Asset Management Program Enhancement Plan: Baseline Assessment Phases I and II

Final Report
Sebtember 2015

CONSTRUCTION MANAGEMENT AND TECHNOLOGY

IOWA STATE UNIVERSITY
Institute for Transportation

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16. Abstract

This project resulted in the development of a framework for making asset management decisions on low-volume bridges. The research focused on low-volume bridges located in the agricultural counties of Iowa because recent research has shown that these counties have the greatest percentage of structurally deficient bridges in the nation. Many of the same counties also have the highest crop yields in the state, creating a situation where detours caused by deficient bridges on farm-to-market roads increase the cost to transport the crops. Thus, the research proposed the use of social return on investment (SROI), a tool used by international institutions such as the World Bank, as an asset management metric to gauge to the socioeconomic impact of structurally deficient bridges on the state in an effort to provide quantified justification to fund improvements on low-volume assets such as these rural bridges. The study found that combining SROI with current asset management metrics like average daily traffic (ADT) made it possible to prioritize the bridges in such a way that the limited resources available are allocated in a manner that promotes a more equitable distribution and that directly benefits the user, in this case Iowa farmers. The result is a system that more closely aligns itself with the spirit of MAP-21, in that infrastructure investments are used to facilitate economic growth for Iowa's agricultural economy.

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ASSET MANAGEMENT PROGRAM ENHANCEMENT PLAN: BASELINE ASSESSMENT PHASES I AND II

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EXECUTIVE SUMMARY

In 2012, the U.S. Congress passed the Moving Ahead for Progress in the 21st Century (MAP-21) Act, which funds surface transportation programs and transforms the policy and programmatic framework for capital investments to guide the growth and development of the country's vital transportation infrastructure. Within many of its goals, MAP-21 supports the economic growth of the country's regions and requires each state to develop a Transportation Asset Management (TAM) plan (FHWA-5 2012).

Therefore, the objective of this study is to develop a framework for the Iowa Department of Transportation (DOT) to help in the prioritization and allocation of resources such that the state's local economies, and more specifically Iowa's agricultural economy, are supported. The proposed TAM framework is the result of a comprehensive literature review, a case study analysis, and several outreach efforts and informal interviews with stakeholders that provided the tools to help identify the user's impact as well as to determine a flexible methodology that could easily be adapted to the current practices and policies of the Iowa DOT.

The research focuses on low-volume bridges located in the agricultural counties of Iowa because recent research has shown that these counties have the greatest percentage of structurally deficient bridges in the nation. Many of the same counties also have the highest crop yields in the state, creating a situation where detours caused by deficient bridges on farm-to-market roads increase the cost to transport the crops. Thus, the research proposes the use of social return on investment (SROI), a tool used by international institutions such as the World Bank, as an asset management metric to gauge to the socioeconomic impact of structurally deficient bridges on the state in an effort to provide quantified justification to fund improvements on low-volume assets such as these rural bridges.

The study found that combining SROI with current asset management metrics like average daily traffic (ADT) made it possible to prioritize the bridges in such a way that the limited resources available are allocated in a manner that promotes a more equitable distribution and that directly benefits the user, in this case Iowa farmers. The result is a system that more closely aligns itself with the spirit of MAP-21, in that infrastructure investments are used to facilitate economic growth for Iowa's agricultural economy.

INTRODUCTION

Problem Identification

The Iowa Department of Transportation (DOT) has a need to develop a plan to enhance its current asset management program by increasing the synergy between the various Iowa DOT central office technical groups and implementing the newly published American Association of State Highway and Transportation Officials (AASHTO) Transportation Asset Management Guide (AASHTO 2011). In fact, the Iowa DOT director went on record stating that the Iowa DOT would log a one-time savings of $11 million through its asset management program (Iowa DOT 2012).

The ability to integrate the information created by the individual asset class data collection programs at the network level in a manner that facilitates meaningful decision-making is a primary long-term goal for the Iowa DOT. At the project's beginning, discussions with the Iowa DOT indicated that the following gaps existed in its current asset management program:

- A comprehensive set of key performance indicators (KPI) that can be used to measure asset performance
- A system to estimate asset values and stochastically compare alternatives
- A formal decision tool to assist asset management decisions based on objective input data
- A program that translates asset management output to terms that can easily be understood by non-engineers and public decision-makers

Project Scope

The project's scope was focused at the strategic and network level rather than on project-level applications. The Phase I study had the following three objectives:

1. Benchmark the state of the practice for the Iowa DOT's asset management program.
2. Compare the Iowa DOT's asset management program with several other successful asset management programs and evaluate it.
3. Develop a strategy for the Iowa DOT to enhance its existing asset management program through increased synergy between asset performance data collection systems, a recommended set of key performance indicators (KPI), and an analysis of resource requirements to achieve the director's goal.

The Phase II study had another four objectives that flowed out of the Phase I work. They are as follows:

1. Develop and present a social return on investment (SROI) workshop for Iowa DOT upper management and county/municipal engineers.

2. Develop an SROI presentation that can be given to various special interest groups and state legislators, such as the Freight Task Force in Des Moines.
3. Complete development of the SROI methodology, document it, and develop a plan to implement the metric across the state.
4. Assist the Iowa DOT with continued development of its pavement asset management program.

Detailed Project Description

The research team conducted the work in two phases. The first, or discovery, phase included the following tasks:

1. Establish/meet with the Project Advisory Committee.
2. Establish a mission and short- and long-term objectives for the asset management plan.
3. Inventory all Iowa DOT systems and processes currently in use that contribute to the existing asset management program.
4. Identify district-level programs that are used to make asset management decisions and evaluate their efficacy and potential for contributing to an enhanced asset management program.
5. Develop and deliver one or more asset management workshops, which build upon the National Highway Institute (NHI) asset management course and accomplish the following objectives:
    a. Educate participants on how asset management is implemented.
    b. Facilitate the development of specific asset management information needs.
    c. Facilitate the development of specific objectives for the enhanced program.
6. Synthesize the information collected in previous tasks and complete a gap analysis on the current Iowa DOT asset management program, identifying both gaps and redundancies.
7. Complete case studies of similar asset management programs in the US, Canada, and possibly New Zealand to identify effective practices for implementing an enhanced program.
8. Develop a high-level asset management framework through which the program can be implemented in Iowa.
9. Prepare the Phase II scope of work in conjunction with the Project Advisory Committee
10. Develop and present a white paper documenting the findings of Phase I and recommending a strategy for developing and implementing an enhanced asset management program.
11. Document the process and present it at the 2013 Transportation Research Board (TRB) meeting.

Phase II entailed exploiting the Phase I outcomes and applying what the Project Advisory Committee determined as the most promising findings to the 2014 local bridge program in a manner that allowed a direct comparison of the actual asset management funding decisions to the hypothetical decisions that would have been made if the Iowa DOT had used the SROI methodology instead of its current approach.

To facilitate scoping, the team conducted the work in two stages. The initial stage focused on the SROI implementation assistance and included the following tasks:

1. Develop and present an SROI workshop for Iowa DOT upper management and selected personnel.
    a. Coordinate with applicable Iowa DOT and Institute for Transportation (InTrans) personnel to develop an agenda for the Iowa DOT SROI Workshop.
    b. Prepare backup material such as PowerPoint presentations and a workshop read-ahead package/workbook, etc.
    c. Execute the workshop.
2. Develop and present an SROI workshop for county/municipal engineers. (This task was deleted by the Iowa DOT.)
    a. Coordinate with applicable Iowa DOT and interested county/municipal personnel to develop an agenda for the Local Agency SROI Workshop.
    b. Prepare backup material such as PowerPoint presentations and a workshop read-ahead package/workbook, etc.
    c. Execute the workshop.
3. Develop an SROI presentation that can be given to various special interest groups and state legislators, like the Freight Task Force in Des Moines.

Stage 2 was conducted in parallel with Stage 1 and consisted of completing the SROI framework development work. This stage included the following tasks:

1. Develop the SROI framework and integrate it into the existing Transportation Asset Management (TAM) program framework for the bridge asset class methodology.
2. Develop a draft SROI guidebook for use at the local level in making TAM decisions for funding asset maintenance and replacement decisions.
3. Prepare for and hold a SROI-TAM integration meeting with Iowa DOT and InTrans subject matter experts.
4. Develop an Iowa DOT asset maintenance and replacement decision-making methodology that integrates SROI into the current Iowa DOT decision-making process.
5. Develop and submit a final SROI guidebook and final research report.

