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Level of Service

What Is It? How Do We Measure It? How Do We Achieve It?

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I suspect that the goal of most winter maintenance organizations is to provide the highest level of service (LOS) possible, within the constraints of available resources and the weather and road conditions encountered. The term LOS is widely used, but the meaning and understanding of the term varies considerably within the snow and ice community.

A general definition that I favor is: "measured or observed road surface conditions at various points in time, during and after winter weather events." This embraces the concept that there are two distinct time periods or windows for looking at LOS - within the winter weather events and after the winter weather events. The important road conditions within a winter weather event may be characterized by such descriptors as:

- Snow accumulation (in, cm) - instant or prior to plowing
- Presence or absence of ice pavement bond
- Measures or subjective assessments of mobility and relative safety (traffic speed/flow, road/lane closures, coefficient of friction, degree of perceived safety, etc.)

- Visual pavement surface condition classification schemes (pictorial template or descriptive)

After a winter weather event, LOS may be similarly characterized, with the additional option of "time to": wheel path bare, center line bare, lane bare, road open, plowing and treating etc.

An understanding of LOS is vital if snow and ice control operations are to be planned and executed with the objective of providing a reasonable balance of safety, mobility, environmental responsibility and cost. Not all roads can have the same priority of treatment, at the same time, and some critical choices have to be made in order to effectively use resources.

NCHRP Project 06-17 "Performance Measures for Snow and Ice Control Operations" is nearing completion. Practitioners had an excellent discussion of the topic at the 2008 TRB International Symposium on Snow Removal and Ice Control Technology. The proceedings are on line at: http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf.

Performance measures for snow and ice control generally fall into three categories: Input Measures, Output Measures and Outcome Measures.

Input Measures

These are usually measures of investment that are used primarily for fiscal and management purposes. Here, these "investments" may be compared with storm severity, output measures and outcome measures. Typical input measures include:

- Fuel consumption or usage by equipment category
- Equipment hours by equipment category
- Personnel hours by labor class

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- Overtime hours by labor class
- Resources expended of various classes of snow and ice control work (plowing, materials spreading, patrolling, pack removal, blowing and drifting snow control, etc.)
- Equipment readiness by class (% "up", calibrated, etc.)

Output Measures

These are usually measures of accomplishment. They can be compared with the other two measures to make judgments about efficiency (unit cost) and effectiveness (cost per outcome). Typical output measures include:

- Lane miles actually plowed and/or treated
- "Deadhead" miles
- Tons of materials used by type

Outcome Measures

These are the "true" performance measures. They measure or judge the result of the snow and ice control operations that were performed to the point of measure or judgment. Typical outcome measures include:

- Time to total bare/wet pavement
- Time to wheel path or centerline bare/wet pavement
- Percent of various surface condition ratings at points in time after a winter weather event, by highway classification
- Time to "normal" traffic speed and flow
- Time to "safe" coefficient of friction, by highway classification
- Customer satisfaction measures (complaints, surveys, etc.)
- Accidents in various time frames during and after the event

There is no accepted or "right" way to measure performance, but each winter maintenance organization should use whatever combination of the measures above that will accomplish the desired management objectives.

There are some "tools" organizations can use to judge or measure level of service during and after winter weather events:

- **Visual Information** - Here trained observers can relate what they see, first hand or on camera images, to a level of service condition that is defined by a template or series of pictures, or a set of written descriptions for various classifications of LOS.
- **Judging Ice/Pavement Bond** -. Being able to identify the presence or ice pavement bond on the road is a key LOS judging skill. Here judgments about the character of snow on the road, the character of material displaced by tire traffic, the sounds of plow equipment and the appearance of the freshly plowed road surface allow an individual to reasonably judge the presence or absence of ice pavement bond.
- **Friction Measurement** - Equipment is becoming available to mount on plow trucks and other vehicles that will provide an indication of the pavement coefficient of friction.
- **Electronic Sensors** - There are a variety of sensors that provide an indication of LOS. Pavement sensors associated with road weather information systems (RWIS) provide an indication of ice/pavement bond at the sensor site. Cameras, traffic volume and speed sensors also provide some basic LOS information about traffic flow characteristics.

