include all that apply}:

* Accurate winter maintenance vehicle operating speeds reflecting differences in operating speed by road class, mode of operation (deadheading, plowing, or spreading), and weather severity {if conducting multiple weather severity scenarios}
* Accurate material spread rates reflecting differences by road class and weather severity {if conducting multiple weather severity scenarios}
* Roadway prioritization and maximum allowable cycle time thresholds for all road classifications
* Restriction on the compatibility between roadways and vehicles/equipment to ensure that all roadways are treated by appropriately sized and equipped winter maintenance vehicles
* Turn restrictions and penalties so that safer/more efficient turning actions are used preferentially and unsafe turning actions are prohibited
* Treatment strategy for multilane highways, including the use of tow plows and wing plows which alter the number of winter maintenance vehicles needed to clear multiple lanes or limit the lanes that can be serviced by a specific vehicle. {If the DOT utilizes echelon plowing that should be explicitly noted here.}
* Treatment strategies for intersections, ramps, turn lanes, and roundabouts where lanes must be serviced in a specific order or where the equipment that is used deviates from that being used on adjacent road segments

# Project Tasks

## Task 1. Project Launch Meeting

The project launch meeting should ensure that there is a common understanding of the project expectations and work plan. It should include a review of the DOT’s winter maintenance plan to ensure that relevant operational considerations are captured in the optimization. The involvement of stakeholders at all levels of winter maintenance operations will help to ensure key operational considerations are not overlooked. Suggested participants include the project champion at the DOT, representatives of the DOT’s GIS or data management division, district supervisor(s), and one or more drivers from service territory(ies) where the optimization is being conducted. The role of DOT staff sharing data for Task 2 should also be reviewed.

3.a. The consultant shall convene a Project Launch Meeting in the first month of the project to review the project work plan and the DOT’s winter maintenance plan. The purpose of this meeting will be to ensure that all relevant operational considerations are captured in the optimization and to finalize the project work plan. The meeting shall include appropriate stakeholders responsible for the state’s winter maintenance and data management efforts, as identified by the DOT.

## Task 2. Data Acquisition and Preparation

During the data acquisition and preparation phase, the consultant should acquire and modify the data described in the “Data Needs and Sources” section of this template: the GIS road network, winter maintenance fleet tabulation, facility locations, service territory boundaries, and winter maintenance operational practices.

3.b. The consultant shall coordinate with the DOT to acquire data on the GIS road network, winter maintenance fleet, facility locations, service territory boundaries, existing winter maintenance routes, and winter maintenance operation practices to provide the starting point for data preparation. Once acquired, the consultant shall review these data for quality and completeness and make any necessary modifications described in the “Data Needs and Sources” section of this RFP or that are otherwise required for compatibility with the winter maintenance optimization software, the optimization scope, and the optimization scenarios.

## Task 3. Draft Route Optimization

For the route optimization task, the consultant will conduct the actual optimization and provide initial routes in an accessible format for the DOT to review. If multiple route optimization scenarios are being conducted, the DOT should consider completing Tasks 3, 4, and 5 for the simplest routing scenario and conducting the route optimization and route review for the additional optimization scenario after one scenario has been completed.

3.c. The consultant shall produce optimized routes for each of the scenarios described in the “Optimization Scenarios” section of this RFP. Optimized routes {and facility locations, service territory boundaries, and fleet allocations, if included in the optimization} shall be provided to the DOT for staff review in the following formats {select all desired formats}:

* Printable turn-by-turn directions in {file format, e.g., .doc or .pdf}
* GIS layer(s) of the routes
* Route files compatible with {navigation device type, e.g. Garmin, TomTom, or Navigon}. If the finalized routes are not compatible with this navigation system, the vendor should propose an alternative format for delivery that supports in-vehicle navigation.

## Task 4. DOT Route Review

During the DOT route review, supervisors and/or drivers should drive each of the routes produced for Task 3 to identify any safety issues or other technical problems that would prevent the implementation of the routes. The duration of this task should be long enough that all routes can be reviewed.

3.d. The DOT shall have {# of weeks} to test and review the initial routes. For each route, the DOT will identify any winter maintenance vehicle behaviors that are unsafe or incompatible with winter maintenance operational practices. The DOT will document where on the route these actions occur and provide a list of required revisions to the consultant.

## Task 5. Route Revisions

After DOT staff have completed the route review, the consultant should revise the initial routes to address the problematic vehicle behaviors identified during the review process.

3.e. The consultant shall modify the optimized routes to address all winter maintenance vehicle behaviors that the DOT identifies as unsafe or incompatible with winter maintenance operational practices. Revised routes shall be provided to the DOT in the following formats {select desired formats}:

* Printable turn-by-turn directions in {file format, e.g., .doc or .pdf}
* GIS layer
* Route files compatible with {navigation device type, e.g. Garmin, TomTom, or Navigon}. If the finalized routes are not compatible with this navigation system, the vendor should propose an alternative format for delivery that supports in-vehicle navigation.

## Task 6. Comparison of Existing and Optimized Routes

Once routes have been finalized, the consultant should compare the optimized routes to the existing routes in order to quantify the changes in cost and performance that would result from utilizing the new route system.

3.f. The consultant shall detail the overall cost and/or service time savings relative to exiting winter maintenance routes and provide a breakdown of savings by garage included in the optimization project. Other indicators of improved performance, such as reductions in deadheading or left turns should also be noted.

## Task 7. Final Report

The project's Final Report should document the development of the optimized routes and the cost/service time savings that these routes produce relative to the existing winter maintenance routes documented in Task 2. Demonstrated cost/service time savings can be a key factor for making the case for implementation.

3.g. The consultant shall produce a narrative final report describing the route optimization process and results. The report shall detail the overall cost and/or service time savings relative to exiting winter maintenance routes and provide a breakdown of savings by garage included in the optimization project.

In addition to the final report, the consultant shall provide electronic copies of the final input files used in the optimization including the finished routable road network, the route system GIS, and the final vehicle table.