

Road Weather Information System (RWIS) & Maintenance Decision Support System (MDSS) Economic Value Tool (EVT)

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ABSTRACT

Maximizing roadway safety, mobility and efficiency, while minimizing maintenance-related costs and reducing environmental impacts, is the common goal of winter maintenance engineers around the globe. Road Weather Information Systems (RWIS) and Maintenance Decision Support Systems (MDSS) (or Road Decision Support Systems) have proven track records in enabling road authorities to meet the aforementioned goals. However there are many more benefits that these systems provide both in economic terms and other less tangible benefits that have largely been overlooked by previous studies.

This paper describes a tool whereby local authorities can plug in their known operational and economic parameters to instantly calculate potential benefits of RWIS and Road Decision Support Systems.

Keywords: weather, winter maintenance, Decision Support System, Road Weather Information System, economic benefits.

INTRODUCTION

Technological advancements have resulted in the proliferation of systems for collecting, transmitting, and communicating data and information. These innovations have propelled the majority of transportation sectors forward in terms of facilitating improved operational decision-making. It is generally recognized that better decisions translate into improved operations, with the potential to reduce costs and increase safety and mobility.

There is widespread consensus that RWIS and Road Decision Support Systems have a direct effect on improved road maintenance efficiency and marked cost savings. Road authorities have reported that Road Decision Support Systems and RWIS have allowed them to reduce their de-icing material costs by up to 40% with associated reductions in traffic accidents by as much as 50%. There is a slew of information on the various benefits, both direct and indirect, that road authorities and their regions can attain. However, until now, it has been difficult to make a simple calculation that allows authorities to understand the potential effects of an RWIS or a Road Decision Support System installation. This in turn has made it difficult for many authorities to justify the outlay for an RWIS or MDSS or indeed secure funding for the continued running costs and maintenance required.

In order to provide an objective approach for road authorities to calculate benefits, we created a tool called an Economic Value Tool or EVT that allows authorities to enter infrastructure and cost information. The embedded algorithms produce calculated savings, based on referenced study findings that provide a breakdown of all direct and indirect cost savings both to the road authority and the immediate economy. The EVT is further addressed in the summary.

This paper describes each of the identified benefits associated with RWIS and Road Decision Support Systems and presents the EVT.

VALUE DESCRIPTION - The Value of a Winter Road Decision Support System can be expressed in several ways. Some of the benefits afforded by such applications can be translated into monetary values in terms of savings and increased revenue. Others are best expressed as improvements to the quality of life of the members of the community served by the operations maintenance organization. These benefits are categorized into three groups:

1. Application User Benefits
2. Community Benefits
3. Indirect Benefits

MATURITY LEVELS - It is worth mentioning that some users will realize different benefits from other users, depending on the level of technological sophistication in use at the moment. To take into account the maturity of the maintenance organization when operating on roads, the EVT takes into account three maturity levels:

1. **Low Maturity** – At this level, the user relies on weather forecasts and not much more, to decide on road surface treatment. There are no means to check on the current surface conditions, and decision makers have to rely on voice or e-mail reports from operators on the actual roads. These users will experience the maximum benefits from using a combination of weather stations, point forecasts, road forecasts, and treatment recommendations which are all outputs of the roads decisions support system and weather stations. They will also require the largest investment in hardware, software, and services.
2. **Medium Maturity** – Organizations at this level use weather forecasts and current conditions data coming from a limited number of weather stations that monitor road conditions. They may have cameras providing visual cues on the conditions of the roads, and they may even get point forecasts from some of those weather stations. They manually decide what the road conditions will be from atmospheric forecasts, point forecasts, and current surface conditions. These users may also have policies in place that standardize the treatment based on current conditions and weather forecasts. They are missing the ability to forecast road conditions (as opposed to atmospheric conditions), access to best practices for recommended treatments, and the ability to manage those treatments in a way that maximizes safety and minimizes cost. Their investment requirements include some hardware to get more current data in more places, and Decisions Support System (DSS) software that provides treatment recommendations and road surface forecasts, even after treatment.
3. **High Maturity** – The only thing these organizations are missing is a roads decision support system that can take their atmospheric forecasts, their current conditions data from an adequate number of weather stations, the point forecasts from those stations, and their mature treatment policies, and create a comprehensive road conditions forecast that changes depending on the type of treatment they, with output from the application, decide to use. These users will then be able to manage their material usage and their labor for road maintenance operations and fleet maintenance, while continually adding and tracking lessons-learned information to their knowledge base. They will be able to run different treatment scenarios, and will start looking at reaching higher levels of sophistication through the additions of newer technologies, such as Automatic Vehicle Location (AVL), mobile weather data collection, thermal mapping, bridge spraying, traffic counting, and more, that can interface with their roads decision support system.