It must be noted that the project was not executed in the continuous manner described in the proposal. It had several Iowa DOT–directed suspensions. These were required because the Iowa DOT was reorganized, resulting in asset management functions/responsibilities to be reallocated. The final result is that several of the tasks were deleted, redefined, or postponed. The rest of this report will detail the major findings as well as a recommendation for future implementation.

STATE OF THE PRACTICE REVIEW

Over the last century, the growth of the population and the modernization of the agricultural industry have not only produced an economic boom, but also have transformed the structure of rural and suburban regions; this change has rapidly increased the demands on transportation systems across the country (Friedberger 1989). However, the U.S. has recently overcome several economic difficulties that have challenged governmental institutions and have put stress on the capabilities to maintain and improve the existing assets as well as to keep up with the growing needs of the users (ASCE 2013).

Good transportation systems have always been a symbol of economic growth, allowing the movement of people and freight as well as permitting markets to extend from local and regional levels to an international scale (Rodrigues et al. 2013). Based on the importance of trade and the distribution of goods for the growth of the nation’s wealth, one of the goals of the federal and state governments is to support economic growth by implementing strategic plans that sustain an infrastructure that responds to the needs of the users and that allows for economic opportunities. In order to achieve this goal, the Federal Highway Administration (FWHA) has required state agencies to develop and implement a TAM plan that consists of an inventory of their assets along with their conditions and to then integrate life cycle, financial, and value engineering analyses into their decision-making process (AASHTO 2011).

As observed in a national TAM peer exchange hosted by the Iowa DOT, the variation in the designs of TAM plans is as wide as the needs of all states across the U.S.; therefore, to narrow the research, this study was developed to focus primarily on the needs of the state of Iowa, a heavily agricultural state with a great deficiency in its rural transportation infrastructure. The current status of the U.S. transportation infrastructure as well Iowa’s is better described in Chapter 4.

Transportation Asset Management and MAP-21

A TAM plan is described by AASHTO as a “strategic plan that helps the DOT to focus on the business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives” (Cambridge Systematics 2002). The goals of a TAM plan are to build, preserve, and operate facilities more cost-effectively with improved asset performance; deliver to an agency’s customers the best value for the public tax dollar spent; and to enhance the credibility and accountability of the transportation agency to its governing executive and legislative bodies (Cambridge Systematics 2002).

DOTs across the nation are required to develop a TAM plan to comply with the recent Moving Ahead for Progress in the 21st Century (MAP-21) Act (P.L. 112/141). The FHWA has summarized this act as follows:

> MAP-21 was signed into law by President Obama funding surface transportation programs at over $105 billion for fiscal year 2013-2014. By transforming the policy and

> programmatic framework for investments to guide the system's growth and development, MAP-21 creates a streamlined and performance based surface transportation program. (FHWA 2012)

Under MAP-21, each state's TAM plan must include, but is not limited to, all pavements and bridges in the National Highway System. Other roads can be included as needed, and the TAM requirement also encourages the states to include all infrastructure along the right-of-way. This strategy should anticipate a long-term plan for the system that considers the life cycle of the assets and identifies a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions to be performed in the most cost effective way. The plan shall include an inventory of the assets, including condition; the objectives and measurements; performance gap identification; life cycle cost and risk management analysis; a financial plan; and investment strategies (AASHTO 2011).

National TAM Peer Exchange Results

A national peer exchange was organized by the Iowa DOT with the intention of learning from the experiences, lessons learned, and challenges faced by other state DOTs during the development and implementation of their TAM plans. The FHWA provides funding for such events, and the Iowa DOT's exchange was conducted in accordance with current FHWA (FHWA 2010) regulations. The exchange involved members of the Iowa DOT and an author of this report traveling to the states of Georgia, Utah, New York, and New Jersey. Meetings were held to provide the Iowa DOT with information about each peer state's TAM program. Additionally, the Iowa delegation presented the major elements of its TAM program and received direct feedback from its peers. The potential for using SROI was one of the elements presented, and the feedback gained during the peer exchange was integrated into the framework proposed in this report.

At the end of the peer exchanges, it was evident that the key to developing a meaningful TAM plan for Iowa was to depart from the current polices and methods implemented by each office within the Iowa DOT. The TAM plan does not pretend to be a clean slate; instead it encourages continuous improvement at all levels of the organization. The Iowa DOT decided to mimic Utah's approach and restructure its organization chart to delegate responsibility for implementing the TAM plan to a specific team. Other states such as Georgia and New York modified the processes within their current organizations and assigned specific members to become TAM champions and lead TAM steering committees.

In addition to the differences in agency organizational charts, each agency has different needs that require individual goals and agency-specific input for the TAM plans. For example, New York has a great need to maintain its existing infrastructure. In order to focus on this need, the state has developed polices that help control the development of new capital projects. In contrast, Utah retains a greater flexibility to allocate resources, which results in a good overall condition of its assets. Additionally, Utah's assets are relatively newer than New York's and are not subjected to the same level of traffic loading.

Another example of the variation in the nation's TAM plans is the inventory and inspection of rural bridges. Iowa does not have direct responsibility for the inventory and inspection of rural bridges. In contrast, New York is responsible for the technical inspection of all bridges in the state, which provides a better overall knowledge of the state's infrastructure, even though the state has no maintenance responsibilities. Iowa relies on county engineering departments for the total administration of the rural bridges. The reliance on external agencies combined with a lack of standardized practices across the state creates a situation where rural bridge assets are not able to compete for resources, which indirectly discriminates against the agricultural sector of the state's economy. The diversity found in the peer exchange validated the notion that no single standard TAM program could possibly fit all needs. In all cases, multidisciplinary teams were responsible for the decision-making and the allocation of resources, and all states needed unconditional, continuous support from agency executives and upper management.

Informal Interviews with Iowa County Engineers

Throughout the course of the research, the county engineers for Marion, Hamilton, Boone, and Story Counties in Iowa were interviewed to get a better understanding of the bridges' prioritization process at the local level, as well as to get an idea of the counties' approach to the TAM plan. Generally, all four counties presented a similar methodology to select the bridges that will be submitted to the state agency as candidates for resource allocation. Their prioritization methodology starts with the worse-first scenario, followed by a subjective opinion based on the engineers' knowledge of the zone and determined by the financial resources available to meet the required matching costs. At the time the interviews were conducted, the Iowa DOT had not developed a plan to communicate the TAM plan to its local agencies and train county agency staff; therefore, there was little understanding of the TAM plan's role in the decision-making process. Nevertheless, by the end of the research, the Iowa DOT has established a TAM County Committee that will work as a two-way communication channel between the state and local agencies.

Measuring Value Added in Transportation Infrastructure

When making decisions about resource allocation for transportation asset construction and maintenance projects, engineers gather a range of performance indicators such as the bridge health index (BHI), the pavement serviceability index (PSI), or the international roughness index (IRI), which measure the physical condition of the assets (Cambridge Systematics 2006). Other common measures are focused on capacity, such as average daily traffic (ADT), accident rates, speed, visibility, life cycle cost (LCC), and others. While these metrics are well-accepted and widely-used, including only condition and traffic-based key performance indicators (KPI) unintentionally results in an asset management program that prioritizes projects by "worst-first" and "most traffic." An example is the Iowa DOT's City Bridge Priority Point Rating Worksheet contained in Appendix B. Worst-first is the expression used for an asset resource prioritization system that waits until the assets are in their worst condition to consider them a priority (Cambridge Systematics 2002). Traffic-based systems assign priority to assets that have the greatest ADT under the fundamental assumption that improvements made will benefit more travelers. In other words, ADT is used as an objective indicator of benefit, inferring a directly proportional relationship between the number of vehicles and the return generated by the investment. When used in this context, ADT also represents the number of users who are impacted by the investment in a specific transportation project. In other words, a passenger car carrying one commuter to work is assigned the same socioeconomic value as a truck hauling cargo or produce to market, an unintentional oversimplification of a complex process that favors urban transportation assets over similar rural assets. The current asset management decision prioritization framework essentially ignores the socioeconomic contribution that low-volume farm-to-market roads make to the economy of agricultural states like Iowa.

