



ADAPTIVE ROUTE OPTIMIZATION (ARO)

System Requirements Specification

This project supports improved winter operations by developing a Concept of Operations and a System Requirements Specification for ARO.

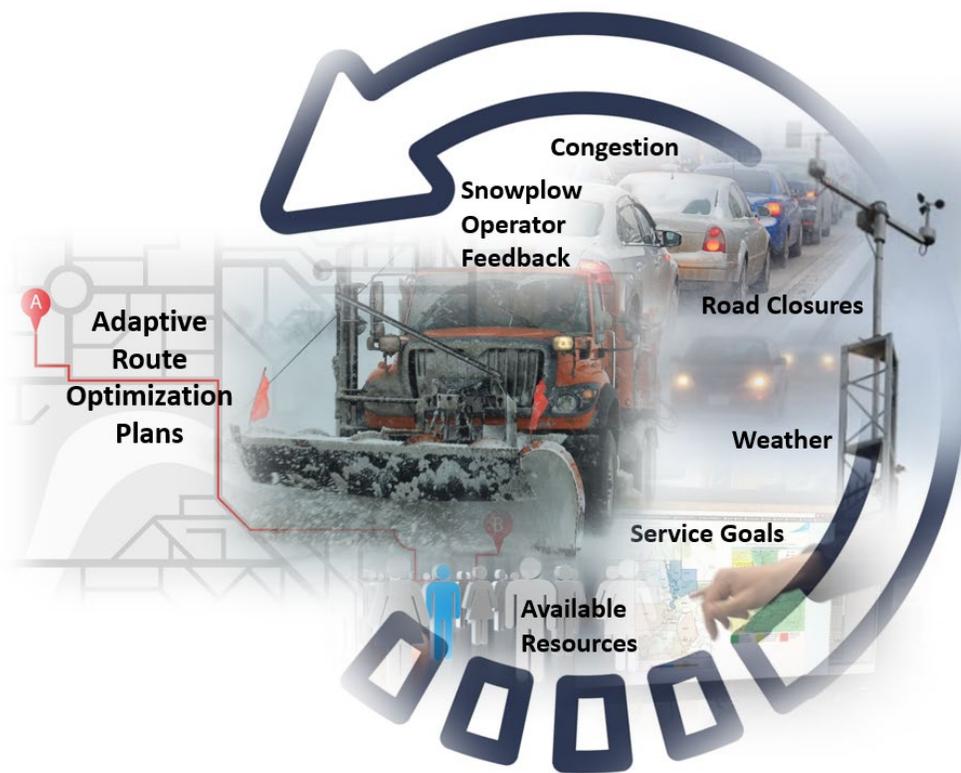
Introduction to ARO

Adaptive route optimization (ARO) is a method of dynamically and effectively routing winter maintenance vehicles across all segments of a road network to meet an agency's maintenance objectives. Agencies using ARO can develop more efficient routing plans that make the most use of staff time, materials, and equipment.

ARO systems incorporate real-time and historical data in a snowplow routing solution for agency maintenance and operations during adverse winter weather. The solution will support a strategic view for maintenance planning and also a tactical view for real-time operations.

ARO systems include agency level of service goals, route and segment priorities, cycle time expectations, and roadway conditions.

Current (real-time) inputs include atmospheric weather, road weather, incidents, work zones, and traffic volumes. Optimized snowplow routing also considers risk in terms of historical crash data, recurring problem areas, and historical weather patterns. Routing also requires inputs on maintenance vehicle access to facilities, turnarounds,



Source: FHWA.

U-turns, intersection snow clearing maneuvers, and deadheading (occurs when the truck travels on a road segment without plowing or spreading material).

Snowplow routing should be dynamic—given that intense weather events are becoming more frequent—and each agency has its own goals and challenges in getting roadways back to pre-storm levels of service. Furthermore, results for a specific segment of roadway depend on factors such as the type of storm and precipitation, timing of operations, and the appropriate treatment types.

Although snowplow routing can be complex, improved efficiency in routing will lead to improved safety for motorists and agency staff.

Federal Highway Administration (FHWA) Provides ARO Resources

To support improved winter operations, FHWA created a *Concept of Operations* (FHWA-HOP-22-004) and a *System Requirements Specification* (FHWA-HOP-22-029) for ARO. The *Concept of Operations* describes the characteristics of a proposed ARO system from the viewpoint of key winter maintenance stakeholders. The *Systems Requirements Specification* serves as an agency resource to help stakeholders understand how to incorporate real-time and historical data toward developing an ARO solution.

Minimum System Requirements for ARO

Since ARO is dynamic, it generates the most effective routing plans for winter maintenance vehicles, with inputs such as agency maintenance objectives, along with current weather, traffic, and resource constraints. Adapting to conditions requires data, information, and basic functionality that agencies need to understand, plan for, and then be able to provide for the system to “adapt” winter operations to varying resource and weather conditions.

At a high level, implementation of an ARO requires:

- Routable roadway network.
- Snowplow truck fleet equipped with automatic vehicle location.
- Driver interface monitor for routing and feedback.
- Supervisor interface monitor for management.

At the agency level, an ARO requires:

- Maintenance resources (e.g., vehicles, drivers, facilities, materials) allocated by services areas.
- Vehicle locations en route (i.e., to receive telematics data).
- Traffic conditions (e.g., incidents, work zones, closures, traffic speeds, and volumes).
- Winter operations treatment plans.
- Atmospheric weather conditions (e.g., precipitation type and rates and temperature).
- Road weather conditions (e.g., pavement status, pavement temperature, and friction).

Non-Binding Contents

The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies. While this document contains nonbinding technical information, agencies must comply with all the applicable statutes and regulations.



Source: FHWA.

Benefits

ARO can enable agencies to respond more quickly and efficiently than possible with current routing systems to changing storm conditions, resource constraints, and service expectations. For example, ARO can improve agency response through:

- Optimizing snowplow routes with reallocation of plowing resources among maintenance facilities and regions.
- Adaptively optimizing routes to changing weather conditions while treatment cycles are underway.
- Tactically reoptimizing snowplow patrols around active incident sites and the resulting congestion.

A successful ARO system implementation can lead to faster restoration of clear pavement, safer roadway conditions for the traveling public, and improved mobility under winter driving conditions. As a related benefit, an ARO implementation facilitates more complete and timely views of operations and winter maintenance activities across the road network. This information will improve awareness within and across the transportation agency and will enable timelier and more effective communications with the public.

ARO can improve human and equipment resource use. Improved routing could reduce total route miles and deadheading, which, in turn, would improve operator satisfaction and morale. Better knowledge of, and refined routing for, planned storm conditions could potentially result in less materials required relative to nonoptimized routing.

Summary

Specific to winter conditions, State departments of transportation currently spend over \$2 billion per year on snow and ice control and over \$5 billion per year on infrastructure repairs due to snow and ice operations, chemical use, and degradation.



Source: FHWA.

Weather pattern changes, road network conditions, available agency resources, and public expectations all affect snowplow route effectiveness.

This project developed systems requirements documentation for ARO that incorporates real-time and historical data for agency maintenance and operations personnel to use during adverse winter weather.

ARO is a powerful tool to help agencies combat winter storms, in view of the changes in resource availability and increased storm frequency and severity.



Source: USDOT/Getty.

<https://ops.fhwa.dot.gov>

For additional information,
please contact:

David Johnson
david.johnson@dot.gov
(202) 366-1301

 [@FederalHighwayAdmin](#)

 [@USDOTFHWA](#)

 [USDOTFHWA](#)



U.S. Department of Transportation
Federal Highway Administration

FHWA-HOP-22-063