APPLICATION USER BENEFITS - From an application user's perspective, the value of a road decision support system when performing winter road maintenance tasks can be described simply as much greater efficiency and reduced costs of winter operations. There are public relations benefits as well that can be categorized under publicity. Efficiency savings exist in several areas. These include savings in labor hours or days, reduction in treatment material (dry and wet) use, infrastructure maintenance cost savings, lower fuel costs, and increased revenue from Toll Roads (when applicable).

LABOR TIME SAVING - Labor time savings can be further categorized into time spent in decision making, the need to treat or not to treat sections of roads during actionable events which affects the operators' time required to deliver the treatment, and other indirect savings such as reduction in stress related absences, cleanup time improvements, and IT labor savings.

DECISION MAKING - It takes time to analyze the current road conditions, the current forecast for the next few hours or days, the status of the vehicles, availability of drivers, availability of materials, budget constraints, current traffic conditions, consensus meetings, and communications to operators and depot managers. McHenry County decision makers may spend around 3 hours before and during each weather event researching all the facts before sending drivers on a treatment run. Using a road decision support system could reduce that decision making time by 66%, or by two hours, each time there is an actionable event. This can translate into a reduction of almost 140 hours during the whole winter season. Applications with visual capabilities such as cameras on the road combined with Road Weather Information Systems (RWIS) stations also provide data to decisions makers that can help reduce or eliminate road checks, thus saving labor, fuel, and time.

ACTIONABLE EVENTS - Not all weather events warrant treatment. However, it is very difficult to know what the road conditions are or will be during and after a snow storm, or how freezing temperatures will affect the pavement after precipitation is detected on the road. Without a road decision support system that uses surface observation data and road condition forecasts, there would be a treatment call-out each time atmospheric conditions and atmospheric forecasts so suggest.

An advanced road decision support system will determine road conditions based on road sensors and thermal mapping of the pavement. Traffic, internal heat stored in the pavement, changing air temperatures and humidity levels, wind, precipitation type, and time of day are all factors that make a direct correlation between atmospheric conditions and road conditions not at all apparent without some scientific analysis and modeling.

Users of a road decision support system will see a treatment call-out reduction of as much as 30%, and sometimes more. McHenry County experienced 60 road winter weather related events during 2010 (which include precipitation, blowing snow, frost, black ice, etc), and could have issued callouts for just 42 of them, thus saving labor, wear and tear of roads and vehicles, and slow down of traffic due to the absence of slow moving maintenance vehicles on the highways when it may not have been needed.

MAINTENANCE OPERATOR DRIVING TIME - Since there will be less actionable events and not all actionable events require full road treatment, a road decision support system can save maintenance organizations as much as 50% driving time, and reduce the number of needed drivers by 20% or more.

McHenry County could have reduced the number of drivers by 6, on average for each event, and drivers might not have been called to treat the roads 18 times had they been using a road decision support system. This could translate to savings of 2500 hours of road maintenance driving time for the season.

OTHER TIME SAVINGS - A road decision support system that uses road maintenance organizations' predefined policies for making decisions regarding road treatment, tends to ease the responsibilities decision makers and operators have when trying to decide when and what treatment to apply. This is especially true when the decision maker is relatively new on his or her job, since much of the knowledge gathered by the predecessors would have been captured by the policies already defined, by the best practices for each road network, and by exceptions and additions to the rules for particular sections of the network. All this knowledge would be captured in the Knowledge Database of the road decision support system, and the decisions would be pre-established by the rules based engine in the software. Any deviations from the standard would be documented and justified by the experience of the decision makers and the operators.

This model tends to improve consistency in decision-making, improve the accuracy of the decisions, and reduce stress on the decision makers. Consequently, there will be less stress related absences and more satisfied managers and operators. Reports will also help with treatment policy optimization, when comparisons of actual results vs past treatment history are available. McHenry County estimates a 75% reduction in stress related absences with the use of a road decision support system.

Winter maintenance groups that use salt for treating the roads will likely also need to clean up after treatment and when the weather event is over. When using a road decision support system the number of treatment callouts due to actionable weather events is reduced, the amount of materials used is minimized, and the number of times crews need to clean up gets also reduced. The time spent on cleanup tasks is proportional to the time savings incurred when no treatment is deemed necessary. For some medium sized cities, this could mean cleanup savings of over 500 hours every season. Users who move their decision making operations to a Software As A Service road decision support system model will not only always get the latest technology as soon as it becomes available, but they will forgo the need to have a full time IT person managing the infrastructure. This translates to savings of 400 hours a year of IT labor. When you combine all these time savings, McHenry County could save, on average, a little over \$135,000 per year.

