TOPIC: Literature Search: Reducing Fuel Used by MnDOT Plows
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Needs Statement:
https://mndot-lrrb.ideascale.com/a/idea-v2/540031

Each year, MnDOT plowing operations use over 1M gallons of diesel fuel, at a cost of over $2M. Technology that is currently installed on our plows has the potential to increase the efficiency of plowing operations, reduce fuel use, and save the agency money.

• New telematics technology installed on many plows allows us to evaluate the plow's engine performance, fuel consumption, and other parameters, according to their specific geospatial location.

• MnDOT also collects data from the Maintenance Decision Support System (MDSS) on weather conditions, salt use, and level of service for the roadways plowed.

Unfortunately, the sheer quantify of data produced by these systems is difficult to manage, analyze, and apply any results. This project would evaluate the data produced by both systems, analyze the results, and assess the potential to combine the data to inform future decisions that are expected to reduce fuel costs. Further, the project would be combined with new route optimization tools to provide further insight about operational decision making.

The results have the potential to increase the efficiency of plowing operations, reduce fuel use, and save the agency money.

Summary: The topic is too specific to MnDOT that no research could be found. An expert and researcher should be hired to study the data produced by both systems and using the results for better decision making in reducing fuel costs.

Resources searched: TRID/RiP, ASCE, Library Catalog, Web

Most Relevant Results:

Least Relevant results:

Methods for Estimating the Benefits for Winter Maintenance Operations
Abstract: The research identified an approach for estimating the benefits of winter maintenance operations in terms of increased safety, reduced travel time, and reduced fuel usage and discussed the limitations of the approach. In addition, data from a state highway agency was used to illustrate applicability of this approach for estimating the benefits accrued from performing winter maintenance operations.
Does winter road maintenance help reduce air emissions and fuel consumption?
Transportation Research Part D: Transport and Environment. 2016/10. 48 pp 85-95

Abstract: Winter road maintenance (WRM) has been shown to have significant benefits of improving road safety and reducing traffic delay caused by adverse weather conditions. It has also been suggested that WRM is also beneficial in terms of reducing vehicular air emissions and fuel consumptions because snow and ice on road surface often cause the drivers to reduce their vehicle speeds or to switch to high gears, thus decreasing fuel combustion efficiency. However, there has been very limited information about the underlying relationship, which is important for quantifying this particular benefit of a winter road maintenance program. This research is focused on establishing a quantitative relationship between winter road surface conditions and vehicular air emissions. Speed distribution models are developed for the selected Ontario highways using data from 22 road sites across the province of Ontario, Canada. The vehicular air emissions under different road surface conditions are calculated by coupling the speed models with the engine emission models integrated in the emission estimation model - MOVES. It was found that, on the average, a 10% improvement in road surface conditions could result in approximately 0.6-2% reduction in air emissions. Application of the proposed methodology is demonstrated through a case study to analyse the air emission and energy consumption effects under specific weather events.

Arizona Department of Transportation Research Center
2007/12. 64p (4 Apps., 14 Figs., 6 Tabs.)

Abstract: The Arizona Department of Transportation (ADOT) introduced simulator-based training in 2004, when maintenance crews in five rural districts received a third-party snowplow safety topics course on the L-3 TransSim VS III simulator. In 2005, a simulator was deployed in the Globe District, initiating a training program for the 60-plus snowplow operators there. Local volunteer trainers, all experienced plow operators, went through a "Train the Trainer" course from L-3 staff. On that basis, in early 2006, all of the district's drivers took a Fuel Management Driving Techniques (FMDT) course on proper shifting techniques for better fuel economy. The goal of this study was to identify the benefits of simulator-based training in fuel economy and driveline repair costs for ADOT's heavy vehicle fleet. It focused on the Globe District, to assess: (1) potential improvements to fuel economy, recorded in the simulator training session, (2) driver performance in the real-world environment, in terms of fuel economy, (3) changes in fuel economy and repair costs related to proper driving/shifting skills. The project attempted to measure fuel performance in a real-world driving environment by establishing a 168-mile round-trip test route between two maintenance yards, on a winding route with many steep grades. Test runs were done with five newly-hired drivers, both before and after the fuel training, in both automatic and manual-shift plow trucks. For the manual transmission fuel runs, on average, a 4.5% improvement was seen. Three years of district fuel and repair histories were reviewed for periods before and after the 2006 training. Five significant "high-mileage" work activity areas were studied. Results were mixed due to many variables, but the critical "snow and ice activity" category did show some improved fuel economy for early 2007. However, the records showed no clear reduction in driveline repairs for January-March '07, but noted that an additional cost of repairs is the time that trucks needing extensive work are out of service. This study used Kirkpatrick's four-level evaluation model to assess if the training improved fuel economy in the Globe District. At the "reaction" level, results are positive; crews say the training did increase awareness and change driving behaviors with regard to fuel efficiency. At the "learning" level, results show some drivers improved but others did worse in post-testing. At the "performance" level, the results are promising: drivers of manual-shift trucks achieved improvement in fuel economy. At the "results" level, aggregate fuel economy figures also show a discernable difference in pre-training and post-training fuel efficiency for key winter maintenance tasks. This study confirmed that operational training can best be measured in quantitative terms, but with challenges. Future ADOT efforts to evaluate simulator training results must first strive to better integrate field data. Training must focus on improved manual gear shifting, and on "best practices" for automatics. The most benefit may come from fully integrating simulators into ADOT's field training program,
which requires strong agency support. Key future requirements are (1) a state-level champion who can enhance simulator training, (2) a new fuel vs. work effort reporting system, (3) formal recognition and incentives for the volunteer local training teams.

