Development of a Method to Determine Pavement Damage Due to Detours

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The research presented in this report provides the basis for the development of a new procedure to be used by the Iowa DOT and cities and counties in the state to deal with detours. Even though the project initially focused on investigating new tools to determine condition and compensation, the focus was shifted to traffic and the gas tax method to set the basis for the new procedure. It was concluded that the condition-based approach, even though accurate and consistent condition evaluations can be achieved, is not feasible or cost effective because of the current practices of data collection (two-year cycle) and also the logistics of the procedure (before and after determination).

The gas tax method provides for a simple, easy to implement, and consistent approach to dealing with compensation for use of detours. It removes the subjectivity out of the current procedures and provides for a more realistic (traffic based) approach to the compensation determination.

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DEVELOPMENT OF A METHOD TO DETERMINE PAVEMENT DAMAGE DUE TO DETOURS

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1 INTRODUCTION

Secondary roads and municipal streets are often used as temporary detours by the Iowa Department of Transportation (Iowa DOT) during construction or maintenance projects on primary highways.

The current Iowa DOT method for determining pavement damage resulting from increased traffic loading is based on the American Association of State Highway and Transportation Officials (AASHTO) Road Test formulas for the calculation of a Present Serviceability Index (PSI) developed in the 1950s. This procedure, used by the Iowa DOT to calculate the PSI, relies on subjective measures of damage (cracking and patching) collected using a windshield survey. It also relies solely on a functional evaluation of the pavement surface.

Advances in pavement condition data collection technologies make it feasible to gather more objective and consistent pavement damage information. Alternatively, other techniques, which do not rely on pavement damage assessment, may serve as equally objective and consistent means to compensate for pavement damage.

2 CURRENT PRACTICES

2.1 Iowa Method

2.1.1 Overview

In accordance with Iowa Code sections 306.41, 313.28, and 313.29, the Iowa Department of Transportation (DOT) must restore municipal or secondary roads used as temporary detours to their pre-detour condition or compensate the local agency for the increased traffic volumes and reconstruct the roadway (if the roadway cannot be restored to the pre-detour condition in any other manner). This practice is outlined in Policy 600.05 of the Iowa DOT Policies and Procedures Manual, with the most recent revision effective January 21, 2004 (Less 1975).

The Iowa DOT uses the Present Serviceability Index (PSI) to evaluate the condition of the pavement before and after the detour and to assess the impact of the detour. The primary components of PSI are the longitudinal profile (pavement smoothness) and surface deterioration (cracking, patching, and rut depth).

Even though the bulk of the work in this project focused on detours, the researchers investigated the haul roads issue and determined that the existing practices in terms of the "dust-control agreement" works for all parties involved. The dust control is referenced in the Iowa Code section 313.4 (The department may expend moneys from the fund for dust control on a secondary road or municipal street within a municipal street system when there is a notable increase in traffic on the secondary road or municipal street due to closure of a road by the department for purposes of establishing, constructing, or maintaining a primary road).

2.1.2 Methodology

PSI is a function of pavement smoothness and surface deterioration. Therefore, the PSI of a pavement segment is established in two parts: 1) determination of the Longitudinal Profile Value (LPV), and 2) determination of the deduction due to the degree of physical deterioration of the segment. The following sections summarize the evaluation and collection techniques used for each input value (Test Method No. Iowa 1004-D).

2.1.2.1 Determination of the Longitudinal Profile Value (LPV)

Historically, the roughness of secondary and municipal road detours was tested with the Bureau of Public Roads (BPR) Roughometer, as outlined in Test Method No. Iowa 1001-C. The resulting BPR values (in inches per mile) were then converted to a LPV using surface type specific correlation equations.

The Iowa DOT currently uses an inertial profiler to objectively measure pavement roughness. The inertial profiler measures roughness/smoothness according to International Roughness Index (IRI) in meters per kilometer. Using surface type specific correlation models described in a 1997 Iowa DOT technical report (MLR-97-7), IRI values are converted to BPR values. The historic BPR-LPV correlation equations are then employed to calculate the longitudinal profile value.

Pre-use and post-use pavement roughness are measured for the entire length of the detour, and the corresponding LPV values are calculated.

2.1.2.2 Determination of the Cracking, Patching, and Rut Depth Deduction

Physical deterioration of the pavement is determined through pre-use and post-use crack and patch surveys along the detour. These surveys are performed on 300-foot representative sections for every two miles of paved roadway, with a minimum of one 300-foot representative section for each flexible pavement section. The survey techniques employed are dependent on the pavement type of the section—flexible or rigid—and are described in the following sections.

2.1.2.2.1 Flexible Pavement

This section presents the condition data collected during the flexible pavement survey (Table 1) and the equation(s) used to calculate the PSI.

Table 1. Flexible Pavement Collection Criteria

Deduction	Definition
Class 2 Cracking, C	The area, in square feet per 1000 square feet of pavement surface, exhibiting alligator or fatigue cracking (cracks have connected together to form a grid-type pattern)
Class 3 Cracking, C	The area, in square feet per 1000 square feet of pavement surface, exhibiting loosening of surfacing segments
Longitudinal Cracking, L	The number of longitudinal cracks exceeding 100' and 1) are open to a width of ¼" over half their length or 2) have been sealed
Transverse Cracking, T	The number of transverse cracks that 1) are open to a width of ¼" over half their length or 2) have been sealed
Faulting, F	The mean vertical displacement, in inches, measured with a 4-ft straightedge
Patching, P	Square feet per 1000 square feet of pavement surface exhibiting repair by skin or full depth patching
Rut Depth, RD	The mean depth of rutting, in tenths of an inch, in both wheel paths under a 4-foot straight edge
Additional Cracking, C_1	Additional linear feet of transverse and longitudinal cracking per 1000 square feet of pavement between the initial and final detailed crack and patch surveys. Only applied if the difference is greater that 150 linear feet per test section. Projected over entire detour length.