MATERIAL COST SAVINGS - Three main types of materials are used when treating roads and runways:

- Dry De-Icing materials
- Wet De-Icing materials
- Fuel to power the vehicles that deliver the treatment

Typically, fuel consumption is a large cost incurred in the delivery of various treatments as well as cleanup tasks, especially during increased gasoline and diesel costs at the pump that create budget overruns. De-Icing materials however, can cost much more than fuel. These costs can be cut dramatically when users are able to pinpoint where treatment needs to take place, and when not to send vehicles out. A road decision support system should not only be able to reduce the number of call-outs in a year, but also specify where in the routes designated for treatment is there a need for de-icing materials as part of that treatment. McHenry County has the potential to eliminate 30% of the callouts as well as reduce the time and materials spent on delivering treatment by 50%. This could translate to savings of over \$400,000 in a winter season, 3% of which would be fuel consumption.

MAINTENANCE AND WEAR SAVINGS - The use of vehicles to treat roads and highways has inherent costs that should be taken into account when assessing the value of using a road decision support system. These indirect costs can be classified as fleet maintenance costs, and infrastructure wear and tear costs. Fleet maintenance costs are vehicle cleaning costs, fleet servicing costs, which include calibrating of equipment, vehicle maintenance, and equipment replacement costs. Every time heavy plows tear through the pavement, new future costs are added to the mix to maintain roads and highways and keep landscapes in acceptable conditions. Since the road decision support system will only advice users to send vehicles out when the policy dictates and thresholds have been reached, this wear and tear of the infrastructure can be reduced by as much of 25% and even more in some cases.

McHenry County estimates that in one year it could realize savings of over \$250,000 due to lower damage to the roads, and reduced vegetation replacement or landscaping costs.

OTHER EFFICIENCY BENEFITS -Users of a road decision support system who must manage Toll Roads will also experience an increase in revenue, due to the confidence the public has in the road conditions of a toll road as opposed to side streets and congested highways, which may or may not be sufficiently treated. Increases of 30% of the number of vehicles that would go on Toll Roads are not uncommon.

SUMMARY OF EFFICIENCY BENEFITS - McHenry County has the potential of saving over \$800,000 a year in efficiency areas alone. This includes short of \$135,000 in labor savings, more than \$400,000 in materials and fuel use, and over \$300,000 in maintenance and infrastructure wear and tear. McHenry County does not have Toll Roads, so there is no increase in revenues due to increased Toll Road usage during weather events.

PUBLICITY AND LITIGATION- Another source of budget savings can be attributed to publicity related items, including reductions in complaint costs and litigation costs. The number of complaints due to weather induced situations can be decreased an estimated 50%, especially if the road decision support system uses communication options to inform the public about road maintenance work taking place in the vicinity. Likewise, the number of successful law suits by the plaintiff will diminish considerably, if the road decision support system can document the action taken based on accepted policies, or deviations from policies with proper justification.

The number of litigation suits is directly proportional to the number of accidents experienced on the treated roads. As proactive treatment of the pavement takes place, fewer accidents are likely to occur. If procedures are followed and documented, there is a lower basis for liability for accidents that do occur, and therefore reduction in litigation costs. It is estimated that the number of accidents due to inclement weather can be reduced by 20% through adequate treatment of the roads when necessary. That could mean an estimated savings of over \$300,000 for McHenry County.

COMMUNITY BENEFITS- The community served by the DSS user will benefit with increased road safety, improved vehicle flow during inclement weather, and better environmental conditions through lower emissions and pollution. Contributions to improved livability through the use of more sustainable practices can be quantified by each user. The community as a whole will experience cost savings in terms of safety, mobility, and environmental benefits.

SAFETY - As mentioned above, when the organization managing the winter maintenance operations uses a road decision support system, the number of accidents directly attributable to inclement weather is likely reduced. It is estimated that this reduction can be of the order of 20% in areas where snow storms are common and the need for treating the roads is high. Typically, accidents due to slippery conditions or lack of visibility can involve multiple vehicles and cost an average of \$250,000, not counting the time lost due to the accident. If there is, on average, one less accident per weather event and there are 60 weather events per year as is the case for McHenry County, the community can expect to save about \$13 Million per year through the use of a road decision support system as opposed to guessing when to treat the roads without one. This translates to 52 fewer accidents every year. Likewise, the number of fatalities and serious injuries due to weather related accidents will be reduced by as much as 40%. If, on average, fatalities and serious injuries cost about \$4.2 Million, the community can save about \$22 Million a year if the appropriate treatment of the roads can save five lives every year. Other community benefit related to safety is the improved access for Emergency Vehicles to help people in distress during weather events either due to accidents on the road or other reasons. Savings to the community of over \$35 Million can thus be attributed to improved safety on the roads during inclement weather.

