THE ECONOMIC COSTS OF PAVEMENT DETERIORATION

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ABSTRACT

This paper investigates the relationship between different highway pavement conditions and their effect on vehicle operating costs based from a variety of research sources. The study reviews different measurements that classify deteriorating pavement conditions, compare the associated cost estimates, and illustrate examples of how these assumptions translate into impacts on the economy. The principle finding of the research is that pavement conditions directly affect vehicle operating costs and that including these assumptions in asset management analysis enable a broader evaluation of the effect infrastructure preservation has on the economy.

Keywords: Asset management; Pavement preservation, roughness, & condition: User-Cost, Benefit-Cost, Economic-Cost.

INTRODUCTION

Highway and bridge transportation systems are important assets and like any system, the condition of the system affects performance and ultimately all users. Recent bridge collapses have raised concerns about the deteriorated condition of the nation's transportation system. A report scorecard published in 2012 by the American Society of Civil Engineers (ASCE) highlights not only the engineering conditions of the national ground transportation network but also identifies the increase in private sector transportation costs which place deficiencies on the US Economy and negatively impact global competitiveness. These are only some indicators of the real and significant costs that can accrue to the economy when investments are not made to renovate, upgrade, and improve existing transportation infrastructure. Asset Management systems are in place to help planners and decision makers understand investment needs, as well as the likely public and private sector costs of leaving needs unmet. One category of Asset Management is improving deteriorating pavement conditions. While pavement condition is a significant focus of Asset Management systems and a major area of public transportation expenditure, economic impact and cost-benefit models often focus almost exclusively on the benefits and impacts of system expansion, congestion management and other performance drivers. Quantifying the true economic costs deteriorating pavement conditions have on the economy can enable Metropolitan Planning Organizations (MPO's) and state Departments of Transportation (DOT's) to assess programmatic trade-offs and invest in economically sound strategies to achieve Asset Management goals within the context of overall transportation investment priorities.

In a blog post "Fix the Trust Fund" by Patrick Natale, P.E. (8), he states:

> "When I go to Capitol Hill, too many Congressmen tell me they aren't hearing from their constituents on infrastructure issues. I then ask, "But are they calling about losing their jobs? Or not being able to make ends meet?" The Congressmen always reply, "Of course."

This dialogue highlights a general lack of understanding regarding the link between transportation investments and economic results which may also apply to investments in pavement improvement. This paper is aimed at documenting the existing state of the practice for assessing the user costs of deficient pavements as well as demonstrating how the current research on the topic can be operationalized within the context of "real world" economic modeling and decision making situations.

OBJECTIVE AND SCOPE

This paper has three objectives:

(1) Document recent and relevant research on user costs associated with deficient pavements in the economic and planning research
(2) Critically evaluate different factors and approaches that have been introduced
(3) Demonstrate how user-costs of deteriorating pavement can be practically included in real-world planning applications.

The over-arching purpose of paper is to present academic research illustrating the relationship between widely accepted indicators of deteriorating pavement conditions and changes in vehicle operating costs, and to furthermore demonstrate the state of the practice in understanding how these costs accrue in the economy. To meet this purpose several examples are given illustrating how this information is used to estimate the impact on local, regional, and state economies. Demonstrating these relationships entails outlining key assumptions, variables, and cost behaviors that deteriorating pavement conditions have on vehicle operating costs and thus on the economy. This paper includes (1) a summary of the current state of the practice regarding user costs associated with deteriorating pavement (2) and assessment and comparison of available methods and (3) a demonstration of how these methods have been applied in different policy and planning settings.

LITERATURE REVIEW

Pavement conditions are primarily measured by two metrics. One is Present Serviceability Rating (PSR) and the other is an International Roughness Index (IRI); both of which are used in this category of research and study in evaluating the association between these indexes and vehicle operating costs. PSR is more of a subjective rating system based on a scale of 1 to 5 and prior to 1993, all pavement conditions were evaluated using PSR values. IRI is now the reporting standard for all states and is calculated by estimating the cumulative deviation from a smooth pavement surface measured in inches per mile (or meters per kilometer) by a measuring tool (e.g. laser) along an interstate or any other road. Links between the two types of rating systems have been made by the FHWA to gauge the relative range of classification for both types as illustrated in Figure 1.