A Guide to Reducing Fuel Consumption with Vehicle Telematics: How to Select the Right Solution
Abstract: Transport telematics technology is maturing and becoming a lot less expensive. GPS systems that used to cost thousands of dollars can now be installed for hundreds. Data collection systems and analysis tools now make it possible and cost effective to quickly adjust route schedules, get bus location information to riders, and let maintenance workers know in real time when a bus in having a problem. Schedule analysis can save the expense of having an employee ride a route to track times. Getting information to riders will itself attract more ridership. And analysis based on vehicle mechanical and geographic data is saving one transit agency $60,000 per month in fuel costs.

Web-Based Telematics Move Beyond Dispensing Data.
Metro. 2011/4. pp 46-50 (2 Phot.s.)

How telematics=day-to-day fleet fuel savings.
Automotive Fleet. 2016/6. pages 32-34 (Illus.)
Abstract: Since the Great Recession, fleet managers have become experts at saving fuel. Telematics is giving them a new edge to find avenues for fuel spend savings.

Improving Vehicle Fuel Economy and Reducing Emissions by Driving Technique.
Conference Title: 15th World Congress on Intelligent Transport Systems and ITS America's 2008 Annual Meeting
Abstract: This paper explores how heavy trucks used in freight transportation can use driving technique to improve their fuel economy and reduce vehicle emissions. The author notes that although the heavy truck fleet is quite small compared to passenger cars, the heavier vehicles can achieve a significant impact in the overall vehicle emissions with only slight changes in the vehicle's motion (speed and shifting habits). The author presents a computer simulation which is based on vehicle dynamics, engine maps of fuel consumption and emissions and other technical data of vehicles and roads as well as driving technique. The output quantities are the fuel consumption and emissions of nitrogen oxides, carbon monoxide, hydro carbons, particulate matters and carbon dioxide. The author also introduces the concept of 'oeschwung', which means utilizing the excess of the speed that can be achieved on downward slopes because of gravity. The grade resistance is negative on downward slopes and causes high acceleration for a heavy vehicle, and no fuel is consumed. The kinetic energy is increased and can be utilized on the next upgrade. However, the 'oeschwung' works only if the vehicle is heavy and the road is hilly. The author concludes that truck drivers are the vital players in this approach, as they can have a positive impact on climate change with their driving techniques. In addition, telematics can be used to improve the driver's information and subsequent driving technique.

Telematics study reveals best practices for increasing fuel economy.
AB Subtitle: Keeping output torque at a lower level by overspecing engines and reducing gear ratios may save up to $200,000 a year for a truck fleet of 100.