The following equation is then used to determine the PSI for flexible pavements:

$$\mathbf{PSI_{Initial} = LPV - \boxed{0.01*(C + P)^{1/2} - 2.0*RD^2}} \text{ — PSI Deduct}$$

$$\mathbf{PSI_{Final} = LPV - \boxed{0.01*(C + P)^{1/2} - 2.0*RD^2 - 0.01*C_1}} \text{ — PSI Deduct}$$

Where: PSI = Present Serviceability Index

$$C = \frac{Cracking,\ ft^2}{\frac{(DetourLength,\ ft * PavementWidth,\ ft)}{1000}}$$

$$P = \frac{Patching,\ ft^2}{\frac{(DetourLength,\ ft * PavementWidth,\ ft)}{1000}}$$

C + P = Measure of cracking and patching of the pavement
LPV = Longitudinal Profile Value
RD = Measure of pavement rutting in the wheel paths
C_1 = Measure of additional cracking

2.1.2.2.2 Rigid Pavement

This section presents the condition data collected during the rigid pavement survey (Table 2) and the equation(s) used to calculate the PSI.

Table 2. Rigid Pavement Collection Criteria

Deduction	Definition
Class 3 Cracking, C	The total linear feet of crack per 1000 square feet of pavement surface that is opened to a width of 0.25" or more over a distance equal to one-half the crack length. The length is the greater of the crack's projection parallel or perpendicular to the pavement centerline.
Class 4 Cracking, C	The total linear feet of crack per 1000 square feet of pavement surface that has been sealed
Patching, P	Square feet per 1000 square feet of pavement surface exhibiting repair of the pavement surface by skin or full depth patching

The following equation is used to determine the PSI for rigid pavements after evaluation of the roadway section:

$$\mathbf{PSI = LPV - \boxed{0.09*(C + P)^{1/2}}} \text{ — PSI Deduct}$$

Where: PSI = Present Serviceability Index

$$C = \frac{Cracking,\ ft}{\dfrac{(DetourLength,\ ft * PavementWidth,\ ft)}{1000}}$$

$$P = \frac{Patching,\ ft^2}{\dfrac{(DetourLength,\ ft * PavementWidth,\ ft)}{1000}}$$

LPV = Longitudinal Profile Value

C + P = Measure of cracking and patching of the pavement

2.1.3 Reimbursement

The PSI is determined for a pavement section before and after its use as an off-site detour. Differences resulting from increased roughness and physical deterioration can then be used to determine the loss of service life of the pavement section. Increased faulting, longitudinal cracking, and transverse cracking may also be used to evaluate loss of pavement service life. This loss of service life can then be converted to “years of service life lost.”

PSI-based reimbursement to local agencies is based on the difference in capitalized worth between the adjusted service life and the original service life. Additional compensation may be provided for the cost of repairable damage not corrected by the Iowa DOT. No standard procedure is utilized to determine the level of repairable damage compensation.

The compensation amount is established through negotiations between the local representative and the Iowa DOT.

Lastly, the Iowa DOT will reimburse the local agency for increased surface maintenance prior to the calculated date of resurfacing. A maintenance cost of $20.00 per mile per year is employed.

2.2 Midwest States

2.2.1 Illinois

Before construction and use of a local road as a detour, an intergovernmental agreement is reached, which generally specifies that the state will restore the route to its pre-detour condition. No formal method exists to determine the loss of serviceability due to the increased traffic. However, the pre-existing condition of the roadway may be recorded through a video log of the route. Local agencies are typically not monetarily compensated for use of their roadways as a detour; the road is simply restored to its pre-detour condition. The state also agrees to the routine maintenance of the route while it is used as a detour.

2.2.2 Nebraska

Nebraska has no formal policy regarding compensation for local roads used as detour. Local agencies are generally not monetarily compensated for use of their roads as detour routes. Routes are simply restored to their pre-detour condition. In some cases, the pavement is mechanically tested before and after use as a detour route. The roughness is tested using a South Dakota Type (SDT) profiler, and a windshield survey is conducted to determine patching and cracking. These values are then used in the Nebraska Serviceability Index (NSI) in much the same way as the Present Serviceability Index (PSI) is used in Iowa.

2.2.3 Kansas

Kansas currently has no formal guidelines regarding compensation to local agencies for use of their roadways as a detour route. Generally, a DOT representative and a local engineer inspect the route prior to using it as a detour, and a verbal agreement is made to restore the route to the pre-detour condition. The route is typically not video logged before using it as a detour, and no serviceability index is calculated. Additionally, no formal document is used for the agreement or for observational inspection of the detour route. In some cases, the road is overlaid before or after its use as a detour route. In most cases, the route is simply patched as needed. The local agency is not monetarily compensated for future service life lost. Local routes have only recently been utilized and recognized as detours for state routes.

2.2.4 South Dakota

South Dakota currently has no formal method to monetarily compensate local agencies for use of their roadways as a detour route. Before the detour is initiated, an intergovernmental, observation-based inspection is conducted. No mechanical testing, video logging, or serviceability measurement techniques are employed. Restoration of the route to pre-detour condition is agreed upon and is the equal responsibility of the contractor and the DOT. No monetary compensation is provided to the local agency for loss of service life; payment is given in the form of restoration. Likewise, future damage is not taken into account. Any future repairs as a result of route use are the responsibility of the local agency.

2.2.5 Missouri

In Missouri, it is very rare to detour a state route onto a local or municipal roadway. When a local road is used as a detour, the route is often overlaid prior to use as a detour in preparation for increased traffic. The contractors are responsible for providing routine maintenance and repairs to the roadway at their cost. However, if the structural integrity of the route is insufficient, the DOT will make necessary repairs at their cost. There is no mechanical system or index employed to determine loss of service life of the detour route. When a local route is used, the actions necessary for using it as a detour are mutually agreed upon by a DOT representative and the local engineer. As stated previously, this action is often taken before using the road as a detour. Local agencies work in conjunction with the DOT to ensure that the route is restored to its initial condition.

2.2.6 Wisconsin

Wisconsin currently does not have a formal method of determining pavement service life lost due to use of a local road as a detour. Representatives of the local agency and the DOT create a log indicating the condition of the roadway prior to its use as a detour. However, no formal document exists for this. The pre- and post-detour condition of the pavement is evaluated through observation only; no formal testing or index is used. On occasion, the route is video logged prior to its use as a detour. While using it as a detour route, the state maintains the roadway. Generally, it is agreed that the route will be restored to its pre-detour condition after its use. Local agencies are not routinely compensated for use of the route as a detour. Additionally, Wisconsin does not typically use non-state highways as detour roads, even if these roads provide better, more efficient access. When local routes, not designated as detours, are used in place of official detour routes, no compensation is given to local agencies for unofficial use of their routes.