An article appeared in the Summer, 2007 *Salt and Highway Deicing Newsletter* for The Winter Maintenance Professional entitled: "Performance Metrics Will Impact Snowfighting: A Perspective". This article provides a glimpse into the future of performance measurement. The article is available on the web at: http://www.saltinstitute.org/publications/shd/shd-summer-2007.pdf

The keys to achieving LOS goals are utilizing appropriate strategies and tactics, using appropriate operational cycle times for both plowing and materials spreading, and using the appropriate snow and ice control materials. In my judgment, NCHRP Report 526: Snow and Ice Control: Guidelines for Materials and Methods, offers the best guidance in this area. It is available on the web at: http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_526.pdf

Table 0-1, and the descriptions that follow, are found in that report. Here, the relative LOS expectations for various strategy and tactic combinations are displayed. In addition to the descriptions, it must be realized that:

1. Operational cycle time is **extremely important** in all of these combinations - the longer the cycle time, the lower the achievable level of service will be.
2. The ability to use the right amount of ice control chemical for prevailing pavement, weather and operational conditions is also **extremely important**. These two considerations are also detailed in *NCHRP Report 526*.

Anti-icing

Anti-icing is a general strategy that attempts to prevent the formation of ice/pavement bond by the timely application of ice control chemicals. Chemicals may be applied before the event (pretreating), early in the event, and as necessary throughout the event. This strategy generally produces a high LOS during and after the event.

TABLE 1. Strategies and Tactics and LOS Expectations

Strategies and tactics	Within-event LOS			After-event LOS		
	Low	Medium	High	Low	Medium	High
Anti-icing			●			●
Deicing	●	●		●	●	
Mechanical	●			●		
Mechanical and Abrasives	●			●		
Mechanical and Anti-icing			●			●
Mechanical and Deicing	●	●		●	●	
Mechanical and Prewetted Abrasives	●			●		
Anti-icing for Frost/Black Ice/ Icing Protection			●			●
Mechanical and Abrasives Containing > 100 lb/Lane-Mile of Chemical	●	●	●	●	●	●
Chemical Treatment Before or Early in Event, Mechanical Removal During Event, and Deicing at End of Event	●				●	

Deicing

Deicing is a strategy of allowing ice/pavement bond to form during an event and periodically treating it with chemicals until the ice/pavement bond is broken and snow/ice can be mechanically removed or displaced by traffic. This strategy generally produces low to medium within and after event LOS.

Mechanical

Mechanical removal is the displacement of snow/ice from the roadway by plows, rotary plows (snow blowers), brooms, and other mechanical means. This, as a strategy, is capable of producing low within- and after-event LOS. At pavement temperatures above 32 degrees F and below about 12 degrees F, higher levels of service may be possible with mechanical removal.

Mechanical and Abrasives

The practice of plowing snow and spreading abrasives (either straight or mixed with a small amount of chemical) is common on lower-volume roads. It also may be a necessary treatment due to low pavement temperatures. As a strategy by itself, it is only capable of producing low within and after event LOS unless the pavement temperature is above 32 degrees F not allowing ice/pavement bond to occur.

Mechanical and Anti-icing

Timely mechanical removal of snow/ice within an event, in conjunction with an overall anti-icing strategy, will produce the highest possible LOS within and after winter weather events.

Mechanical and Deicing

Mechanical removal in conjunction with a deicing strategy within an event will produce low to medium LOS within and after winter weather events. This primarily results from controlling the depth of loose snow and ice on the roadway.

Mechanical and Prewetted Abrasives

Mechanical removal plus treatment with abrasives that have been prewetted with liquid chemical is capable of producing low within- and after-event LOS. Pavement temperatures above 32°F that will not allow ice/pavement bond may allow higher levels of service to be achieved. Limited research shows prewetting abrasives might produce a slightly higher LOS than a stockpile mix alone.

Anti-icing for Frost/Black Ice/Icing Protection

Pretreating areas susceptible to frost/black ice/icing that may occur in the absence of precipitation with liquid chemical is a proven effective anti-icing tactic that prevents ice formation. Since the ice does not form, the LOS is always high.

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Mechanical and Abrasives Containing More Than 100 lb/Lane-Mile of Chemical

"Rich" abrasives/chemical mixtures containing more than 20 percent chemicals by weight have been used for many years. They are capable of providing all ranges of LOS, depending on pavement and weather conditions. The LOS provided is generally in proportion to the amount of chemical in the mix and the application rate. Research has shown that to produce a high LOS, a strategy of using pure chemicals alone will be more effective and less costly than using mixtures of chemicals and abrasives.

Chemical Treatment Before or Early in an Event, Mechanical Snow/Ice Removal During an Event, and Deicing at the End of an Event

This is a hybrid strategy suitable for lower priority roads that produces a medium after event level of service for a small chemical investment. The initial chemical application seems to prevent a strong ice/pavement bond. This, in conjunction with the later chemical application and any solar pavement warming, leads to a fairly quick recovery. This is particularly effective when the chemicals are placed in a narrow band around the center of a two-lane crowned roadway.

Final Statement

The information presented above should give the reader a basic insight into level of service, performance measures and how to achieve desired LOS. The challenge will be putting it all together into an operational plan.

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