Figure 1: Relationship between PSR and IRI

Condition Term Categories	PSR Rating		IRI Rating (inches/mile)		Interstate & NHS Ride Quality
	Interstate	Other	Interstate	Other	
Very Good	≥ 4.0	≥ 4.0	< 60	< 60	Acceptable 0 - 170
Good	3.5 - 3.9	3.5 - 3.9	60 - 94	60 - 94	
Fair	3.1 - 3.4	2.6 - 3.4	95 - 119	95 - 170	
Mediocre	2.6 - 3.0	2.1 - 2.5	120 - 170	171 - 220	Less than Acceptable > 170
Poor	≤ 2.5	≤ 2.0	> 170	> 220	

Over a dozen sources of research were reviewed to review the comprehensive research and estimated values in order to compare ranges of vehicle operating costs. The most in-depth quantitative research linking pavement roughness to vehicle operating costs is found in a study by Barnes and Langworthy (4) at the Humphrey Institute of Public Affairs at the University of Minnesota. In their research, they identified that deteriorating pavement affects "…maintenance, tire, repair, and depreciation costs." Their baseline assumption was that a PSI of 3.5 or better (an IRI of about 80 inches/mile or 1.2 m/km) will have no impact on operating costs. They then adjusted for a poor pavement quality with a PSR of 2.0.

The adjustments used implied an extra O&M cost of 2.6 cents per mile (5.5 cents per mile for trucks) between the smoothest and the roughest pavement which also includes depreciation costs. Assuming an average of 12,000 miles per year, this translated into an additional $300 in extra costs per year due to deteriorated pavement conditions. Barnes and Langworthy (4) disaggregated these operational costs into additional category detail for autos, pickups/vans/SUV, and commercial trucks for baseline conditions and extremely poor pavement quality in Table 1 and Table 2.

Table 1: Baseline costs (cents per mile) (PSR 3.5)

Cost Category	Automobile	Pickup/van/SUV	Commercial Truck
Total	15.3	19.5	43.4
Fuel	5	7.8	21.4
Maintenance/Repair	3.2	3.7	10.5
Tires	0.9	1	3.5
Depreciation	6.2	7	8

Table 2: Extremely poor pavement quality (cents per mile) (PSR 2.0)

Cost Category	Automobile	Pickup/van/SUV	Commercial Truck
Total	17.9	22.5	48.9
Fuel	5	7.8	21.4
Maintenance/Repair	4	4.7	13.1
Tires	1.1	1.2	4.4
Depreciation	7.8	8.8	10

These estimates are in line with another study by Papagiannakis and Delwar (9) where they calculated that a unit increase in IRI (in m/km) will lead to a $200 per year increase in maintenance and repair costs. Assuming that the range in IRI between the smoothest and roughest pavement on a major U.S. highway is around 2 m/km, this translates into $400 in extra costs per year. Assuming 12,000 miles a year, this implies an extra cost of 3.3 cents per mile, which would amount to a 60% increase of maintenance and repair costs from the baseline level.

These two studies are the most comprehensive in terms of an actual cost values associated with pavement conditions whereas other studies have only evaluated specific categories of costs or indices of cost increases. One study conducted by the FHWA (11) only evaluated PSR ratings to related depreciation adjustment factors for roadway surface conditions.

The findings from these studies have already been put into practical use. Kansas DOT (6) in a report analyzing the economic benefits of highway preservation funding, modeled a "… 5.5% increase in the per-mile vehicle operating cost due to pavement deterioration" which was derived from the Barnes and Langworthy (4) report.

OBSERVATIONS FROM DEPTH INTERVIEWS

To supplement the understanding provided in the literature, in-depth interviews were conducted with experts in the trucking and logistics community. Key organizations consulted included:

(1) The Tioga Group
(2) American Trucking Association (ATA)
(3) American Trucking Research Institute (ATRI)
(4) Kansas Department of Transportation (KDOT)

The interviews pointed to general categories of costs that are directly affected by adverse conditions caused by pavement deterioration. They include:

1) Tires: This can vary depending on the inflation level and condition of the tire

2) Wheel alignment: Affected by pot holes, curbs, breaks and vibration of road. Oil seal leaks.

3) Sheet metal / electrical wiring: Affected by vibration - this can affect the body integrity and metal fatigue.

4) Suspension: Effect on springs, axels, and sub-frame.