Energy efficiency in winter road maintenance: a road climatological perspective.
Earth Sciences Centre, Goteborg University. A. 2015. (154) 46
Abstract: Practices in winter road maintenance are dependent on the climate and weather impacting roads and the road users' requirements. As in many other fields of transportation, it is of interest to investigate fuel efficiency potentials in the different aspects of the road maintenance area. The main focus of this thesis was on investigating energy use in winter road maintenance activities in southern Sweden. It is crucial to
understand which parameters are of the largest significance in slipperiness, as well as to investigate the weather information that the operations are based on, since the climate is the reason for requiring winter road maintenance in the first place. The original energy use needs to be set, to be able to know whether efficiencies are made. In this thesis, two approaches were taken to understand if existing fuel consumption models for heavy-duty vehicles could be applied within winter road maintenance or whether in-vehicle fuel data such as data from vehicle manufacturers should be used instead. Finally efficiency potentials were explored with the use of a route optimisation programme for winter road maintenance practices. The climate data analyses showed that frost warnings are the most common type of slipperiness in the southern parts of Sweden. If such warnings were to be under- or overestimated, it could have a large impact on the energy used, since unnecessary slipperiness treatments could be performed. Furthermore, the mobile water depth measurements indicated that it is possible to detect differences in water depth along roads and that exit ramps could be interesting in terms of changed treatments, since the water depths were quite large on those ramps. From the use of the fuel consumption model included in the Swedish National Road and Transport Research Institute, or VTI, winter model, it was concluded that anti-icing would not be energy efficient in terms of traffic energy use, since drivers tend to drive at higher speeds on salted roads. Snow density and amount would however, impact fuel consumption, which is why the removal of snow could save traffic energy use. The best method to evaluate energy use during winter road maintenance was the use of in-vehicle data. The existing fuel consumption model used in this thesis, underestimated the fuel use, which implied that the energy use in winter road maintenance practices depends on other aspects than what was stated in the model calculations. Such other aspects seemed to be the weather and way of work that in turn demand significant changes in speed. Changes in speed was also regarded as a potential efficiency measure, as the velocities of the heavy-duty vehicles seemed on average to be below what was estimated as the most fuel-efficient speed for this type of vehicle. Using the route optimisation programme further put a way for evaluating efficiency potentials. It was shown that installing underground heating systems or road surface—installed salt spreaders at strategic locations could save fuel use, as would changing operations from sanding to salting, as well as adding extra materials depots during the sanding operations. The analysis also indicated that additional materials depots for anti-icing measures would not result in any change in fuel use. The thesis has contributed to finding ways to reduce the use of both vehicles and fuel.

Salting Route Optimization in Hungary.

Abstract: In many European countries including Hungary, winter conditions produce disruption of traffic, as well as the increase in road users’ (vehicle operating, time delay and accident) costs. In most areas, the severity of winter conditions varies from year to year. Modern society has become more vulnerable to these effects. The primary objective of winter maintenance is to provide snow and ice-free conditions on the highway network. Compared with other road activities, winter maintenance is characterized by the need for a fast response, and by the impacts of the measures taken being short-lived. That is why scientifically based methodology (optimisation of winter maintenance techniques) is needed to reduce the above negative consequences. The main aim of the research work carried out at KTI Non-Profit Ltd, Budapest was to optimise the efficiency and the timing of salt storage and road de-icing policy as a function of environmental, economic and traffic safety aspects. The selected methodology, Capacitated Arc Routing Problem helps the road managing agencies in optimising road winter maintenance fleet routing, with reduced air pollution, fuel consumption, in accelerating the related activities, besides in reducing road user costs significantly. In the research work performed several scenarios on different decentralisation levels of salt storage depots were also modelled, and investigated from environmental and economic view-points. The scenario on heavy de-icing vehicles of standard load capacities with a centralized depot was considered as standard variant, while the
heavy vehicles of variable load capacities and the silos with unlimited capacities were also modelled. A Cost Benefit Analysis of the timing of salt depot decentralisation proved that the immediate set-up of silos is the most economic and efficient variant. The methodology developed can also help the local road administrations in devising their winter policy documents covering the related objectives, standards, intervention levels, priorities for action within the road network, the response times, snow clearing and salting routes, salt spreading rates, and personnel strategy.

Winter Model: Road Condition Submodel.

Abstract: The road condition model presented in this paper is a submodel in the Swedish winter maintenance management system, the Winter Model. The Winter Model will make it possible to assess the most important effects and their monetary value of changes in winter maintenance strategies and operations in Sweden. The effects are assessed for road users, road administrators, and the environment. The submodel road condition model is the central part of the Winter Model. The road condition model will characterize the state of a winter in terms of a road condition description hour by hour. The road condition model provides input data for other models where different effects such as accident risk, travel time, fuel consumption, road management costs, and environmental effects are assessed. In the first stage the author has developed a model that will describe how road conditions are affected by weather, maintenance measures taken, and traffic on two-lane rural roads with a width of 7 to 9 m and speed limit of 90 km/h. To a great extent, the basis for developing the road condition model will be data already collected from nine observation sites, during one or two winter seasons, with the purpose of developing another submodel of the Winter Model, the accessibility model. For several periods, data from these observation sites contain information hour by hour regarding weather, traffic flow, initial road condition, and maintenance measures taken. Also specified types of road condition development “mainly connected with snowplowing and anti-icing treatment” can be studied.

Additional information has been collected in special field surveys from the winter of 2002""2003. One survey covers the development of ruts down to the pavement in hard-packed snow or thick ice, caused by vehicles with studded tires. Also the mechanism for a wet or moist road to dry out has been studied. The road condition model will initially consist of the following nine submodels. The first five submodels are related to measures and the last four to traffic and weather: (a) anti-icing treatment, (b) snowplowing combined with anti-icing treatment, (c) snowplowing, (d) gritting, (e) grading, (f) rut development in hard-packed snow or thick ice, (g) condensation, (h) splashing from a wet road, and (i) drying of a moist road.