To measure the value added by transportation projects, methodologies such as the Transportation Economic Development Impact System (TREDIS), Trip Reduction Impacts of Mobility Management Strategies (TRIMMS), SROI, and the Highway Development and Management Model (HDM-4) have been developed to include the social, economic, and environmental impact to the users and allow for a cost-benefit analysis. The salient aspects of the three systems are reviewed below.

TREDIS

This system translates changes in traffic volumes, vehicle occupancy, speed, distance, reliability, and safety into direct cost savings for household and business travel. Additionally, it applies dynamic, multi-regional economic impact simulation to estimate the impacts of changes on employment and income growth over time. At the same time, it translates changes in market access and intermodal connectivity into effects on agglomeration, dispersion, and scale economies for industry sectors. TREDIS essentially performs the following three analyses:

- It calculates the net present value (NPV) of project benefits and costs from the differing perspectives of federal, state, and local agencies.
- It calculates the local, state, and federal tax revenue impacts of projects, programs, or policies, as well as public and private economic impacts of tax, toll, and pricing scenarios.
- It shows the patterns and impacts of economic cash and commodity (tonnage and vehicle) flows to, from, and within a given study area (TREDIS 2014).

In 2008, the Kansas DOT empaneled an interdisciplinary group of professionals to measure the economic impact of rural and urban projects. The group sought to find a methodology that modeled job creation and gross regional product, and it selected TREDIS. The model monetizes travel time, safety impacts, and access to new and expanded markets to help measure project outcomes (Turnbull 2013). Two examples of rural projects in Kansas where this methodology has been used are the new I-35 interchange in McPherson and the expansion of US-54 in southwest Kansas from Greensburg to Haviland. The project cost for the I-35 interchange in McPherson was $13 million, and the economic impact was $94 million. The project cost for the expansion of US-54 was $56 million, and the estimated economic impact was $9 million. The Kansas DOT uses the economic impact figures as a general indication of a project’s economic benefits to initiate projects that will more significantly benefit state and local economies (Turnbull 2013).

One of the lessons learned from this experience was that data by themselves would not draw a complete picture of the conditions. In order to make informed decisions, stakeholders need to be involved in the process, which concurrently helps in the communication process and reduces resistance (Turnbull 2013).

TRIMMS

This system estimates the impacts of a broad range of transportation demand initiatives and provides a program cost-effectiveness assessment, such as net program benefit and benefit-to-cost ratio analysis. TRIMMS evaluates strategies directly affecting the cost of travel, like public transportation subsidies, parking pricing, pay-as-you-go pricing, and other financial incentives. It also evaluates the impact of strategies affecting access and travel times (TRIMMS 20014). The Florida DOT supported a study to enhance the TRIMMS model and quantify the net social benefits of a wide range of transportation demand management (TDM) initiatives in terms of emission reduction, accident reduction, congestion reduction, excess fuel consumption, and adverse global climate change impacts (Concas and Winters 2009).

SROI

This methodology integrates different indicators to facilitate infrastructure capital allocation decisions. The algorithms are designed to integrate the social value of improved infrastructure to economic growth and social equity in the impacted communities (The SROI Network 2012). International development agencies like the International Center for Tropical Agriculture (CIAT), the Consultative Group on International Agricultural Research (CGIAR), and the World Bank (Van de Walle 2008) strive to quantify each potential project's impact on economic, social, and safety requirements. CIAT and CGIAR have implemented SROI as an analytic tool to assess social impacts in financial terms and quantify the broad economic effect of their projects.

A study applying SROI was done in Scotland to evaluate the "transport to employment" (T2E) scheme. In the study, two groups of stakeholders were identified, and a monetary value was assigned to the first group in relation to the social benefits of increased employment to the client based upon net increased income. On the other hand, for the second group the monetary value to the state was assessed in terms of the reduction in welfare payments offset against increased tax contribution. This social value created by T2E has been assessed against the project's investment (Wright et al. 2009).

HDM-4

The World Bank developed this model to measure the road users' cost (RUC) in developing countries with unpaved and paved roads. This indicator is used to calculate the cost-benefit ratio of different roadway projects. The model is designed to analyze unit road user costs using algorithms with input variables for speed, travel time, road condition, safety, type of vehicle, local economic characteristics, and emissions. The tools allow the analyst to differentiate between gravel and paved roads as well as calibrate the model to fit specific locations of interest (WB 2013).

The Malawi National Roads Authority implemented HDM-4 to examine the economic benefits of periodic maintenance, or rehabilitation, on specific road projects and to scope the cost of reducing the country's backlog of maintenance on both paved and unpaved roads. This analysis mode served to examine the economic viability of upgrading specific earth roads and to determine the traffic threshold at which it was economically viable to seal unpaved roads (Le Baras et al. 2009).

Iowa Rural Road Data Issues

The primary challenge for this research was the lack of low-volume road data. Rural roads do not receive the same level of data collection effort as primary roads. Consequently, it was necessary to create models that estimate a portion of the data needed for this research. In all cases, the estimating models maximized the use of available field data and were based on a close comparison of assets of similar size, condition, and capacity where sufficient data were found. While this condition of insufficient data was not unknown, it does point to the issue discussed above regarding the unintentional neglect of low-volume assets in rural locations.

Initially, the average number of trucks that use a road versus the average number of smaller vehicles was needed. These data were available for a few bridges across the state. Table 1 shows the Iowa DOT's classification of a station that collects daily data throughout the year.

Table 1. Iowa automatic traffic recorder classification

		13 classes		3 classes		Volume only
Rural Interstate		10		10		0
Municipal Interstate		4		3		4
Rural Primary		42		35		1
Municipal Primary		4		11		10
Rural Secundary		7		7		12
Municipal Streets		4		2		8
TOTAL	**174**	**71**		**68**		**35**

Adjusted from Iowa DOT 2013

The stations are classified by their locations as Rural Interstate, Municipal Interstate, Rural Primary, Municipal Primary, Rural Secondary, and Municipal Streets (Iowa DOT 2013) and by the type of device used to count the vehicles. One of the three devices can only count total volume and cannot distinguish between vehicle classes. The second device is able to distinguish three different types of vehicles based on length. The last device, which was used in this study, has the ability to differentiate counted vehicles based on the 13 vehicle classifications from the FHWA , shown in Table 2.

Table 2. Highway Performance Monitoring System (HPMS) vehicle classes

CLASS GROUP (Heavy Trucks: 8–13)	DESCRIPTION	NO. OF AXLES
1	MOTORCYCLES	2
2	ALL CARS CARS CARS W/ 1-AXLE TRAILER CARS W/ 2-AXLE TRAILER	2 3 4
3	PICK-UPS & VANS 1 & 2 AXLE TRAILERS	2, 3, & 4
4	BUSES	2 & 3
5	2-AXLE, SINGLE UNIT	2
6	3-AXLE, SINGLE UNIT	3
7	4-AXLE, SINGLE UNIT	4
8	2-AXLE, TRACTOR, 1-AXLE TRAILER (2&1) 2-AXLE, TRACTOR, 2-AXLE TRAILER (2&2) 3-AXLE, TRACTOR, 1-AXLE TRAILER (3&1)	3 4 4
9	3-AXLE, TRACTOR, 2-AXLE TRAILER (3&2) 3-AXLE, TRUCK W/ 2-AXLE TRAILER	5 5
10	TRACTOR W/ SINGLE TRAILER	6 & 7
11	5-AXLE MULTI-TRAILER	5
12	6-AXLE MULTI-TRAILER	6
13	ANY 7 OR MORE AXLE	7 or more

Source: FHWA 2013

For purposes of this study, the 13 vehicle classes were divided into two groups:

- Light: Groups 1 to 7
- Heavy: Groups 8 to 13

Iowa DOT's existing program includes the following components:

- Bridge asset management using AASHTOWare Bridge Management (formerly Pontis)
- Pavement asset management using Deighton Total Infrastructure Management System (dTIMS)
- A sophisticated geographic information system (GIS)
- An aggressive asset condition data collection system
- Similar systems/programs for other major asset classes

RESEARCH METHODOLOGY AND VALIDATION

The research objectives articulated in the previous section led to the following hypotheses, which the research methodology was designed to test:

- Because the current Iowa DOT TAM program is primarily based on traffic volume and asset condition for capital project decision-making, low-volume assets are at a disadvantage; therefore, activities with a high economic impact, such as those of the agricultural industries, located on low-volume assets suffer a negative impact.
- Adding SROI to current TAM KPIs as a needed asset metric will provide rational justification for allocating resources to low-volume assets that service high-impact agricultural activities and improve stakeholder communications.