The interviews also re-iterated the understanding from the literature that truckers currently absorb costs for rough conditions encountered on their delivery routes and in most cases pass these costs along to shippers in the long-term. Consequently operating costs incurred due to deficient pavements, in the long-term are likely to be reflected in the landed cost of goods based on how likely they are to be shipped over deteriorated facilities in transit. However, the interviews provided helpful insight by indicating that the added costs may not manifest themselves while the truck is driving under these bad pavement conditions but will likely occur at a later point in time depending on the age and lifespan of the truck. Accordingly it is possible that trucking firms may be challenged to identify the conditions that contributed most to operating and maintenance costs. This suggests that the economic costs are more likely to be passed on to trucking-dependent shippers in general, more so than concentrated only on shippers utilizing a particular route.

The interviews confirmed that trucking firms seldom re-assign their routes in the event of deteriorating pavement conditions because they are not authorized to extend the number of miles that they travel. Professional and judgment-based estimates of the per-mile vehicle operating cost of shipping goods by truck (e.g. including overhead) is in the range of $1.50 to $2.00 per mile. Subjective estimates figured that deteriorating pavement conditions will raise the cost per mile by $.01 or $.02, further confirming some of the general observations found in the literature.

METHODOLOGY AND FINDINGS

Upon critical analysis, the above literature review indicates that the Barnes and Langworthy (4) study to provide the most comprehensive and detailed information on the degree to which pavement deterioration has a direct increase on several categories of vehicle operating costs. However in order to validate this conclusion, the study team has conducted sensitivity testing on actual data from a “real world” project to determine how results derived using the Barnes and Langworthy (4) method results compare with other methods cited in the literature review (which also contained explicit vehicle operating cost estimates based on corresponding pavement conditions). The Barnes and Langworthy (4) study was compared to both the technical documentation of the Highway Economic Requirements System- State version (12) “Estimating the effects of pavement conditions on vehicle operating costs” NCHRP Report 720 (2). The category of “Good pavement” was categorized as a PSR of 3.5 or an IRI of 83 in/mi and “Poor pavement” was categorized with a PSR of 2.0 or an IRI of 213 in/mi as present by Barnes and Langworthy (4). Three categories of vehicle operating costs were evaluated between the three sources of research; Maintenance & repair, Tire wear, and Depreciation. Fuel usage was not included in the cost comparison because some research speculates this category to be more associated with travel speeds and because it was it not included in the Barnes and Langworthy (4) study.

The cost comparison in Tables 3-5 are categorized by vehicle type (automobiles, vans/suv’s, and trucks), the cost index for both Good and Poor pavement, and the % change. A cost index was used because of the variance in initial vehicle operating cost information, to control for year of expenditure dollars, and because the NCHRP 720 (2) report only provides a cost index measurement which was converted from meters per kilometer to inches per mile.

The estimated increase in costs for vehicle maintenance and repair from Good to Poor pavement was between 25% and 27% for Barnes and Langworthy (4), 27%-64% for HERS-ST (12) and 4%-7% for NCHRP 720 (2).

Table 3: Maintenance & Repair: Cost Index Comparison

Cost Category - Maintenance & Repair		Good pavement Index: PSR 3.5 (IRI 83 in/mi)	Poor pavement Index: PSR 2.0 (IRI 213 in/mi)	% Change
Auto - mobiles	HERS-ST	1.01	1.65	64%
	Barnes & Langworthy	1.00	1.25	25%
	NCHRP 720	1.00	1.04	4%
Van/SUV	HERS-ST	N/A	N/A	N/A
	Barnes & Langworthy	1.00	1.27	27%
	NCHRP 720 (Van/SUV)	1	1.04/1.07	4%/7%
Trucks	HERS-ST	1.00	1.30	30%
	Barnes & Langworthy	1	1.25	25%
	NCHRP 720	1.00	1.04	4%

The estimated increase in costs for tire wear from Good to Poor pavement was between 20% and 26% for Barnes and Langworthy (4), 28%-62% for HERS-ST (12) and 1%-3% for NCHRP 720 (2).