2.2.7 Minnesota

The Minnesota DOT (Mn/DOT) employs two methods for reimbursing local agencies for use of their roadways as a state detour route (Mn/DOT 1991, 1995, 1996). The first method is the Gas Tax Method, which is intended to account for the road life lost as a result of the detour. The Gas Tax Method is based on the gas tax income generated from

traffic using the detour. This method is utilized for most local roads being used as detours by the Mn/DOT, except when compensation is expected to be less than $500.

Throughout the life of the detour, Mn/DOT is responsible for signing, striping, and ordinary maintenance. These responsibilities may be addressed as pay items in the contract by Mn/DOT maintenance personnel and operating funds or included in an agreement with the local agency. Because of staff and equipment limitations, Mn/DOT may not be able to perform the required ordinary maintenance. In such instances, the local agency may be compensated for maintenance of the roadway through the gas tax method, the gas tax method plus 15% (for roadways in poor condition), or at a flat rate of $500/mile/month.

If the local agency does not feel that the Gas Tax Method will provide adequate compensation for the incurred reduction in pavement life, they may perform an Equivalent Overlay Method (EOM) analysis before the detour route is used. EOM analysis is typically performed when the local agency feels that the road is in poor condition and will be significantly impacted by the detour. Local agencies are responsible for the EOM testing and analysis costs (by a Mn/DOT approved firm), which may cost $3,000 to $4,000. Therefore, additional compensation may be negated by the cost of performing the test. The EOM determines the equivalent overlay required on the road so it is not greatly affected or damaged by the detour traffic. Mn/DOT then provides compensation for computed values in excess of twice the gas tax computations, in addition to the gas tax method. Like Iowa’s PSI-based method, the EOM may be influenced by weather and season.

3 COMPENSATION STRATEGIES

Based on the review of the compensation practices of Iowa and seven other Midwestern states, it is apparent that the compensation strategies of the Iowa and Minnesota DOT's are the most fully developed. Specifically, all other states simply establish a formal or informal interagency agreement for the State to restore the detour route to its pre-detour condition. In most cases, the pre-existing condition is assessed through visual observation only, with little or no mechanical testing or measurement techniques employed.

The two compensation strategies outlined in this section are pavement damage (condition) based and traffic (gas tax) based. Both Iowa and Minnesota use condition-based approaches for determining the loss of road life resulting from the detour. However, the Iowa DOT uses before and after condition assessments, while Mn/DOT simply conducts an assessment before the detour. Additionally, the preferred compensation approach in Minnesota is a gas tax based approach.

3.1 Pavement Damage (Condition) Based

The pavement damage method is similar to what the Iowa DOT is currently utilizing (measure condition both before and after the detour), but using more consistent and objective methods and procedures to accomplish the evaluation of condition. The pavement damage method is based on developing a relationship between pavement condition and the value of the pavement (see Figure 1).

Figure 1 shows the relationship between the pavement condition and its value. These curves would have to be developed for different pavement types and traffic levels. The pavement condition can be expressed in different measures, including the following:

- Functional distress (Pavement Condition Index – PCI)
- Structural (Falling weight)
- Roughness (Ride – IRI) and rutting

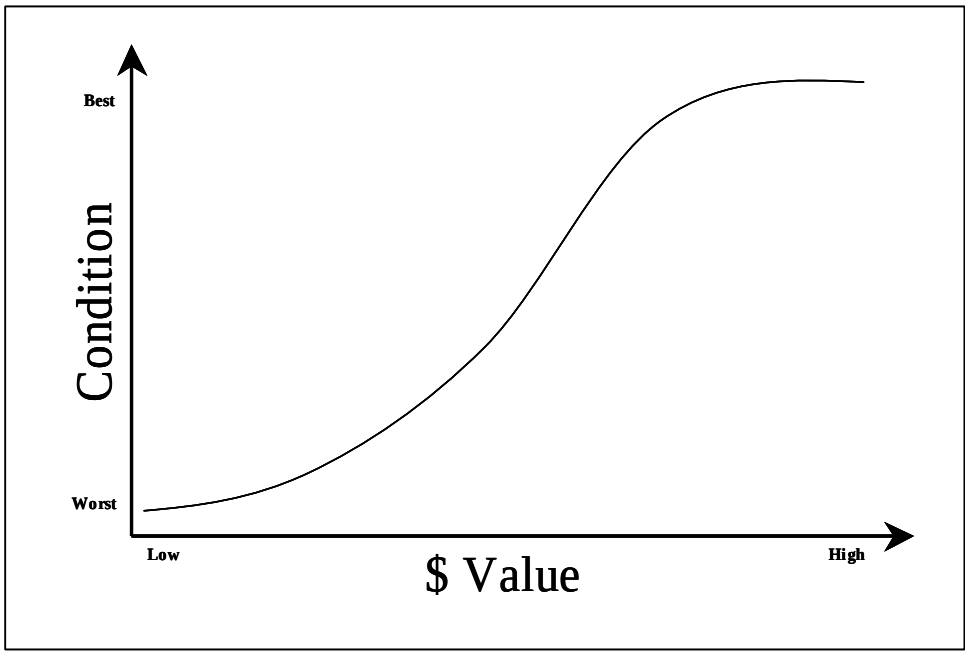

Figure 1. Condition/Value Correlation

A combination of the three measures can be also used to develop the condition/value relationship. Whichever condition measure is selected, the pavement condition needs to be evaluated before and after the detour road is used in a consistent, objective, and cost effective way. When the researchers looked at the available options in terms of condition evaluation, it was concluded that this option would not be very feasible to implement.

The original idea was to have Roadware (the contractor collecting pavement condition information for the Iowa Pavement Management Program [IPMP]) collect the same information on detour roads. Several issues needed to be addressed to make this feasible. A list of these issues is as follows:

- Roadware collects condition data in Iowa on a two-year cycle, with the northern half of the state done in even years and the southern half in odd years. This implies that additional transportation costs are needed to cover segments that fall outside the collection cycle if they happen to be a detour road.
- Since condition needs to be evaluated before and after, it means Roadware has to go back to the same location twice. Even if it is in the collection cycle for that year, it will still mean more transportation cost.
- Roadware is working on a schedule to finish the data collection in a period of 5 months (late spring to early fall). Adding the detour roads, especially off the cycle segments, would not only increase the time, but will also increase the cost for the Iowa DOT and local agencies.