Figure 1 explains the structure of the research process.

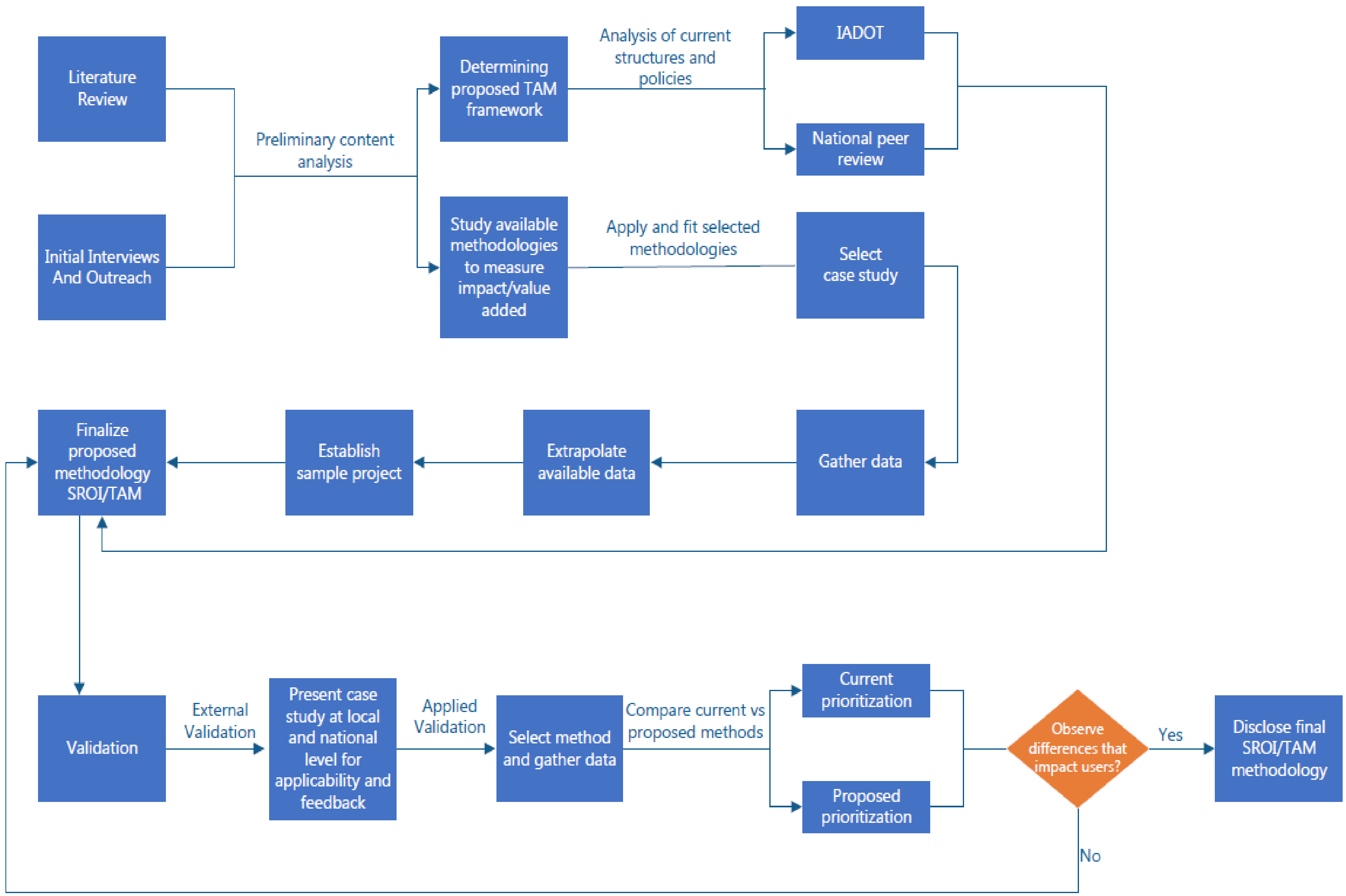

Figure 1. TAM/SROI methodology and validation framework

To achieve the objective of this research, an intensive literature review was done throughout the entire period of the investigation in the following areas:

- Iowa’s agricultural economy
- Traffic behaviors in Iowa’s rural zones
- Vehicle operating costs/users’ costs
- Cost-benefit analysis
- Prioritization process of bridges
- Bridge management
- Iowa transportation infrastructure
- Transportation asset management

To evaluate all possible alternatives, the literature review was done at the regional, state, national and international levels.

At the regional level, informal interviews were conducted with farmers and county engineers. At the state level, the Iowa DOT Urban Engineer and the Offices of System Planning, Transportation Data Management, and System Monitoring were contacted as part of the outreach. A summary of these interviews can be found in Appendix A. Additionally, international work done by the World Bank was evaluated. Lastly, a national peer exchange with the states of Georgia, New Jersey, New York, and Utah was organized in conjunction with the Iowa DOT Transportation Asset Management program and acted as the external validation for the SROI framework.

Methodology for Data Gathering

Methodology to Calculate Value Added

The selection of the methodologies to be used in the calculation of the value added due to bridge replacement and maintenance projects was done using a comparison matrix (see Table 3).

Table 3. Methodology selection matrix

Key Characteristic	TREDIS	TRIMMS	SROI	HDM-4
Can be applied to urban context	X	X	X	X
Can be applied to rural context			X	X
Supports measuring environmental impacts		X	X	X
Supports measuring stakeholders' impacts	X	X	X	X
Has been used in a transportation context	X	X	X	X
Provides tools to calculate ROI			X	
Involves the LCCA of the assets			X	
Measures road users' costs by vehicle type				X
Measures road users' costs by road type				X
Helps identify stakeholders and impacts	X	X	X	
Measure user's time costs	X	X		X
Easy to calibrate and adjust to context			X	X

All four approaches found in the literature review were compared using nine main characteristics. The characteristics were selected as the result of a problem statement analysis that was based on the needs of the stakeholders in the context of agency performance goals.

A methodology was needed that would be flexible enough to allow for future use for other asset classes besides rural bridges and able to be implemented under different circumstances and stakeholders. However, for the purposes of this research, the analysis of the selected approach was limited to rural bridge assets to demonstrate proof of concept. As such, the focus of the subsequent analysis is on one application that measures the impact of agricultural vehicles on asset management decisions. The analysis explores the hypothesis that the current asset management decision-making process seems to have neglected the value that agriculture brings to the state's road network, as demonstrated by the finding that the road network shows greater deterioration in the agricultural zones of the state (ASCE 2013). This finding indicates a potential bias against rural stakeholders in zones where resources have not currently been allocated.

Based on the requirements, one key comparison was whether or not each methodology differentiated between urban and rural users. The analysis also determined whether or not the software could differentiate between gravel roads and paved roads, because the literature showed that this aspect generated differing impacts on the road's users. On the other hand, to cover the social aspects of the value added, the selected methodology needed to include variables such as safety, emissions, and value of time costs.

TREDIS and TRIMMS have been used to measure the impacts of transportation projects on users, but they are essentially "black boxes" where the analyst is not able to control or adapt the algorithm to model local requirements and constraints. HDM-4 and SROI provide more flexibility in the process. They allow the use of the proposed methodology in different contexts to calculate the return on investment of alternatives, which can be used to compare the impacts among candidate projects. This approach can also be used as a performance measurement tool by a transportation agency to calculate the overall return on a given year's program, which in turn allows the SROI of the current year's program to be compared to past years' programs.