Table 4: Tire wear: Cost Index Comparison

Cost Category - Tire wear		Cost Index: PSR 3.5 (IRI 83 in/mi)	Cost Index: PSR 2.0 (IRI 213 in/mi)	% Change
Auto - mobiles	HERS-ST	1.01	1.63	62%
	Barnes & Langworthy	1.00	1.22	22%
	NCHRP 720	1.00	1.02	2%
Van/SUV	HERS-ST	N/A	N/A	N/A
	Barnes & Langworthy	1.00	1.20	20%
	NCHRP 720 (Van/SUV)	1.00	1.01/1.04	1%/3%
Trucks	HERS-ST	1.00	1.28	28%
	Barnes & Langworthy	1	1.26	26%
	NCHRP 720	1.00	1.02	2%

The estimated increase in depreciation costs from Good to Poor pavement was between 25% and 26% for Barnes and Langworthy (4) and 6%-15% for HERS-ST (12). Depreciation costs were not evaluated in NCHRP 720 (2)

Table 5: Depreciation: Cost Index Comparison

Cost Category - Depreciation		Cost Index: PSR 3.5 (IRI 83 in/mi)	Cost Index: PSR 2.0 (IRI 213 in/mi)	% Change
Auto - mobiles	HERS-ST	1.00	1.06	6%
	Barnes & Langworthy	1.00	1.26	26%
	NCHRP 720	N/A	N/A	N/A
Van/SUV	HERS-ST	N/A	N/A	N/A
	Barnes & Langworthy	1.00	1.26	26%
	NCHRP 720 (Van/SUV)	N/A	N/A	N/A
Trucks	HERS-ST	1.00	1.15	15%
	Barnes & Langworthy	1	1.25	25%
	NCHRP 720	N/A	N/A	N/A

Based on the comparisons of each source of research, the Barnes and Langworthy (4) study estimates are in between those of HERS-ST and NCHRP 720. They are also closely in line with results from the Papagiannakis and Delwar (9) study and the interview results. For this reason, subsequent taks of this study use the Barnes and Langworthy (4) vehicle operating cost estimates as the foundation values for estimating the effects of pavement deterioration. These cost estimates are presented in Table 6 for Fair and Poor pavement conditions.

Table 6: Vehicle operating costs by pavement condition

Mode	V.O.C. per mile increase	Pavement Condition
Car	**$0.026**	Poor
	$0.010	Fair
	$0.000	Good
Truck	**$0.000**	Poor
	$0.055	Fair
	$0.028	Good

Because IRI is the current standard of pavement deterioration measure, Table 7 provides a cross-walk between PSR and IRI range of values.

Table 7: Pavement condition measures by PSR and IRI values

Pavement Condition	PSR	IRI Range	
		Low	High
Poor	2.0 & worse	170	Max IRI Value
Fair	2.5	106	169
Good	3.5 (& higher) to 3.0	0	105

PRACTICAL APPLICATIONS

Having validated the Barnes and Langworthy (4) methodology, the next task of the current research has been to apply the relationships operationalized by Barnes and Langworthy (4) within the context of actual planning and programming evaluations. In each case, the underlying approach has been to (1) assess the monetary value of the cost stream associated with deteriorating pavement in comparison to a 'base-case' in which pavement could be maintained to a target condition, (2) treat the difference in user cost as the societal benefit of preserving the pavement to the target level, (3) apply the benefit within the context of wider benefits which may accrue as a result of a preservation program (such as capacity enhancement, elimination of bride weight restrictions and associated detours or safety improvements) to determine the relative contribution of preservation to the overall benefit and (4) use an economic impact model [in this case the Transportation Regional Economic Development Information System (TREDIS)] to translate this benefit into actual impacts on various economic performance indicators.

The "real world" examples offered here include an assessment of a statewide preservation program in Vermont, a case-study of transportation economic benefit on a corridor in Colorado, and a series of rural projects in Idaho.

VERMONT PROGRAMMATIC ANALYSIS

For the Vermont Agency of Transportation (VTrans) (1), EDR group assessed the economic benefits and impacts of meeting Vermont's highway, bridge and rail funding targets. Under the current revenue projections, the funding supporting Vermont's transportation system would not enable the system to be maintained at today's levels.

Projections from VTRANS indicate that an additional investment of $662 Million beyond current funding levels was needed to keep Vermont's Highways maintained to today's levels for the period of 2012 to 2040.