MOBILITY - Improvements in traffic flow are another benefit of better road treatment during weather events. Many factors are responsible for a slowdown in traffic speeds, aside from treacherous conditions. These include congested highways, slow moving vehicles that treat the roads, accidents, and overcapacity due to closures of other roadways. Traffic can have a beneficial effect in road treatment. As more vehicles use the road, the heat created by them helps with melting of snow and ice. However, heavy traffic will also disperse dry materials used to treat the roads, rendering the treatment less effective than intended. It is important to know when to send vehicles out for plowing and treating the roads so the traffic flow and safe traveling speeds can be maximized. Proper use of a road decision support system could positively affect the economy of the community, by increasing safe traffic speeds and actually encouraging business people to go out during inclement weather. McHenry county estimates that average speeds on the highways can be increased 20 MPH and the number of cars will increase by 10% after proper road treatment has taken place. On a \$15 Billion economy, the number of driving hours saved would be over 5 million, which translates to an economic benefit of over \$200 Million during the winter season. Another benefit to improved traffic flow is easier access to hospitals, schools, libraries and other public places that contribute to a higher quality of life in the community.

ENVIRONMENT - An often disregarded benefit of using a road decision support system is the benefit to the environment arising from the lower usage of vehicles, the lower usage of chemicals on the road that may get into the water stream, and the smoother traffic flow that reduces start-stop activities that create much pollution. Drinking water standards are constantly being challenged by the amount of pollutants in the water. One of the main pollutants is attributed to salt used for winter road maintenance operations. Recommendations given by a Roads Decision Support System should optimize the use of materials to increase the friction on the road, while minimizing the amount used, which in turn minimizes pollution and direct costs. Even though there will be more automobiles on roads which presumably are clearer and easier to navigate with a road decision support system in use, the start-stop action produces much more [NOx/VOC/CO and CO2 Emissions](#) than cars driving the same distance at more constant speeds. It is estimated that the McHenry County community will see savings of over \$1 Million in one winter season.

INDIRECT BENEFITS - Other indirect benefits of using a DSS can be expressed in terms of efficiency, publicity, and safety. These benefits may not have a direct translation to a monetary value except for saving time to the individuals who use it, but they provide accountability and tracking benefits which can prove invaluable at a later day in the not too distant future, not just from a liability perspective, but also regarding to continuous improvement of processes, operator and decision maker training, budgeting for next year, trend analysis, and more.

OTHER EFFICIENCY BENEFITS

Performance and Cost: We have already seen how the use of a road decision support system will improve performance or reduce cost both at the user level as well as in the community. Advantages of advanced systems help you select the right treatment materials to use for changing conditions, as well as helping with treatment vehicle utilization selection. When there is no need to treat with materials, only send the plows. For pre-treatment activities don't send the heavy plows. Knowing when to do each one saves time and money.

Status Reports: In order to track resources in general, including year to date expenses, driving times for maintenance operators, contractor use, and materials use, a complete set of reports is very beneficial. These reports include:

- Budgeting reports
- Trend analysis reports
- Material usage vs. cost reports
- Restock alerts reports
- Historical Reports
- Current conditions Reports
- Forecast Reports

Better Planning: A road DSS application will certainly help with planning such activities as weed spraying, cleanup, and general operations. A good system will also keep track of decisions made, justification from deviations, and results. The ability to show both atmospheric forecasts and road forecasts from 3 hours out to 3 days out, will also simplify and improve planning activities, communications, and readiness.

Performance Tracking: The ability to track decisions, actions taken and results, will allow the users of road decision support systems to record driver hours, communicate better with all personnel involved in Operations, track key performance indicators to measure contractors and optimize those expenses. In addition, performance tracking allows for forecast verification and improved forecast accuracy, because it shows which forecasts were accurate under what conditions, and gives the forecast provider valuable data needed to improve their performance. This is true for both atmospheric forecasts and road forecasts.

Streamlined Operations: Using a web based system that minimizes logins, screens, and the use of multiple applications, will not only simplify the decision making process, but will also make a decision recommendation based on the users' policies continuously available with factual objective data (RWIS).