Finally, SROI provides the tools to evaluate all possible stakeholders and the different impacts they experience in an inclusive methodology. Meanwhile, HDM-4 provides an easy calibration of the algorithms, which allows for a direct comparison of impacts based on different types of vehicles, different locations, and different types of roads. Consequently, integrating and adjusting SROI with HDM-4 provides the best conditions for the development of the proposed methodology. The combination offers the ability to be applied to different scenarios. It can measure social, economic, and environmental impacts according to the current needs of the agency and account for continuous changes in population, land use, deterioration of assets, and the allocation of resources over time.

Estimating Rural Road Traffic

The Iowa DOT has seven traffic count stations located on rural secondary roads that can also differentiate between the 13 vehicle classes. Out of the seven stations, only five stations had enough data that could be used to develop a trend that describes the relationship between traffic and agriculture in Iowa. Appendix B shows the data available for stations 300, 301, 303, 307, and 312 from 2009 to 2012.

Station 307 was selected for use in estimating traffic data for rural roads where no data exist because it had the most complete data set and was sited near a grain elevator, which is a typical destination for rural road agricultural traffic. Figure 2 shows the growth in heavy truck traffic during the harvest months of September and October.

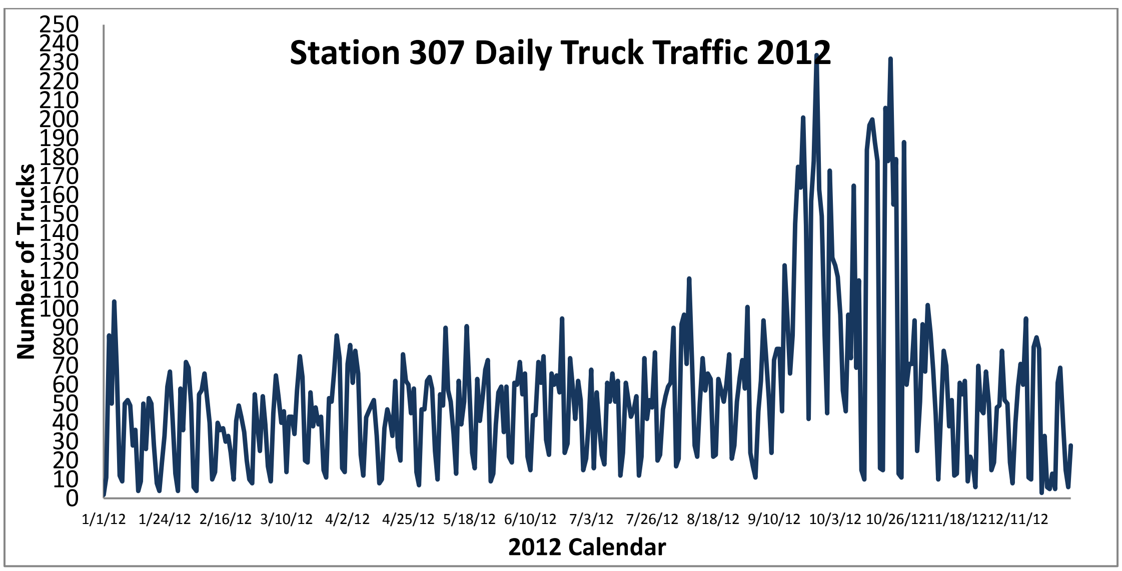

Figure 2. Station 307 daily truck traffic in 2012

Figure 3 shows the daily traffic of light vehicles, which represents a more constant volume across the year when compared to the changes observed in heavy truck traffic.

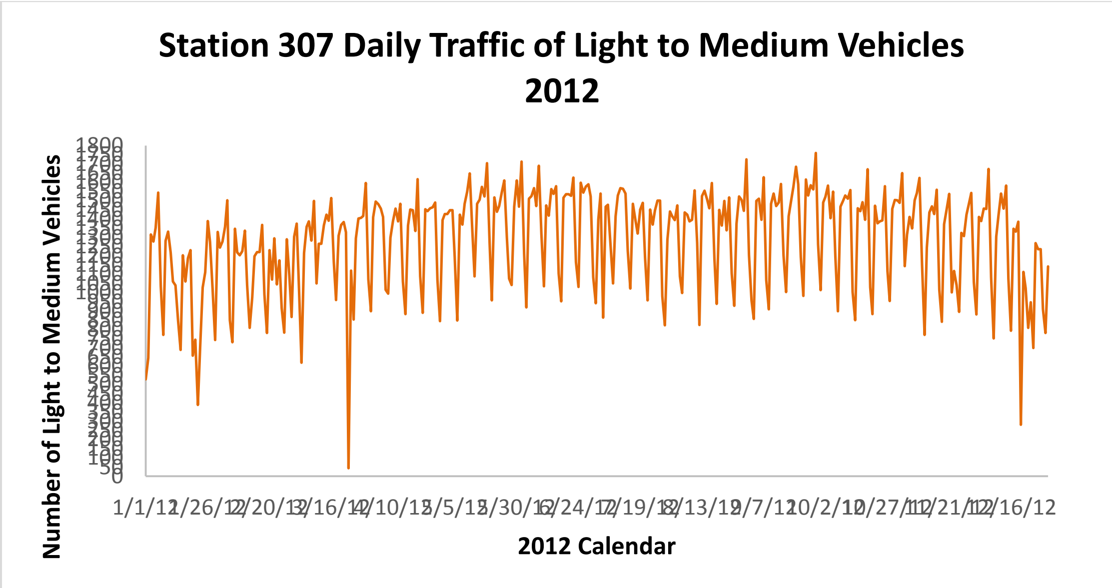

Figure 3. Station 307 daily traffic of light to medium vehicles in 2012

These daily traffic counts were used to model the traffic on the roads used in the case studies. The roads used in the case studies only had one day of data available plus the estimated total annual average daily traffic (AADT) calculated by the engineers of the Iowa DOT. These two numbers were used to estimate the daily traffic, assuming that the unknown number of vehicles is directly proportional to the traffic of a road located in similar zones, i.e., rural zones. Figure 4 and Figure 5 are the graphical representations of the application of the model.