Based on these issues, it was determined that the pavement damage (condition) based method would not be feasible to implement under the current circumstances.

3.2 Traffic (Gas Tax) Based

The following excerpt from Mn/DOT Detour Management Study, January 1991, best describes the basis of the traffic (gas tax) compensation method:

> All gas tax income raised by any road authority is generated by traffic using some specific road segment.
>
> When traffic that normally uses one road segment is detoured to a road segment owned by another jurisdiction, the income generated by this traffic is made available to the owner or jurisdiction of the accepting roadway.
>
> Computation of the gas tax generated by detoured traffic involves applying the gas tax paid per mile by the detoured traffic to the total vehicle miles traveled over the length and duration of the detour. (Mn/DOT 1991)

The local detour is considered a primary roadway throughout the duration of the detour. Therefore, through the gas tax method, the revenue generated by traffic using the detour is returned to the local agency. However, since only a portion of the state and federal gas tax is designated for highway use, the compensation provided to the local agency is not the entire gas tax income. Definition of this "highway" portion of the gas tax is one of the four primary components of the gas tax method. The other components are: vehicle miles of travel on the detour, fleet fuel economy, and state and federal gas tax rates. Each component entails various data elements and assumptions, which are discussed in the following sections.

3.2.1 Vehicle Miles of Travel

Vehicle miles of travel (VMT) is a measure of roadway use. In the gas tax method, VMT is the product of the length of the detour, duration of the detour, and traffic volume along the detour.

VMT = Detour Length (mi) * Detour Duration (days) * Traffic Volume

While the length and duration of the detour are easily determined from the construction plan, the traffic volume using the detour may not be as easily estimated. The traffic volume on the detour may be influenced by a number of factors, such as length and duration of the detour, traffic characteristics (local v. through traffic), seasonal variations, and alternate route availability. Furthermore, the detoured roadway may not possess a constant traffic volume throughout its extent. Therefore, an approach to estimating traffic volumes must be defined. For example, traffic volumes along the detour can be measured before, after, or during its use, or a proportion of the average annual daily traffic (AADT) along the detoured roadway can be assumed to utilize the detour. If the detour traffic volumes are to be measured, the agency responsible for data collection must also be defined.

3.2.2 Fleet Fuel Economy

To determine the fuel consumption attributable to the detour, the average fuel economy for the vehicles must be defined. Average fuel economy may be defined for each vehicle type using the detour or for the vehicle fleet in general. Use of vehicle type specific fuel economies would require significantly more detail in traffic data collection. Therefore, definition of an average fleet fuel economy is recommended. This value should be used as a standard for all gas tax computations.

Several approaches may be utilized to define average fleet fuel economy. One approach is to consider system-wide fuel use and travel characteristics (VMT). Using these data, the average fuel efficiency for different vehicle types, e.g. passenger cars and combination vehicles, can be calculated. Given these values and the proportion of system-wide travel associated with each vehicle type, weighted average fleet fuel economy can be estimated.

Another approach is to use values published by the Environmental Protection Agency (EPA), National Highway Traffic Safety Administration (NHTSA), or Federal Highway Administration (FHWA). However, these fuel economy estimates are for passenger cars and trucks only. EPA estimates are performance-based, while the NHTSA values are based on Corporate Average Fuel Economy (CAFÉ). FHWA fuel economy estimates are presented in the annual Highway Statistics and are calculated in a manner similar to first approach described.

The fleet fuel economy value may need to be reviewed and adjusted annually to account for changes in the fleet.

3.2.3 Gas Tax Rates

While state and federal gas tax rates are readily available, different fuel types (gasoline, gasohol, and diesel) are taxed at different rates. Two approaches may be used to define the appropriate state and federal fuel tax rates: 1) a single, average gas tax for all fuel types can be defined, or 2) the standard tax rate for a single fuel type can be used. Independent state and federal rates should be defined in both of these approaches.

Average state fuel tax values may be calculated based on fuel consumption trends within a state. Given the tax rate for each fuel type and the portion of total fuel consumption attributed to each type, an average fuel tax rate can be calculated. However, fuel consumption trends may vary. Moreover, in some states, such as Iowa, the gas tax rate for gasoline and ethanol-blended gasoline may change annually, depending on the percentage of ethanol-blended gasoline sold. The average state gas tax value may need to be reviewed and adjusted annually to account for tax rate and/or consumption changes.

Average federal fuel tax values may be calculated in a manner similar to the average state fuel tax. As on the state level, federal gas tax rates are fuel type dependent. Additionally, only a portion of the total federal gas tax for each fuel is designated for highway use (Highway Trust Fund Highway Account). Federal gas tax based revenues are distributed

to states independent of fuel type consumption within the state. Therefore, the average federal gas tax rate should be based on national fuel consumption trends. The federal gas tax may also need to be reviewed and adjusted annually to account for legislative changes.

3.2.4 Portion of Gas Taxes Applicable to Highways

Not all revenue generated from state and federal gas taxes is allocated for highway use. Therefore, not all gas tax revenue generated along the detour should be returned to the local agency. The gas tax revenue provided to the local agency should be limited by the percentage of the gas tax applicable to highways, specifically for maintenance and improvement activities. These percentages, on the state and federal levels, are generally not clearly defined. Additionally, federal gas tax based revenues are distributed to states independent of fuel type consumption within the state. States may receive less revenue than contributed (donor states), more revenue than contributed (recipient state), or revenue approximately equal to the contribution.

Given state and federal statute, past funding trends, and assumptions regarding Highway Trust Fund (Highway Account) distribution status, estimates of the percentages of gas taxes applicable to highway maintenance and improvement must be derived.

3.2.5 Mn/DOT Gas Tax Method Example

Mn/DOT's gas tax method was first defined in 1991. Since 1991, only minor modifications to the original methodology have been adopted.

3.2.5.1 Assumptions

The Mn/DOT gas tax method employs six primary assumptions. All original assumptions have remained unchanged since implementation of this methodology, although fuel taxes have changed during this time period. These assumptions are used to calculate the net state gas tax, net federal gas tax, and a combined tax factor, which are also presented in this section.