Deficient pavements also impose costs on Vermont's economy in the form of higher vehicle operating costs for cars and trucks. When pavement is in "Good" condition (as defined by an International Roughness Index (IRI) of 95 or less) cars and trucks can pass with a normal vehicle operating cost. However, as pavement declines into "Fair" conditions (IRI of between 95 and 170) or "Poor and Very Poor" (IRI of more than 170), vehicle operating costs tend to increase considerably. These costs reflect additional wear and tear, reduced fuel efficiency and lower overall service life for cars and trucks on Vermont's transportation system. Table 8 below illustrated the percentage of pavement in each condition category based on current and future-funded scenarios.

Table 8: Expected Vermont Pavement Conditions Under Current Funding Levels

Pavement Condition	Fully Funded System	System if Today's Gaps Continue
% of VMT in "Good" Pavement Condition	31%	19%
% of VMT in "Fair" Pavement Condition	23%	12%
% of VMT in "Poor" or "Very Poor" Pavement Condition	46%	69%

Applying the vehicle operating costs associated with each category of pavement condition, an additional $677 Million of vehicle operating costs are expected to accrue due to pavements in "Fair", "Poor" or "Very Poor" condition that could be better maintained if the funding gap were resolved.

Overall, in the period from 2012 to 2040, the $677 Million cost of Vermont's deteriorating pavement conditions to reduce the state's business output by nearly $674 Million, costing Vermont's workers nearly $231 Million in wage income and reducing the state's Gross State Product (GSP) by over $279 Million. By 2040, Vermont's economy is expected to employ 380 fewer workers than it could if the pavement funding.

COLORADO CASE STUDIES

To better articulate the benefits and value of Colorado's transportation system and transportation investments to the State's economy and integrate economic impacts into key decision-making activities, the Colorado Department of Transportation (CDOT) contracted to have several case studies developed to serve as educational examples. CDOT staff led the selection of four projects, one of which was US-287; a rural corridor reconstruction project over a long stretch (130+ miles) of a 2-lane highway dominated by freight traffic from just outside Denver south to the Oklahoma state line.

This section of U.S. 287 (also known as the "The Ports to Plains corridor") starts at the ports of Texas close to the Mexico border, runs through southeastern Colorado to Denver as U.S. 287, and continues north to the plains of Canada. The route was designated a strategic corridor by the U.S. Senate in 1997 because of its importance to truck freight. It is important to the Colorado economy because of its access as a major entry point to Mexico, because it serves the large and growing Texas consumer market, and because it can be used to carry goods produced in Texas, such as oil, gas, and energy equipment to the emerging industries along the route such as Colorado, Utah, Wyoming and North Dakota.

Starting in 1998, CDOT undertook a major reconstruction of the stretch of U.S. 287 from just outside Denver, south to the Oklahoma border. The reconstruction included a complete resurfacing with more durable concrete to better handle the route's heavy truck traffic. It also included upgrades such as widening the road's shoulders and the addition of several passing lanes.

Reports from road users indicate that the project has been successful. In an interview for this study, a representative of the Colorado Motor Carriers Association stated, "Our drivers indicate that the U.S. 287 upgrade is a clear and welcome improvement. The improvements have enhanced safety and mobility, which make the corridor much more attractive."

Pavement improvement was evident as the percent of "Good" pavement increased from 32.6% to 98.5% after the project. "Fair" pavement reduced from 17.6% to .7% and "Poor" pavement from 49.8% to .8%. The corridor has seen a steady increase in truck and vehicular traffic and a slight decrease in the average speed.

Transportation Performance Benefits

The most significant economic benefit stems from the improvement in pavement quality that resulted from the project. In 2000, only 33 percent of the pavement on U.S. 287 was considered to be in "good" condition, while a full 50 percent was considered to be in "poor" condition. Poor pavement condition results in increased wear and tear on vehicles– things like tires or suspensions wearing out sooner, or more extreme damage requiring immediate repair from hitting large pot holes and rough patches. These impacts are particularly problematic on roads with higher speed limits, such as the 65-mph-U.S. 287.

As a result of the project, the route's pavement went up to 98.5 percent "good" and less than one percent in "poor condition" by 2011. The benefits spread over all users is estimated to have contributed $57 million to the Colorado economy as of 2013. These benefits will continue to accrue over time, and are estimated to total $127 million by 2040.