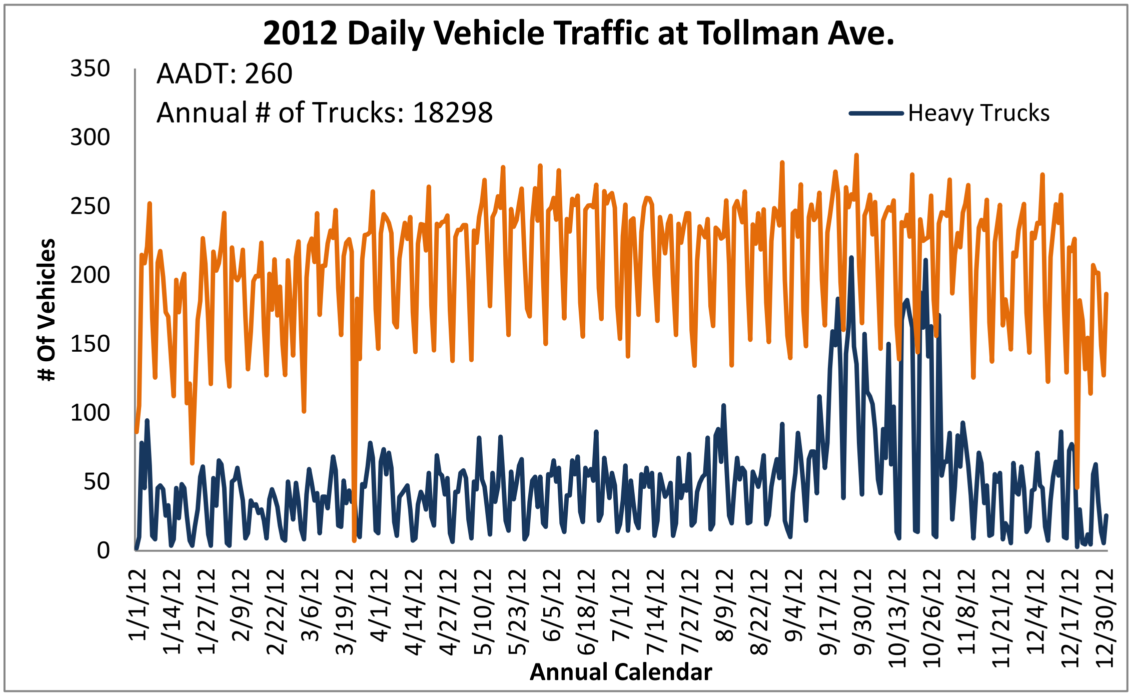

Figure 4. Daily vehicle traffic at Tollman Ave. in 2012

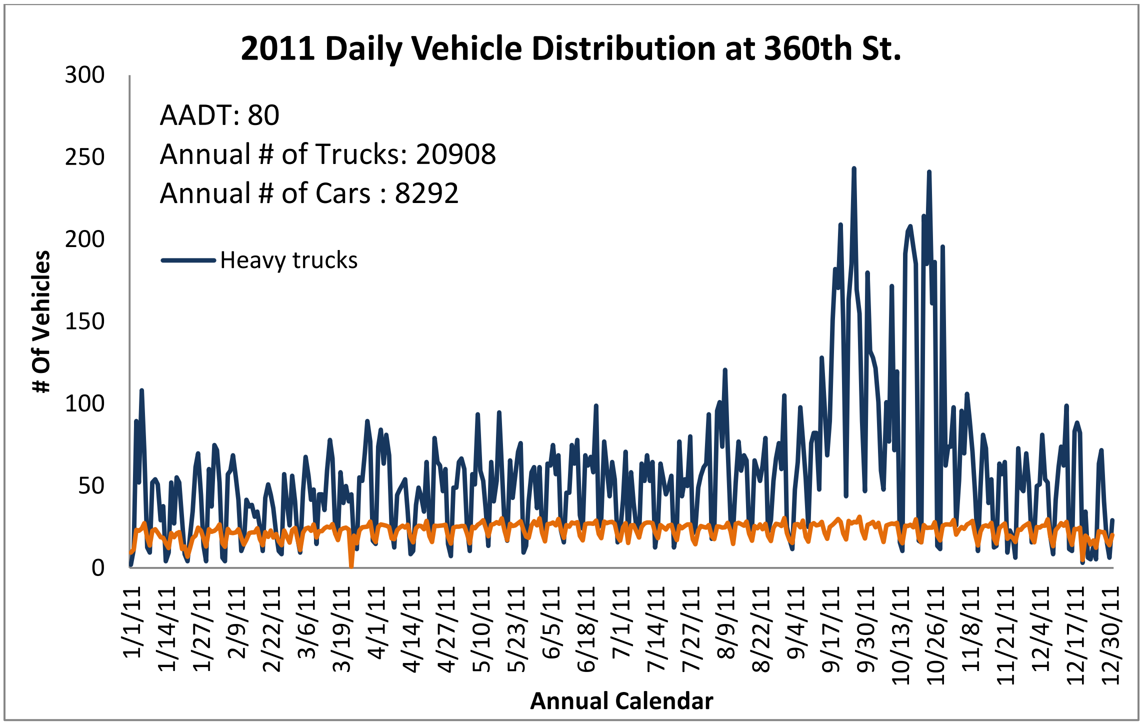

Figure 5. Daily vehicle traffic at 360th St. in 2012

Validation

Validation of the findings and proposed methodology was done at two levels. The first level was an initial external validation of the literature review and a case study done at the county level via informal interviews with county engineers. Secondly, a state-level validation was done to evaluate the proposed framework and methodology.

Appendix A presents the reports of the informal interviews conducted with four Iowa county engineers. Among the most important outcomes of these interviews for the validation process was the feedback provided by the Hamilton County engineer. The conclusions of the initial case study involving two bridges in Hamilton County were presented to the county engineer, and he was asked for his opinion. He was very familiar with these bridges and their zone of influence and affirmed having to go through the same scenario and arriving at the same conclusion as the one provided in the case study using the proposed methodology. The difference between his method of prioritization, which uses his expertise and extensive knowledge of the zone, and the method of the proposed system is the lack of tools available in the county engineer's method to provide a consistent prioritization process to ensure transparency in the process.

At the state level, the validation was done by comparing the 2014 City Bridges Candidate List, used to prioritize and allocate resources, to the proposed methodology. This validation method was designed to test for applicability and demonstrate whether implementing the proposed methodology would result in a different allocation of resources at the same time that it increased the SROI ratio of the projects.

The research was deliberately structured to provide publishable results in a logical progression from journal paper to journal paper. The result was that four journal papers were written and submitted, and as of August 2015 three have been published or accepted for publication. A bibliography for the journal papers is included in Appendix C.

ASSET MANAGEMENT DECISIONS USING SOCIAL RETURN ON INVESTMENT

This project's findings were articulated in a compilation of four different journal articles whose content and sequence was purposefully selected in accordance with the principal objective of the research mentioned above. The logic used to select and organize the topics of these articles consisted of seven phases. First, a conceptual methodology was developed using SROI to measure socioeconomic impact based on the literature review. Second, a case study was used to pilot test the methodology using data available from the Iowa DOT and introduce a method for calculating the RUC using HDM-4, a methodology developed and widely used by the World Bank to measure impact. At the same time, this phase presents the proposed framework for implementing the methodology of the TAM plan. Subsequently, due to the large variability observed in the Iowa DOT data collected, a stochastic model was developed to quantify the variability and incorporate it into the decision-making process. Finally, the methodology and the framework were validated by comparing the allocation of resources obtained using the current prioritization method versus that obtained using the proposed methodology. The articles are summarized as follows:

- The first article was submitted to the TRB and was accepted for presentation and publication at the 2014 TRB Annual Meeting. The article discusses the fundamentals of SROI. Additionally, it confirms the need to integrate a socioeconomic metric to overcome the Iowa infrastructure deficiency located primarily on the state's low-volume roads.

- The second article was submitted to the Institution of Civil Engineers' *Journal of Infrastructure Asset Management* and accepted for publication. The article presents a case study analysis that compares the actual impact of two bridges with similar conditions but whose AADT and type of road differ. The results of the case study showed the importance of understanding the impacts on different kinds of users and highlighted the disproportionate importance given to the total AADT.

- The third article was submitted to and accepted for presentation at the 11th International Conference on Low-Volume Roads. It was also accepted for subsequent publication in *Transportation Research Record*, *Journal of the TRB*. A sensitivity analysis was done to understand the variation within different indicators. The article demonstrates how different resource allocation decisions could occur when evaluating the risk of closing a bridge versus the risk of only reducing the posted rated capacity of the bridge. In other words, the article quantifies the socioeconomic impact created when only heavy trucks are forced to detour against that created when all traffic must detour.

- Finally, a fourth article was submitted for publication to *Public Works Management and Policy*. It is currently under review for publication. This final article presents the validation of the proposed SROI framework for prioritizing rural bridges by evaluating its outcome for 96 bridge candidates competing for 2014 fiscal year funding and comparing the outcome to the actual allocation of 2014 funds based on the current methodology.

SROI as an Asset Management Metric

State and local transportation agencies have been encouraged by the FHWA to implement a TAM program as a tool to more effectively distribute their limited resources. To evaluate and prioritize asset maintenance, rehabilitation, and replacement options, DOTs must identify specific KPIs to measure asset condition, traffic volume, and cost efficiency for comparison with other assets in their networks. Each state has specific needs, which require the agency's TAM program to be tailored specifically to the requirements of the local economy. Such is the case for states where the transportation network is a key contributor to a broad-based agricultural economy. Unlike highly urbanized states, agricultural states are dependent on their low-volume rural roads to sustain the state's economy. The paper analyzes the social and economic impact that asset preservation decisions have in Iowa, a typical agricultural state, and propose a methodology for calculating the SROI to better measure the economic impact that the rural bridges have in the transportation of soy and corn across states like Iowa. The research shows that the areas with highest yield of corn and soy in Iowa are also the areas with the greatest percentage of rural deficient bridges, confirming the need to integrate a socioeconomic metric into the suite of condition- and capacity-based KPIs to ensure that asset management resource allocation decisions do not unintentionally neglect an important sector of the state's economy, merely because the volumes of traffic are lower than in urban regions.