OTHER PUBLICITY BENEFITS

Transparency: As explained above, a good road decision support system will allow for a comprehensive maintenance plan that will stand scrutiny in legal engagements. The availability of such a plan on an external web site can prove beneficial to keep media relations in good standing. The ability to publish information relevant to road maintenance is actually required in some countries, and such a system can automate those activities.

Marketing: This can be a very valuable tool for users who have Toll Road responsibilities. It is a good way to reassure drivers that the roads are safe because of advanced technology being used in some highways that have the ability to sense road conditions, forecast near term conditions with high accuracy, and enable optimized treatment of the pavement in preparation for, during, and after a weather event takes place.

OTHER SAFETY BENEFITS

Safety: Better planning provides better information. Better communication enables that information to reach the community, which increases the safety on the roads through more accurate expectations, or less surprises.

SUMMARY - The benefits addressed in the previous sections have been entered into an Evaluation Value Tool (EVT), a web based tool known as RoadDSS Value Calculator Figure 1 below shows the introductory and input page, which also allows for currencies to be specified, so that the tool can be used in different countries.

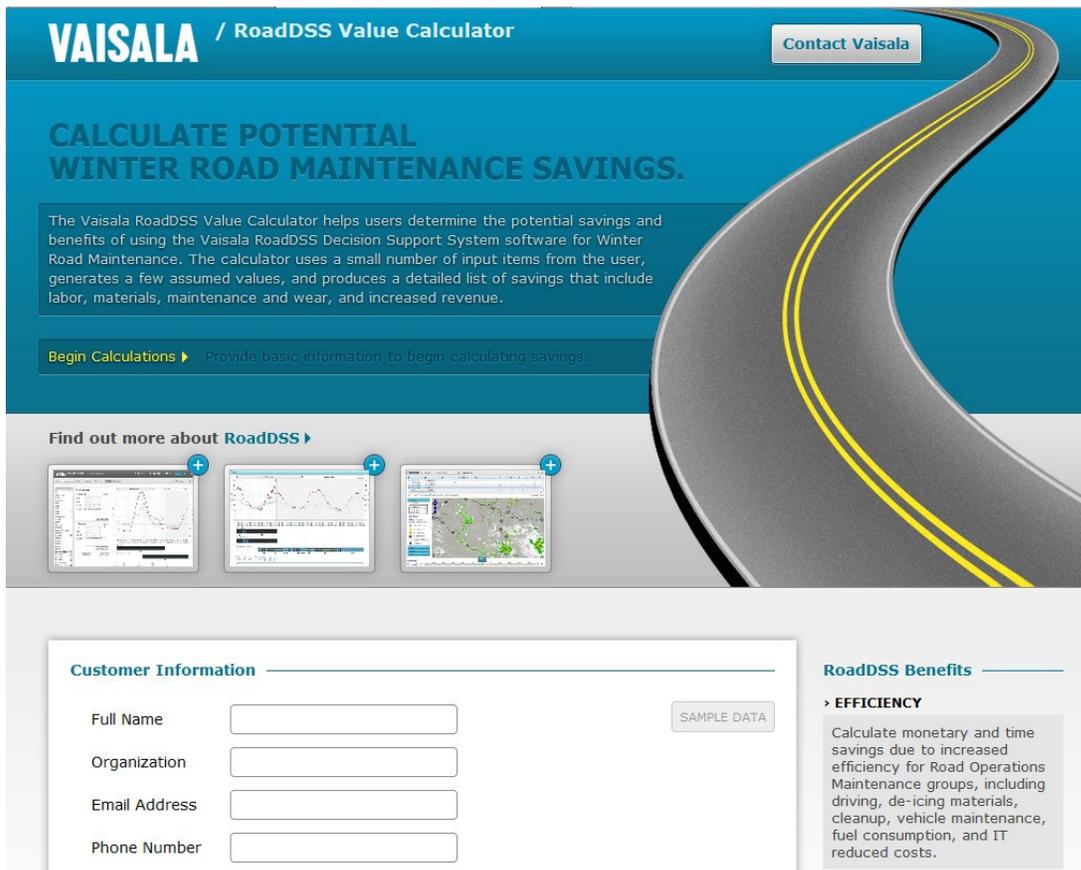


Figure 1 - EVT Introductory Page

CONCLUSION

The Economic Value Tool will enable road authorities to make rapid assessments of the benefits that RWIS and Road Decision Support Systems bring, and assist with convincing and spreading the word to non-experts that there is a real value in investing in systems that ultimately save both lives and money.

The tool allows for localized assessment of savings at the maintenance organization level and at the community level. It shows potential benefits for the local economy in terms of savings, and for the environment (reduced transportation related pollution, chemical use).

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