Economic Impacts

Three permanent non-construction jobs are estimated to have stemmed from the additional spending in the economy from user savings associated with decreased vehicle maintenance costs which is expected to rise to 7 by 2040. While three is a small number by most standards, in a struggling rural economy even a small handful of additional job creation is a welcome development. Output from these cost savings is expected to grow from $4M through 2011 to $18M by 2040.

An Efficient Freight Corridor

Efficient truck travel is vital to the health of Colorado's economy. One of the greatest benefits the U.S. 287 corridor provides is a direct and uncongested route to deliver the goods needed to generate economic activity. According to a Greg Fulton of the Colorado Motor Carriers Association, congestion is particularly problematic for truckers because drivers are legally only allowed to work for a certain number of hours each day. Once that limit is reached, operations must stop.

However, at some point truckers will drive a less direct route or choose congestion over a lack of safety and road quality. “If the highway is in extremely poor condition and creates a perceived safety hazard or requires substantially slower speeds to traverse, truck drivers will avoid the roadway,” reports Mr. Fulton. Maintaining routes for trucks to get to their destinations efficiently is therefore an important strategy for the State economy.

The alternate route for drivers currently using U.S. 287 to drive between Texas and Denver, and beyond, is I-25, which runs through several large metropolitan areas. Trucks using this alternate route would not only increase miles travelled, but would also be exposed to increased congestion delays and the associated costs. Without the upgrades to U.S. 287, fewer trucks would be able to safely use the route, particularly when hauling oversized loads.

IDAHO RURAL PROJECTS

For the Idaho Department of Transportation (ITD), 28 rural projects were evaluated to determine the performance drivers of transportation benefits accruing to Idaho household and businesses. EDR Group used Idaho's pavement management data, traffic forecasts, safety and other data elements to derive comparative economic benefits for these projects in Idaho's STIP.

Among the benefit categories of travel time/reliability, safety, and environment, savings in vehicle operating costs were estimated based on the improvement in pavement conditions. Eight of the projects were determined to include a preservation benefit by preventing prevent pavement roughness from getting below a given threshold for a certain number of years. The associated savings in per-mile vehicle operating costs from improved pavement accrues to cars and trucks when gets below a given threshold.

The pavement conditions for each of these 8 projects were evaluated using the IRI index score for both the base and project scenarios. Each IRI score falls within an IRI range that corresponds to a Good, Fair, and Poor pavement condition category as shown in Table 7. If IRI score in the build scenario falls into different pavement condition category than the base scenario (e.g. poor to fair, poor to good, or fair to good), then vehicle operating costs are adjusted to reflect according to the changes in the pavement conditions.

The table below outlines the impacts associated with improvement in pavement conditions due to lower vehicle operating costs. Improved conditions are expected to add an additional $31M in business output, $10M in wages, and 26 jobs in the year 2030. These impacts represent between 19% and 25% of the total impacts driven by other benefit categories which indicate the influence pavement conditions have within the context of economic impacts.

CONCLUSIONS

Overall, this research shows that the literature to date on assessing user costs of deteriorating pavement supports broad inclusion of pavement preservation benefits in planning and business processes like project and programmatic scoring, benefit-cost and economic impact analysis. It is found that agencies without intricately sophisticated models and data can benefit from this type of analysis, and that such inclusion can help to articulate both the rationale and importance of highway preservation investment.

However, this research has also demonstrated significant needs for future research. In particular, the values available from Barnes and Langworthy (4) (more than 11 years old) are largely out-of-date, and may not be keeping pace with truck and pavement technology. While the existing research allows inclusion of user benefits of pavement preservation – further testing is needed to establish robust, transferrable and validated methods for assessing the role of additional factors such as climate, urban-rural character of roads, terrain, vehicle types (including LCV's), fuel economy, fuel prices, safety, travel speeds and other factors on actual user cost. Significant research has been done into how these and other factors affect the actual pavement condition – or direct user costs in certain instances, however many are assumed to be too subtle to affect actual per-mile user costs or for wide application to the community of users. The upcoming synthesis on user costs of pavement deterioration presents an opportunity to provide a framework for both applying and supplementing existing research. The current paper is offered as an example of how even the very high-level and general observations of the relationship between pavement condition and per-mile user costs can and should be relevant to planning and programming decisions.

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INTERVIEWS

Organizations: American Trucking Association, American Trucking Research, Kansas Department of Transportation, and TIOGA.