U.S. Department of Transportation
Federal Highway Administration

ROAD WEATHER MANAGEMENT PROGRAM

Source: USDOT/Getty

ADAPTIVE ROUTE OPTIMIZATION

Concept of Operations

This project supports improved winter operations through the development of a Concept of Operations and a System Requirements Specification for Adaptive Route Optimization.

Introduction

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, subject to weather conditions, traffic, and resource constraints. ARO can enable agencies to respond more quickly and efficiently to weather extremes, resource constraints, and service expectations.

This Concept of Operations (ConOps) describes the characteristics of a proposed ARO system from the viewpoint of key winter maintenance stakeholders. The ConOps objectives include:

Capture

- Capture the shared user needs, expectations, goals, and objectives of an ARO system.

Describe

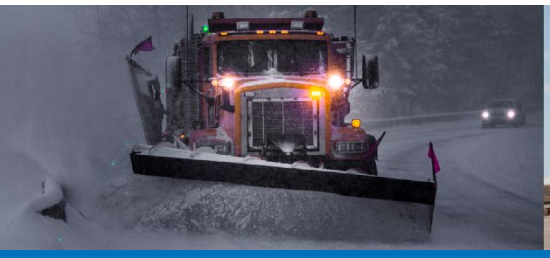
- Describe the information from multiple viewpoints which includes the potential impacts of ARO for all stakeholders and their existing and future processes. This includes an analysis assessing potential ARO benefits, limitations, and issues or disadvantages.

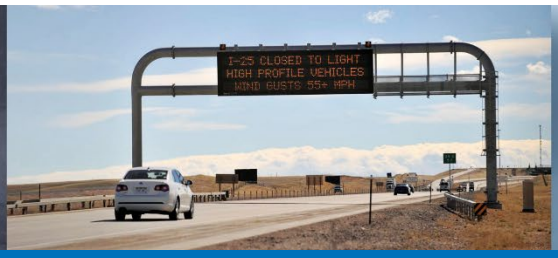
Provide

- Provide a bridge from the problems and stakeholder operational needs to the system level requirements.

The ConOps report highlights the fact that changes in weather patterns, incidents, work zones, available agency resources, and public expectations degrade maintenance vehicle route effectiveness. Intense weather events, like snow, ice, rain, winds, hurricanes, droughts, and dust storms are becoming more frequent. Maintenance vehicle routing effectiveness is further complicated given that each agency has their own goals and challenges in getting roadways back to pre-storm levels of service. Also, results for a specific segment of roadway depend on factors such as the storm type and intensity, the time of day, location complexity of where storm hits, and the types of treatments used.

Source: USDOT/Getty





Current State of Practice

The ConOps characterizes the current state of routing practices and impacts. Agencies are faced with the fact that winter maintenance, during a storm, uses a lot of resources over a relatively short amount of time and is highly dependent on agency capabilities in terms of:

- Treatment capacity as determined by fleet availability, truck capacities, and material accessibility throughout the network.
- The availability of qualified staffing before, during, and after a given storm.
- Weather that can vary from expected forecasts and historical norms by a range of factors like timing, intensity, precipitation type, and location.

Unfortunately, recent highly variable weather patterns are producing extreme weather events that impact motorist safety and agency capabilities to keep the roads safe.

Source: FHWA

Justification for and Nature of Changes

Winter maintenance is expensive and typically consumes a big part of an agencies budget, so any gains in operational efficiency will produce both safety and monetary savings.

Most agencies in the United States are using manual or fixed snowplow routing based on historic weather patterns. However, extreme weather events are more common now and they continue to impact both motorists' safety and travel reliability.

It is not uncommon to see news headlines showing the aftermath of yet another interstate roadway brought to a halt due to a record-breaking snowstorm that results in havoc and leaves travelers pleading for accountability.

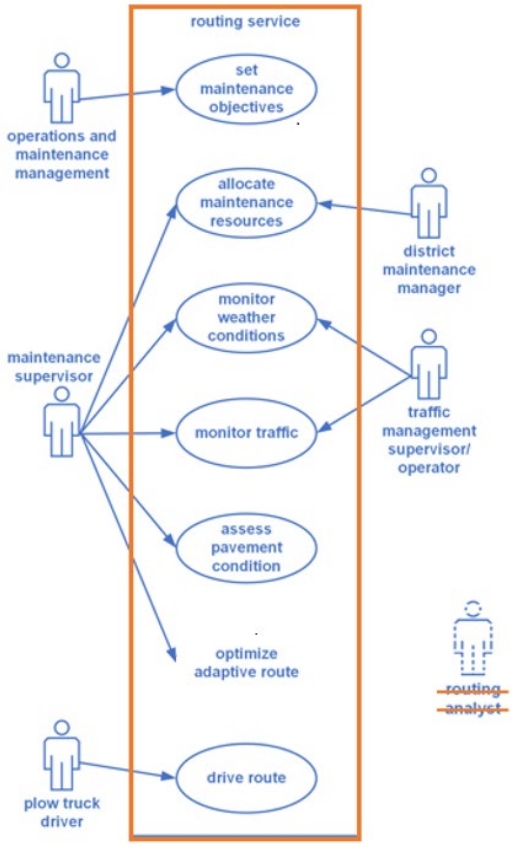
Achieving the capability to adapt to rapidly changing conditions requires new tools. Fortunately, ARO can enable agencies to respond more quickly and efficiently to changing storm conditions, resource constraints, and service expectations.