Integrating Social Impact to Bridge Asset Management Decisions

Understanding the socioeconomic impacts that rural bridges have on states that are dependent on the agricultural industry provides a valuable perspective for public transportation agencies to prioritize the allocation of bridge maintenance funds. Currently, low-volume bridges are at a disadvantage for being allocated maintenance funding in typical asset management programs due to the low ADT statistics. The authors propose a methodology to quantify the socioeconomic impact of low-traffic bridges on farm-to-market roads using SROI for making asset management funding decisions. The methodology also demonstrates how these rates can be used as a key performance indicator. It provides several alternatives to incorporate SROI into current project prioritization processes and better allocate scarce maintenance funding. The authors found that factors like road surface type and percentage of heavy vehicles influence a given asset's SROI, potentially justifying investing in a low-volume bridge over others with higher traffic volumes. The authors concluded that current processes for asset management resource allocation are unintentionally overlooking the contribution of assets to a farm state's economy by relying on traffic volume as the primary measure of network utility.

Applying SROI to Risk-based Low-volume Bridge Asset Management Plans

State DOTs implement risk-based TAM systems to standardize risk-oriented procedures and assist decision-makers in allocating available funds. These procedures aim to lead agencies to make effective decisions to allocate funding to repair, replace, or maintain those assets that provide the highest overall value to all stakeholders. Because reliable tools to measure and compare the socioeconomic impact of different resource distribution alternatives of bridge maintenance funds are lacking, decisions are driven by the AADT and the experience of decision-makers. While AADT certainly measures the number of users that would benefit if funding is allocated for a given bridge project, it fails to account for the impact that a given bridge has on state or regional economic growth. Relying on AADT puts low-volume bridges on farm-to-market roads at a distinct disadvantage when competing for scarce funding, as shown by the large number of structurally deficient low-volume bridges located in croplands in Iowa, a state whose economy is based on agriculture. This paper proposes a methodology to integrate the socioeconomic impact of funds allocated to maintenance/repair with AADT and consider the consequences of this decision. The authors demonstrate the use of a stochastic two-way sensitivity analysis on the SROI as the primary metric on two typical Iowa bridges and found that adding SROI to the decision-making process provides a mechanism to more efficiently allocate available resources.

Measuring User Impact to Support Economic Growth through Transportation Asset Management Planning

The MAP-21 Act was created, among other objectives, to support the economic growth of regions. With this in mind, the methodologies and policies used to allocate construction and maintenance funds for infrastructure rehabilitation provide a way for state DOTs to spur economic growth. Economic downturns have opened the eyes of decision-makers, highlighting the importance of a transparent and cost-effective allocation of resources. This study proposes adding social and economic components to the current prioritization method for low-volume rural bridges in Iowa and evaluates the potential change in the distribution of funding among the state’s structurally deficient bridges. The proposed method identifies stakeholders and the value added of infrastructure projects to the state’s agricultural economy, and the researchers conclude that the addition of socioeconomic factors to the current decision method could increase the net benefit of the investments to the community.

CONCLUSIONS

The first step before embracing the development of regulations and polices is to clearly understand what results are expected once the new strategy gets implemented. This was the case for the Iowa DOT, which was required by the FHWA to develop and implement a transportation asset management plan that fulfilled a number of goals in order to provide better services to users, increase economic support, and improve the state's infrastructure. After studying the current condition of the state's infrastructure and the needs of the users located in regions where the economy of the state is based, it was clear that this project needed to focus on the rural areas, more specifically on the bridges that serve the agricultural industry.

Several methodologies were examined, but two were found to be the best fit for the needs. The proposed methodology was based on an integration of SROI with HDM-4, which is used by the World Bank to measure the impact of its projects. This methodology integrates the social, economic, and environmental impacts of projects and differentiates between the type of users' vehicles, the type of roads, and the risk of not providing the required funding to the structures.

After testing the proposed methodology, it was found that higher AADT did not necessarily represent a higher impact. There were several other variables that played an important role, and therefore the stakeholders were divided in two categories based on the size of their vehicles. This way only the impact on the vehicles affected by the posting or closing of a bridge could be discriminated, and the impact of a maintenance or rehabilitation project was not inflated.

Therefore, considering a scenario where the bridge would be posted, i.e., reducing the weight allowed to cross over the bridge, versus a complete closure drove the attention of this research to bridges located in zones with a greater volume of heavy traffic, which indeed represented the rural zones with greater economic productivity. If these bridges were to be posted, the heavy trucks would be forced to detour while smaller vehicles would still be able to cross. Moreover, classifying the users into these two groups also helped to distinguish the different impacts based on the vehicle operation cost; as expected, heavy commercial vehicles had greater RUC. This indicator was helpful in the case of bridges that could be closed to help identify how many more small vehicles would represent a higher impact compared with a bridge with a lower AADT but a greater percentage of heavy trucks.

The proposed methodology was designed to be used as an additional indicator for the funding needs of individual assets; furthermore, it is an excellent tool to help measure and communicate the performance of the DOT as a summary of the fiscal year, providing a clear and objective explanation of the allocation of resources and how these impact the community. Nevertheless, this methodology is not static, and it should be considered dynamic. The proposed TAM framework can be updated every year based on a given year's final performance report or based on changing inputs from stakeholders. This permits the agency to reevaluate stakeholder needs and changing economic interests. Therefore, if a decrease in serviceability is observed in other sectors of the transportation system, such as emergency/evacuation routes that result from changes in population and land use, as well as accelerated deterioration of the assets under analysis, the model can be adjusted to address the changes as they occur. This adjustment will provide a greater measure of equity to stakeholders and permit funds to be disbursed in the coming fiscal year that positively impact the growth sector. After comparing the allocation of the 2014 annual budget for the candidate bridges using the current system to the recommended distribution of the resources provided by the proposed methodology, it was found that if the resources would have been allocated using SROI, not just the Iowa DOT method, the impact generated would have been increased by 24%. Moreover, out of the total local bridge candidates list, allocating resources using SROI reduced the percentage of bridges that will remain in a structurally deficient condition from 52% to 32%.

Some of the limited accuracy of the final result is the result of the limited information available on the LCC of bridges as well as traffic counts and vehicle classification. If more accurate results are desired, the DOT would be required to expand the resources needed to understand traffic on low-volume roads, as well as keep better records of the maintenance provided to the structures throughout their life cycles.

Using SROI in a TAM plan must be seen as a valuable KPI that should be used in conjunction with other traditional indicators. SROI alone does not supplant the current prioritization systems; instead, it supports and enhances them as part of the process of continually improving the way decision-making is done. SROI is not a deterministic indicator that could be used alone to prioritize assets. Some of the method's limitations are based on scenarios were the SROI cannot be calculated due to the lack of one of the variables. Such cases include where the bridge is the only access to a specific location, such as agricultural facilities, recreational facilities, or any other services valued by the community. In this case, the SROI index is not available, but the impact is great.

Eventually, this methodology could be applied to other geographic zones as well as to other assets. However, this study was completed based on the needs and requirements of the state of Iowa, the DOT, and the users; therefore, the implementation of this methodology in a different context would require a calibration of the system based on the specific requirements of the region and stakeholders. Therefore, the major findings of this research are summarized as follows:

- Because classic asset prioritization methodologies are primarily based on traffic volume plus asset condition for capital project decision-making, low-volume assets are at disadvantage, and high economic impact activities (HEIA), such as those of the agricultural industries located near low-volume assets, suffer a negative impact.

- Adding SROI to the TAM plan as a KPI adds new value to the body of knowledge, provides rational justification for allocating resources to low-volume assets that service HEIA, improves communication and transparency, and enhances the credibility of decision-makers and legislation.

- Integrating the social impact into the evaluation of infrastructure projects is a current need that promises a tremendous impact on different areas of the decision-making process for maintenance and new construction funding allocation. Not only does this methodology ensure that current tax dollars are spent in the most cost-effective way possible, but it also ensures an infrastructure network that is socially responsible and sustainable for current and future generations.