VTI Rapport. 2014. (834) 70

Abstract: The aim of the Winter model is to estimate and put a value on the most important impacts of strategies and measures in winter road management for road users, road management authorities and society at large. A first version of the Winter model, with all its sub models, was published 2006 in VTI report 531 (The Winter model. Stage 2. Final report) http://urn.kb.se/resolve?urn=urn:nbn:se:vti:diva-6420. Because the level of ambition with the first version of the Winter model was to achieve a working prototype there are improvements to make within different areas or sub models. The improvements consist of actions with a wide variety of work from a few hours to several years of analysis, modelling and programming. The presentation of the project will begin with a list of important short- and long-term bug fixes and improvements to the Winter model and their rank (priority 1--3). The next chapter describes the implemented bug fixes and improvements with priority 1. The report is finished with a sensitivity analysis of the Winter model. Here the uncertainties in the various sub models are estimated. It is found that, in terms of socio- economic total costs, the uncertainties in accident risk and consequences of accidents have greatest influence. Since the purpose of the Winter model is to compare
different strategies and actions the socio-economic total costs are not of the most interest. Instead the
difference in socio-economic costs between alternatives, that is what benefit is gained from the changes in
strategy or action, is of interest. Such a marginal cost analysis has been done with data from the calculation of
socio-economic total costs. Here, the benefit can be estimated of more salting which will decrease the
proportion of snow and ice on the road and increase the proportion of bare ground. It turns out that the most
important components of the socio-economic marginal costs are the reduction in accident costs and secondly
the reduction in travel costs.

Tema Vintermodell: val av standardklass på vintervaghallning med hansyn till energieffektivitet
(Energy effectiveness depending on choice of winter maintenance classification standard).
VTI Rapport. 2015. (858) 46
Abstract: The Winter Model has been developed within a project called The Winter Model. The aim of the
project, which started in the early 2000s, was to assess social and economic consequences of different winter
maintenance strategies for road users, road authorities and local communities. The aim of this study was to
calculate the change in fuel consumption when the winter maintenance classification standard is lowered on
the road i.e. response times and start criterion is increased. Within this project, the fuel consumption model
was refined and can now take into account how fuel consumption is affected by the amount of water or snow
in the ruts on the road. During the project, six scenario runs were carried out for a 100 km long road section
located in Sweden's central climatic zone. Weather data was obtained from the winter season 2006--2007.
Winter maintenance classification standards, and traffic flow volumes were varied during the scenario runs. In
one scenario run, the winter maintenance classification standard was lowered from Standard Class 1 to
Standard Class 2. This increased the allowable time to carry out the maintenance action from 2 hours to 3
hours -- applicable to a Standard Class 1 road, salted, and with a traffic volume of 16,000 vehicles.
Comparisons indicate a 1,100 litre reduction in total fuel consumption and maintenance costs was reduced by
5%.

VTI RAPPORT. 2006. (531) pp100p (Refs.)
Abstract: The aim of the Winter Model is to estimate and put a value on the most important impacts of the
strategies and measures in winter road management for road users, road management authorities and society
at large. The main report itself is a summary of the reports that describe the submodels in the Winter Model.
The hub of the model is the Road Condition Model which, on the basis of weather data, undertaken road
management measures and traffic, calculates road conditions hour by hour during the winter season. The
Road Condition Model controls calculations in the effect models: Accident Model, Accessibility Model, Vehicle
Cost Model, Environment Model and Model for Road Management Costs. The Accident Model calculates
accident rates, accident types and consequences, all coupled with different road conditions and their duration.
The Accessibility Model calculates the effect of different road conditions on mean speeds and trip times. The
Vehicle Cost Model calculates the costs of fuel consumption and corrosion due to road salt. The Environment
Model calculates the impacts on roadside vegetation due to road salt. The Model for Road Management Costs
calculates both the direct costs of the measures and the costs of damage to, and wear of, road surfacing, road
markings etc as a result of road management measures (A).

Winter model: road condition model (Tema Vintermodell: vaeglagsmodellen).
VTI RAPPORT. 2006. (529) pp43p+app (15 Refs.)
Abstract: The Road Condition Model is the central part of the Winter Model. The reason for this is that it
produces input data for most of the models that describe effects of different kinds, such as accident risks,
travel times, fuel consumption and environmental impact. The road condition model supplies a condition
assessment for winter in the form of a road condition description on an hourly basis. According to the
requirements of the client, the road condition model is confined to describing road conditions for two-lane roads
with oncoming traffic in rural areas. At this stage, the model is also confined to describing road conditions in
the traffic lane. No account is thus taken of hard shoulders, if any. The aim of the project is to develop a