- The average fleet mile per gallon is **17.5 mpg** (recommended by the Office of Highway Programs).
- The current state gas tax is **20 cents per gallon** ($\mathbf{S_t}$). (Used to calculate the net state gas tax.)
- The constitutional provision limiting the state's portion of the gas tax income will remain unchanged, at **62%**. (Used to calculate the net state gas tax.)
- The Federal gas tax is **14 cents per gallon** ($\mathbf{F_t}$), with **8 cents per gallon** available for highway use ($\mathbf{F_t - 0.06}$). Only **7.2 cents per gallon** is used on Federal Aid System highways ($\frac{7.2}{8} = \mathbf{0.9}$). (Used to calculate the net federal gas tax.)
- Minnesota receives **100 percent** of the Federal Gas Taxes generated in the State.
- The amount of State and Federal Gas Tax Incomes available for roadbed improvements on non-interstate segments and assignable to another jurisdiction, if

such a segment is detoured, is **35% (F_f,F_s)**. (Used to calculate the net state and federal gas tax.) (Mn/DOT 1991)

- Net State Gas Tax = 0.62 * S_t * F_s
- Net Federal Gas Tax = 0.9 * (F_t – 0.6) * F_f
- Combined Tax Factor = Net State Gas Tax + Net Federal Gas Tax

3.2.5.2 *Gas Tax Income Generated by Detour (I)*

The gas tax income generated by the detour is calculated using the detour parameters (length, duration, and traffic volume), average fleet fuel economy, and the combined tax factor presented in the previous section. Since the combined tax factor and fleet fuel economy are constants, the only variables in the gas tax income equation are detour length, duration, and traffic volume.

$$I = \frac{ADT * Length(mi) * Time(days)}{mpg(fleetwide)} * Combined_Tax_Factor$$

$$I = 0.00392 * ADT * Length(mi) * Time(days)$$

3.2.6 Limitations and Caveats

While the proposed gas tax approach is consistent and objective, several interrelated assumptions are required to perform the analysis. As discussed previously, the definition of individual assumptions may be met with varying levels of difficulty. Furthermore, some assumptions have a far greater impact on the final analysis results than others.

The basis for the gas tax approach, returning the gas tax revenue generated along a roadway to the appropriate highway-operating agency, is not a standard practice. A systems-level approach to highway funding is typically employed. The funding available for different functional classes of roadway is considered collectively and then redistributed throughout the system to individual projects or roadways through a prioritization or needs-based approach. In other words, if the primary road were not detoured, the gas tax income generated by it would not likely be directly used for its maintenance, improvement, or repair.

4 PROPOSED METHODOLOGY

In this section, a new approach to compensate local agencies for pavement damage and road life lost resulting from a primary detour will be outlined. The basis for this approach is the gas tax method.

4.1 Assumptions

The first step in creation of a new, gas tax based compensation approach is to define all appropriate data elements, data acquisition methodologies, and assumptions. The assumptions presented in this section may be reevaluated or adjusted as additional information becomes available or other factors are considered.

4.1.1 Vehicle Miles of Travel

The three primary elements required to estimate detour use (vehicle miles of travel) are the length of the detour, duration of the detour, and traffic volume along the detour. It is recommended that the detour length be obtained from the construction plans or measured in the field using an in-vehicle distance-measuring instrument (DMI). Detour duration should be measured by the actual number of days that the detour was in use. Therefore, the reimbursement contract should not be finalized until project completion. A preliminary contract may be drafted based on the proposed project duration and corresponding active detour use.

It is recommended that the most recent Iowa DOT (Office of Transportation Data) data of traffic volumes along the detoured roadway be utilized to estimate the traffic using the detour. If the traffic volumes change along the detoured route, a weighted average traffic volume, based on volume and road segment length, will be calculated and applied. All vehicles using the detoured road will be assumed to use the detour. While this assumption may not be entirely accurate, it may help account for damage to other local roads used as alternate routes but not officially designated as the detour.

If the available traffic volumes are more than two years old, the local agency may request that the Iowa DOT collects traffic data along the detoured route, using standard Office of Transportation Data traffic collection procedures. Additionally, if the local agency questions the accuracy of the Iowa DOT traffic volumes for the detoured route, it may collect traffic data along the route at its expense. Both the Iowa DOT and the local agency must mutually accept the traffic volumes ultimately used for VMT calculations. The interagency contract will be delayed until the traffic volumes are formally accepted by both agencies.

Vehicle miles of travel (VMT) will be calculated using the following equation:

$$\text{VMT} = \text{Detour Length (mi)} * \text{Detour Duration (days)} * \text{Traffic Volume}$$

4.1.2 Fleet Fuel Economy

An average fleet fuel economy will be used to eliminate the need for class specific traffic volume data. This average fleet fuel economy will be based on Iowa Department of Revenue fuel consumption trends, by fuel type, and Iowa DOT Office of Transportation Data travel (VMT) trends, by vehicle class. Average fuel economy in Iowa from 1999 to 2002 is approximately **17 mile per gallon**. This value is also consistent with national trends. See Appendix A, section 1, for additional details.

The fleet fuel economy value may need to be reviewed and adjusted annually to account for changes in the fleet.

4.1.3 Gas Tax Rates

A single, average state gas tax, for all fuel types will be utilized. This rate will be based on the current state gas tax rates (gasoline, gasohol, and diesel) and Iowa Department of Revenue fuel consumption trends, by fuel type. Average state gas tax in Iowa beginning in 2000 is approximately **20.3 cents per gallon**. See Appendix A, Section 2, for additional details. The average state gas tax value may need to be reviewed and adjusted annually to account for tax rate and/or consumption changes.

A single, average federal fuel tax, for all fuel types will be utilized. This rate will be based on national fuel consumption trends, by fuel type, and the portion of the fuel tax designated for the Highway Trust Fund, Highway Account. Assuming that the majority of gasoline used nationwide is not ethanol-blended, the average federal gas tax is approximately **16.8 cents per gallon**. See Appendix A, Section 3, for additional details. The federal gas tax may also need to be reviewed and adjusted annually to account for legislative changes.