ARO has the potential to restore pavement conditions faster, reducing weather-related risk and improving mobility.

Agencies using ARO can develop more efficient routing plans that makes the most use of staff time, materials, and maintenance equipment.

Concepts for Adaptive Route Optimization

The ConOps report identifies the anticipated future state of ARO for winter maintenance in contrast to current practice. There are four key areas described which includes **routing** and **system components** (summarized here) and **snowplow truck details** and **system concepts** (see ConOps report).



Source: FHWA

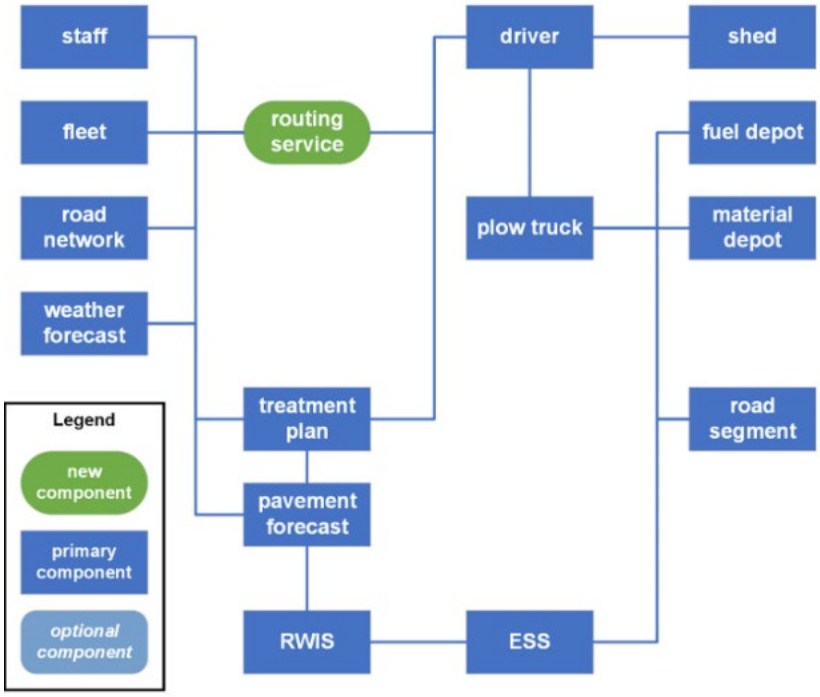
For **Routing**, an ARO system will differ from current practice as noted below and illustrated in the graphic to the right:

- A boundary is added to indicate that the scope of a new routing service includes all the use cases in the diagram.
- The previous "plan route" use case is changed to "optimize adaptive route."
- In current practice, a routing analyst may assist maintenance supervisors in setting up, or optimizing, winter maintenance routes. This role is often filled by a maintenance supervisor or a contractor specifically brought in to recommend route improvements. This current role is effectively replaced by the routing service as illustrated in this graphic by the dashed lines and strikethrough text.

For **System Components**, an ARO system will differ from current practice as follows:

- The routing plan is replaced with a new routing service that dynamically provides optimized route plans adapted to current conditions.
- The pavement forecast, previously an optional component, becomes a primary component of an adaptive optimized solution.

Acronyms: "RWIS" (road weather information system), "ESS" (Environmental sensor station)



Source: FHWA

Operational Scenarios

The ConOps includes three scenarios to highlight an ARO system's interfaces and functions. Each scenario helps to describe how a future ARO system should operate given different circumstances. The scenarios include what an ARO needs to be able to do given **shifting resources**, **changing weather forecasts**, and when faced with an **incident en route**.

Source: FHWA

Potential Impacts

The ConOps report considers the potential impacts an ARO system might have on the operations of an organization which includes:

- **Operational Impacts** - ARO capabilities put a premium on real-time operations data. A truly adaptive system will want the best available data to initialize the routing plan, and the data will need to be refreshed as maintenance activities are underway. From a maintenance management view, improved routing capabilities can lead to more flexibility in staffing and equipment within and among maintenance facilities and districts. Maintenance management can continuously monitor and provide feedback to ongoing activities.

- **Organizational Impacts** - ARO may have significant organizational impacts within an agency. At management levels, it will potentially drive a tighter coupling between traffic and maintenance operations during winter weather events. This necessitates clear and direct communications but offers benefits to transportations systems management and operations, as well as to maintenance.

- **Impacts while developing the ARO system** - Intensive and focused stakeholder information will be needed to overcome the lack of, or mixed, experience with adaptive routing optimization.

Analysis

The ConOps provides an analysis of the potential advantages, opportunities, disadvantages, and limitations for developing an ARO system. As agencies move beyond static route optimization to ARO, the public travelling public will experience faster restoration of clear pavements, safer roadway conditions, and improved mobility during winter driving conditions.