### Background
For transportation departments responsible for winter road maintenance (WRM), performance measurement and establishment of service standards are the essential ingredients for their ensured success. This has become even more so recently due to increased privatization of winter maintenance work and increased public concerns over the detrimental effects of road salt on the environment, the infrastructure, and the vehicles. However, there are two particular challenges in establishing appropriate WRM performance measures and service standards. First, the main determinant of winter maintenance efforts and outcomes is the snow storms which vary over space and time considerably, which makes it difficult to conduct some of the common performance measurement tasks such as performance benchmarking and trend analysis. Second, the relationships between the outcomes of maintenance operations (e.g., safety and mobility), outputs (e.g., bare pavement recovery time and pavement friction), and inputs (e.g., amount of salt used and hours of operations) are confounded by many uncontrollable variables such as storm severity, road characteristics, and traffic conditions, making it difficult to develop performance measures and service standards that are both outcome oriented (attributable) and controllable. Therefore, WRM remains to be a sector that lacks uniform performance measures and service standards.

### Why Measure Performance?
To tell a convincing story, we must use numbers with meanings, over space and time considerably, which makes it difficult to develop performance measures and service standards. That is both outcome oriented (attributable) and controllable. Therefore, WRM remains to be a sector that lacks uniform performance measures and service standards.

### Performance Measurement Framework
**Inputs**
- Winter work schedule
- Winter maintenance status
- Equipment readiness
- Weather

**Process**
- Lane-km plowed
- Lane-km salted
- Lane-km sanded
- Traffic condition
- Snow condition

**Outputs**
- Lane-km salted
- Lane-km sanded
- Lane-km plowed
- Traffic

**Outcomes**
- Bare pavement regain time
- Traffic condition
- Response time
- Salt usage

### Performance Measures
**Effectiveness Measures**
- Bare pavement regain time
- Traffic
- Accidents

**Efficiency Measures**
- Cost per lane km
- Salt per lane km

**Environmental Impact Measures**
- Salt per lane km
- Salt per season

### Maintenance Service Standards
**BP Repair Time**

### Alternative Performance Measures
**Goodness of Performance Measures**
- Meaningful (linked to goals)
- Controllable (linked to inputs)
- Robust (Less random)
- Support benchmarking

**Trade-Off of Best Performance Measures**
- More meaningful
- More noise
- More controllable
- Easier to monitor

### Safety & Mobility Benefits of Alternative LOS
- **Collision Frequency and Severity Models**
  
- **Trip-making utility and travel time savings Models**
  
### Relation between Collision Frequency and RSI
Optimum level of service from safety perspective can be identified by investigating nonlinear relationship between collision frequency and road surface index through nonparametric modeling.