4.1.4 Portion of Gas Taxes Applicable to Highways (Net Gas Taxes)

Approximately **5.0 cents per gallon** of the average state gas tax is assumed to be available for highway improvement projects and maintenance on the primary road system. This value represents the net state gas tax. This value is based on the 47.5 percent allocation of the Iowa Road Use Tax Fund (RUTF) to the Primary Road Fund and past Iowa Five Year Program distribution trends of this funding (*In 2003, the Iowa DOT allocated 1.75% of their RUTF to cities and counties for the purposes transfer of jurisdictions roads. This allocation has no significant impact on the calculations of the portion of gas tax applicable to highways and will not change the final results*). Specifically, past Program trends suggest that roughly half of the Primary Road Funds are used for highway improvement projects and maintenance on the primary road system. Additionally, since the local detour routes are considered a primary roadway during their use, they fall under the 47.5 percent primary road RUTF allocation, instead of the city, secondary, and street fund allocations. See Appendix A, Section 4, for additional details. This value may need to be reviewed and adjusted annually to account for legislative and/or distribution changes.

Approximately **5.0 cents per gallon** of the average federal gas tax is assumed to be available for highway improvement and maintenance on the primary road system. This value represents the net federal gas tax. The value was based on three primary trends: 1) Iowa's reimbursement level from the Federal Highway Trust Fund, Highway Account for 2001 and 2002; 2) the percentage of Iowa's reimbursement which is attributable to fuel taxes; 3) the percentage of Iowa's reimbursement that has been directed to the National Highway System (NHS) and Surface Transportation Program (STP-applicable to primary roads only) for 2001 and 2002. Since new highway funding legislation was enacted in 2001, the most recent available apportionment data (2001 and 2002) were utilized in trend assessment.

Historic trends indicate that Iowa is neither a donor nor recipient state. The majority of the revenue from the Federal Highway Trust Fund, Highway Account, is generated through gas taxes—over 80% in Iowa and nationwide. Lastly, approximately 30% of Iowa's reimbursement from the Highway Account has been directed to the National Highway System and STP funds applicable to the primary system. See Appendix A, Section 5, for additional details. This value should be reviewed and adjusted annually to account for legislative and/or apportionment changes.

Summing the state and federal net gas tax values yields the combined tax factor of **10.0 cents per gallon** or **0.10**. This value is approximately three cents per gallon higher than the combined tax factor that the Mn/DOT uses, which is **0.0686**. The majority of the discrepancy results from the net federal gas tax. Specifically, Mn/DOT has not adjusted their combined tax factor since 1991, while the federal gas tax has increased by over four cents per gallon.

4.2 Gas Tax Income Generated by Detour (I)

The gas tax income generated by the detour is calculated using the detour parameters (length, duration, and traffic volume), average fleet fuel economy, and the combined tax factor presented in the previous section. Since the combined tax factor and fleet fuel economy are constants, the only variables in the gas tax income equation are detour length, duration, and traffic volume.

$$I = \frac{ADT * Length(mi) * Time(days)}{mpg(fleetwide)} * Combined_Tax_Factor$$

$$I = \frac{ADT * Length(mi) * Time(days)}{17mpg} * 0.10$$

$$I = 0.00588 * ADT * Length(mi) * Time(days)$$

5 METHODOLOGY COMPARISON

To compare the new methodology to the existing practice of the Iowa DOT, a number of recent detours (23), ranging in length from one-half mile to over twelve miles and in duration from five days to over nineteen months, were reviewed, and the resulting monetary compensation was compared to the proposed gas tax method (see Table 3). For over half (12) of the agreements, Iowa DOT compensation was based primarily (50% or more), or solely, on the repairable damage component of the agreement. Specifically, in six of these agreements, no loss of service life compensation was provided. As mentioned earlier, there is no standard method or procedure to determine the repairable damage component, which makes the current practice more subjective.

The gas tax method provided less compensation than the Iowa DOT contract in almost half (11) of the agreements included. The total compensation provided by the Iowa DOT in five of these agreements was less than $1,000 each. Additionally, the duration of these detours was approximately a month or less (except for one).

The gas tax method provided more compensation than the Iowa DOT contract in 12 of the agreements. Gas tax method compensation varied and there was really no identifiable pattern to the results other than the fact that the detour period in most of these cases was three months or higher.

The most surprising result was the fact that the total resulting compensation for both methods for all the agreements differed only by $2,323 out of a total of over $460,000 in total agreements. Even though the research team considered 23 agreements covering varied lengths and detour periods, a definite conclusion could not be determined concerning the financial impact of the new methodology on both the Iowa DOT or cities and counties.

Table 3. Example sections comparison

Year	Length (mi)	AADT	Duration (Days)	Iowa DOT Compensation ($)				Gas Tax ($)	Difference ($)
				Loss of Service Life	Repairable Damage	Increased Maintenance	Total		
1999	2.925	3,090	61	7,242.76	14,897.50	85.58	22,225.84	3,241.84	-18,984.00
2000	1.9	4,200	143	101.00	1,484.00	18.00	1,603.00	6,709.90	5,106.90
2000	0.96	11,550	35		3,400.00		3,400.00	2,281.91	-1,118.09
2000	0.48	7,275	9		675.00		675.00	184.80	-490.20
2000	0.65	870	33	268.33			268.33	109.73	-158.60
2000	10.4	5,350	137	12,254.14			12,254.14	44,821.36	32,567.22
2000-2001	8.3	4,230	578	15,751.91	150,725.90	1,457.82	167,935.63	119,322.85	-48,612.78
2001	7.2	2,980	10		876.80		876.80	1,261.61	384.81
2001	9.75	3,060	30	737.30	4,670.00	333.05	5,740.35	5,262.89	-477.46
2001-2003	7.63	6,800	451	72,062.46	36,300	73.15	108,435.61	137,590.14	29,154.53
2002	0.48	1,190	14		5,497.00		5,497.00	47.02	-5,449.98
2002	12.279	4,320	75	17,488.73	11,762.17	4,370.31	33,621.21	23,392.97	-10,228.24
2002	0.64	3,480	86	200.00			200.00	1,126.25	926.25
2002	4	7,400	92	12,966.00		168.00	13,134.00	16,012.42	2,878.42
2002	6	6,700	123	41,221.00	2,967.00	98.00	44,286.00	29,074.25	-15,211.75
2002	0.47	7,000	92	607.00	44.00	38.00	689.00	1,779.76	1,090.76
2002	9.42	3,260	86	3,811.92			3,811.92	15,529.03	11,717.11
2003	0.683	8,100	83	1,102.27	1,400	71.40	2,573.67	2,699.98	126.31
2003	0.174	5,700	83		1,300		1,300	484.04	-815.96
2003	0.5	5,900	166	1,186.29	9,560.10		10,746.39	2,879.44	-7,866.95
2003	11	3,200	176	25,416.85	2,587.13		28,003.98	36,427.78	8,423.80
2003	7	3,320	116	660.33	902.56		1,562.89	15,851.54	14,288.65
2004	7	2,070	5					426.01	426.01
Grand Total							$468,840.76	$466,517.51	-$2,323.25

6 IMPLEMENTATION PLAN

For this new process to be implemented, several issues need to be discussed and agreed upon among all parties involved in a detour, including the Iowa DOT, counties, and cities. Following is a description of each issue:

- Evaluate methodology with respect to Iowa Code
  The Iowa Code sections 313.28 and 313.29 describe the process to be followed when a detour is designated. It discusses the inspection of the condition of the road before the designation and also mentions a compensation amount based on excessive traffic upon the detour. It is our opinion that the current code language would work with the new gas tax based methodology, but further investigation is needed by the legal office at the Iowa DOT. If changes to the Iowa Code are required, then those changes shall reflect the gas tax based process and need to be developed by the Iowa DOT and their local partners.

- Traffic volume determination
  The research team tried to utilize all available data and minimize the cost and effort to implement the new methodology. The methodology discussed in this report covers the different aspects of traffic volume determination on the detour. Even though we provide for different options to determine the traffic volume, it is our opinion that the Iowa DOT, in cooperation with cities and counties, reach some sort of a standard that all parties agree on. That standard can become part of the procedures developed.

- Evaluate and/or adjust assumptions, particularly gas tax rates and federal funding levels, annually
  In addition to the traffic using the detour road, the next most important factor in determining compensation is the gas tax rates and the federal funding the state receives. The methodology section in this report discusses the assumptions that were made to determine the compensation rate per vehicle mile traveled. Those assumptions use the current state gas tax, the federal gas tax, and the portion of the federal funds that the Iowa DOT receives and uses for highway maintenance, rehabilitation, or reconstruction. Other assumptions can be also included, but the researchers feel that the gas tax rates and the federal funding received cover the lion share of the variability that might result in compensation. It is our opinion that those figures are reviewed annually and a rate determined on January 1st of every year is used for the entire year detours.

Once all of the above issues are discussed and a process is developed, the new methodology based on gas tax can replace the current detours procedures.

7 CONCLUSIONS AND RECOMMENDATIONS

The research presented in this report provides the basis for the development of a new procedure to be used by the Iowa DOT and cities and counties in the state to deal with detour. Even though the project initially focused on investigating new tools to determine condition and compensation, the focus was shifted to traffic and the gas tax method to set the basis for the new procedure. It was concluded that the condition-based approach, even though accurate and consistent condition evaluations can be achieved, is not feasible or cost effective because of the current practices of data collection (2 year cycle) and also the logistics of the procedure (before and after determination).

The gas tax method provides for a simple, easy to implement, and consistent approach to dealing with detours compensations. It removes the subjectivity from the current procedures and provides for a more realistic (traffic based) approach to the compensation determination.

The following is a list of the recommendations:

- A committee of Iowa DOT personnel, city, and county representatives should be formed to take the results of this research and turn them into a new set of procedures that will replace the current process.

- The committee should discuss the issues presented under the implementation plan (Iowa Code, traffic, and gas tax rates) and establish guidelines to be followed by the new procedure. The researchers will work with the committee if needed to finalize the details.

APPENDIX A: GAS TAX INCOME COMPUTATION ASSUMPTIONS

SECTION 1: AVERAGE FUEL EFFICIENCY

Recommended value: 17 mpg

Iowa

- Using Iowa Department of Revenue fuel consumption and Iowa DOT VMT data from 1999 to 2002, the average fuel efficiency for Iowa is 17.8 mpg for cars, trucks, vans, motorcycles, and single unit vehicles and 4.7 mpg for combination vehicles (or 17.5 mpg and 5.6 mpg, respectively, if all single unit vehicles with three or more axles are considered with combination vehicles). The average fuel efficiency for all Iowa vehicles is 16.7 mpg.
- Beginning in 2000, the average fuel consumption in Iowa was 73% gasoline and 27% diesel.

United States

- In 2000 and 2001, the average fuel efficiency of passenger cars and other 2-axle, 4-tire vehicles was 20 mpg.
- The average fuel efficiency for single-unit 2-axle 6-tire or more and combination trucks was approximately 6 mpg.
- The average fuel efficiency for all motor vehicles was approximately 17 mpg.
- The average fuel efficiency for passenger cars was approximately 22 mpg. (FHWA Highway Statistics 2001, Table VM-1, http://www.fhwa.dot.gov/ohim/hs01/vm1.htm)
- The average vehicle age from 1995 to 2002 is approximately eight years. (http://www.bts.gov/programs/jts/V2N1/2pickrell.pdf, http://www.polk.com/news/releases/2003_0211.asp)
- The average EPA adjusted fuel economy for MY 1995 to 2002 is approximately 24 mpg for cars, 17.5 mpg for trucks, and 21 for cars and trucks.
- The average NHTSA CAFÉ fuel economy for MY 1995 to 2002 is approximately 28.5 mpg for cars, 21 mpg for trucks, and 25 mpg for cars and trucks. (EPA Light-Duty Automotive and Fuel Economy Trends: 1975 through 2003, p. A-5)
- The average fuel efficiency for vehicles that account for over 90% of the national VMT is approximately 20 mpg. The average fuel efficiency for all vehicles is approximately 17 mpg.
- In 2000 and 2001, approximately 92% of national VMT was attributable to passenger cars and other 2-axle, 4-tire vehicles.
- In 2000 and 2001, approximately 7.5% of national VMT was attributable to single-unit 2-axle 6-tire or more and combination trucks.

SECTION 2: STATE GAS TAX

Gasoline: 20.1¢ per gallon (variable, see http://www.state.ia.us/tax/educate/mvfrate.html)
Gasohol: 19¢ per gallon (variable, see http://www.state.ia.us/tax/educate/mvfrate.html)
Diesel: 22.5¢ per gallon
Aggregate: 20.28¢ per gallon

For State of Iowa fuel use trends, see http://www.iowaworkforce.org/trends/fuel.html.

- Beginning in 2000, approximately 27% of all fuel purchased and taxable for highway use was diesel, and 73% was gasoline (48% gasohol, 52% gasoline). Alternatively, 34% of the total taxable motor fuel was gasoline, and 40% was gasohol. Trends suggest gasohol will represent an increasing greater portion of the Iowa fuel consumption, i.e., 63% of gasoline in the first quarter of 2003.

Average ¢ per gallon: (40% * 19¢ per gallon) + (34% * 20.1¢ per gallon) + (26%*22.5¢ per gallon) = 20.28¢ per gallon

SECTION 3: FEDERAL GAS TAX

Gasoline: 18.4¢ (15.44 Highway Trust Fund, Highway Account)
Diesel: 24.40¢ (21.44 Highway Trust Fund, Highway Account)
Gasohol: 13.10¢ (7.64 Highway Trust Fund, Highway Account)
Aggregate: 16.76¢ per gallon

- In 2000 and 2001, approximately 78% of national fuel consumption was attributable to passenger cars and other 2-axle, 4-tire vehicles.
- In 2000 and 2001, approximately 22% of national fuel consumption was attributable to single-unit 2-axle 6-tire or more and combination trucks.

Average ¢ per gallon: (78% * 15.44¢ per gallon) + (22%*21.44¢ per gallon) ~ 16.76¢ per gallon

SECTION 4: CONTRIBUTION OF STATE GAS TAX TO PRIMARY HIGHWAY CONDITION IMPROVEMENT

Recommended value: 5¢/gal

Iowa

Using past trends, the following data were derived:
- 47.5% of the Road Use Tax Fund (RUTF) is allocated to the Primary Road Fund (PRF).
- ~91% of Primary Road Fund (PRF) is generated by 47.5% allocation (1997-2002).

- ~42% of RUTF is generated from fuel taxes (1997-2002).
- ~52% of Primary Road Fund (PRF) is used for Highway Improvement Programs and roadway repair and operations
    - ~48% of Primary Road Fund (PRF) is used for Highway Improvement Programs (1997-2000).
    - ~4% of Highway Operations maintenance funds are used for roadway repair and improvements.
        - ~25% of Highway Operations program is used for maintenance activities.
        - ~15% of Highway Operations maintenance funds are used for road repair and improvement.
        - Note: Project Development and Maintenance portions of Highway Operations program were explicitly stated in FY1996-1999, 2000 Programs. These percentages were assumed to remain relatively constant.

Assuming the gas tax portion and non-gas tax portion of the RUTF are distributed to the Primary Road Fund at the same rate of 47.5%, independent of percentage contribution to RUTF, then the numbers are as follows:

- Gasoline: (20.1¢/gal)*(47.5% RUTF to PRF)*(52% PRF to HIP& Repair) ~ 4.96¢/gal
- Gasohol: (19¢/gal)*(47.5% RUTF to PRF)*(52% PRF to HIP& Repair) ~ 4.69¢/gal
- Diesel: (22.5¢/gal)*(47.5% RUTF to PRF)*(52% PRF to HIP& Repair) ~ 5.56¢/gal
- Average: (20.28¢/gal)*(47.5% RUTF to PRF)*(52% PRF to HIP& Repair) ~ 5.01¢/gal

SECTION 5: CONTRIBUTION OF FEDERAL GAS TAX TO PRIMARY HIGHWAY CONDITION IMPROVEMENT

Recommended value: 5.0¢/gal

Iowa

The following data were derived from information available for the most recent Federal transportation legislation (2001, 2002) and historic Iowa trends. Given the possible differences between past and current funding legislation, assumptions were made predominately based on the most recent funding details.

- In 2001 and 2002, gas tax revenues represented approximately 67% of the Federal apportionments and allocations to Iowa.
- In 2001 and 2002, national highway system (NHS) dedicated funds and surface transportation program (STP) funds (applicable to primary roads) represented

approximately 30% of the total federal apportionment to Iowa. The applicable portion of STP funds is 37.5% of 80% of the total STP apportionment.

- Fuel taxes represent approximately 83% of Iowa's contribution to the Federal Highway Trust Fund Highway Account and 87% nationally.
- Fuel taxes represent approximately 82% of Iowa's allocation from the Federal Highway Trust Fund Highway Account.
- Since 1997, approximately 63% of Iowa's allocation from the Federal Highway Trust Fund Highway Account has been directed to the Highway Improvement Program.
- Beginning in 2000, approximately 27% of all fuel purchased and taxable for highway use was diesel, and 73% was gasoline (48% gasohol, 52% gasoline). Alternatively, 34% of the total taxable motor fuel was gasoline, and 40% was gasohol. Trends suggest gasohol will represent an increasing greater portion of the Iowa fuel consumption, i.e., 63% of gasoline in the first quarter of 2003.

United States

- In 2000 and 2001, approximately 78% of national fuel consumption was attributable to passenger cars and other 2-axle, 4-tire vehicles.
- In 2000 and 2001, approximately 22% of national fuel consumption was attributable to single-unit 2-axle 6-tire or more and combination trucks.

Average ¢ per gallon: (78% * 15.44¢ per gallon) + (22%*21.44¢ per gallon) ~ 16.76¢ per gallon

Assuming a consistent NHS and STP apportionments and an equivalent proportion of the gas tax revenue funding each:

(30% * 16.76¢ per gallon) ~ 5.03¢ per gallon

Notes:

- The aforementioned values were calculated based on a comparison of the state and federal fiscal year data. However, the beginning and ending of the state and federal fiscal years do not coincide. State fiscal year: July 1 to June 30. Federal fiscal year: October 1 to September 30.
- In 2002, approximately 55% of the gasoline purchased in Iowa was gasohol, which is taxed at a lower rate with lower contribution to the FHTF Highway Account. However, since the FHTF is a pooled fund, the impact of Iowa's decreased contribution to the fund, as a result of gasohol use, will be ignored.

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