- One of the areas of project evaluation questions whether the developers have considered the needs of the surrounding community and asked not just if the project is done right but also if it is the right project (ISI 2012). SROI provides the tools needed so developers can answer this question and engineers can design and build infrastructure projects that respond to social, economic, and environmental needs.

FUTURE RESEARCH NEEDS

This project started out with a very broad mandate to study all asset classes, but as it progressed it became focused on developing a mechanism that helps integrate low-volume bridges into the list of candidates for maintenance and rehabilitation funds. Even though the algorithm was developed to include the key indicators, there are some external variables that were not covered in this study that are recommended to be analyzed in future studies:

- This study included only the positive impact generated for the users by the execution of maintenance projects. Accepting the fact that there are not sufficient resources to maintain all bridges, some will be exposed to posting or even closure. The negative impact caused by detouring the traffic generated by these bridges to adjacent roads and bridges as well as the impact on the community were not calculated, and it would be necessary to compare the breaking point where the positive impacts outweigh the negative impacts for better decision-making.

- A better understanding of the bridges' life cycles and the way different maintenance treatments could extend their life cycles or reduce the structures' overall maintenance costs will provide an opportunity to include this variable in the decision-making process. This will help answer the question of whether some of the large bridges that were left off of the funding list could cost more to maintain in the future if no maintenance is done now. At this point, the prioritization has been based on rehabilitation of the bridges more than on preventive maintenance, and there are no records of how this preventive treatment plays a role in the decision-making process.

- In the calculation of the NPV for the LCC and benefits of the assets, this study used 4% as the discount rate based on recommendations from the FHWA (FHWA 2003). However, it would be important to study the sensitivity of this rate and the reason behind it. For instance, the 4% rate suggested for transportation projects may not be appropriate for a social and economic setting outside of transportation. Factors such as type of discount rate and nominal versus real rate could affect the selection of the rate and how it affects the decision-making process. If inflation were to be considered as part of the discount rate, it may be necessary to consider inflation rates calculated using the consumer price index for social aspects and the construction cost index for transportation projects. Similarly, previous studies done on the life cycle cost analysis (LCCA) of pavement treatments have shown that a low discount rate may favor higher costs and a longer-lived alternative (Gransberg et al. 2010).

- Different methods could also be analyzed in the selection of the discount rate. The FHWA Guidelines for Life Cycle Cost Analysis report mentions that "estimating the discount rate is not a straightforward matter. Furthermore, there is no consensus on how to value the real earning capacity of these public funds. The choice of the discount rate is one of the most debatable topics in public project evaluation" (Ozbay et al. 2003). The report suggested four different philosophies that could inform the selection of the discount rate, including opportunity cost of capital, societal rate of time preference, zero interest rate, and cost of borrowing funds.

- Similar research needs to be conducted on the remaining Iowa DOT asset classes.

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APPENDIX A. SUMMARY OF COUNTY/CITY ENGINEER INTERVIEWS

Marion County – Brian Hatch, Engineer

The meeting with the Marion County Engineer Mr. Brian Hatch was held on July 9 2013 at the Marion County Office in Knoxville. When introduced to a TAM plan, Mr. Hatch noted that no information had been communicated from the state agency to the county engineers about the needs and advantages of this plan. The prioritization process at Marion County is still done based on the "worse-first" scenarios, as well as the availability of the resources. For instance, there is a $4 million bridge that requires rehabilitation, but the county does not count that bridge with the 20% required by the state to match available funds. This means that not only do the worst bridges get funded, but also only the smallest projects. There is also a judgmental influence on the decision-making. If an engineer does not consider a bridge to be important for the community, it will not be included in the potential candidates. Marion County Engineers do not have a standardize method to measure the importance of those structures.

By January 2013, Marion County had 7 closed bridges, 3 bridges posted under 7 tons, 6 bridges with capacities between 8 and 15 tons, 9 bridges with capacities between 16 and 22 tons, 12 bridges with capacities between 23 and 29 tons, and 4 bridges with capacities between 30 and 40 tons. From 2002 to 2012, 68 bridge projects have been completed with an average cost of $150,927. The costliest projects were executed in 2002 for $1,671,822 while the least costly projects involve repairs for $3,741 in 2006.

Hamilton County – Dan Waid, Engineer

The meeting with the Hamilton County Engineer, Mr. Dan Waid, was held on February 25, 2014 at the Hamilton County Office. Mr. Waid is an experienced engineer and has been the County Engineer of Hamilton County for over 7 years. He has an excellent knowledge of the county, the bridges, and technicalities and these attributes help him make excellent decisions with regards to the transportation assets of Hamilton County. Hamilton County also hires the same bridge consultants as Boone County to conduct the inspection of their bridges. The reports submitted by the consultant contain all the details required to make decisions for the bridges in the county. The county engineer prioritizes the needs for funds for the bridges based on factors such as the ADT, traffic flow, and businesses around the area, political aspects, detour length, and other physical aspects. The two bridges on the first case study belong to this county. The conclusions of the case study were presented and compared with the way he arrived at the decisions regarding the bridges. Through the discussion, it could be concluded that the county engineer had arrived at the same decisions as the study through his own logical analysis of the situation. There was not a standardized process or methodology followed to arrive at this conclusion. The discussions from the meeting were in alignment with the study and proved as an external validation for the study.

Boone County –Robert J. Kieffer, Engineer

The meeting with the Boone County Engineer, Mr. Robert J. Kieffer, was held on March 17, 2014 at the Boone County Office. According to Mr. Kieffer, Boone County currently has 200 miles of paved roads and 800 miles of gravel roads which contain the majority of the bridges in the county. Out of the total 105 bridges in the county, 18 bridges are posted. These contain some bridges that are too narrow for trucks and larger vehicles. Boone County hires a bridge consultant to conduct inspections on the bridges in the county every 2 years and makes its decisions regarding the management of assets based on the reports submitted by the consultant. This report also contains the estimated remaining life of any bridge structure.

Some major indicators that are considered while making decisions are the traffic pattern, traffic flow (count), prospective businesses that would be affected, classification of the gravel roads such as farm-to-market, detour length, and user costs. Emphasis is given to those with lesser useful life remaining. Another important factor influencing the decision-making process is the political aspect. The decisions are discussed with the Board and also communicated to the farmers every year at the meetings with the Farm Bureau. Farmers are also encouraged to communicate through emails or letters or walk in anytime and discuss their views with the County Engineer. Some of the maintenance work done on paved bridges include sealing of the bridge decks every 5 years, removal of debris of the piers, and erosion.

Boone County generally considers low-volume bridges any bridge with and ADT of around 20 vehicles /day or lower. For a typical bridge on a gravel road, the construction costs would be around $400,000. The main problems faced in the construction or replacement of bridges in this county is the acquisition of the Right of Way (ROW) for the bridge. An interesting example stated in the meeting was the Wagon Wheel Bridge in the west side of the county across the Des Moines River. It has been closed for almost 4 years now. Though it had a high ADT and people have to take a detour around the bridge now, it has not been possible to replace the bridge since the cost would be around $4 million. It would not be practical to justify spending the limited funds on just one bridge. Another interesting factor that was discussed in the meeting was that Boone County does not follow any specific methodology to forecast the ADT through its bridges.

Story County – Darren Moon, Engineer

The meeting with the Story County Engineer Mr. Darren Moon was held on May 22, 2014 at the Story County Office in Nevada, IA. Story County has 200 bridges longer than 20 feet and another 76 bridges less than 20 feet. These bridges range from 13 feet to 410 feet long. Out of these 276 bridges, 50 have a sufficiency rating below 50, and 80 bridges are posted with load or width restrictions. It includes 74 bridges listed as “structurally deficient” or “functionally obsolete”. According to the County Engineer, the Federal Bridge Funding received is $330,000 per year.

Major indicators such as bridge posting, sufficiency rating, total ADT are used to prioritize budget allocation for the bridges of Story County. Detour length, when considered, is generally not greater than 4 miles. As observed in other counties, political issues influence the decision-making process greatly. The county keeps track of any major maintenance work done on the bridges through its life span. In general, temporary replacement work is done on bridges with the intention of extending its service life by a few more years.

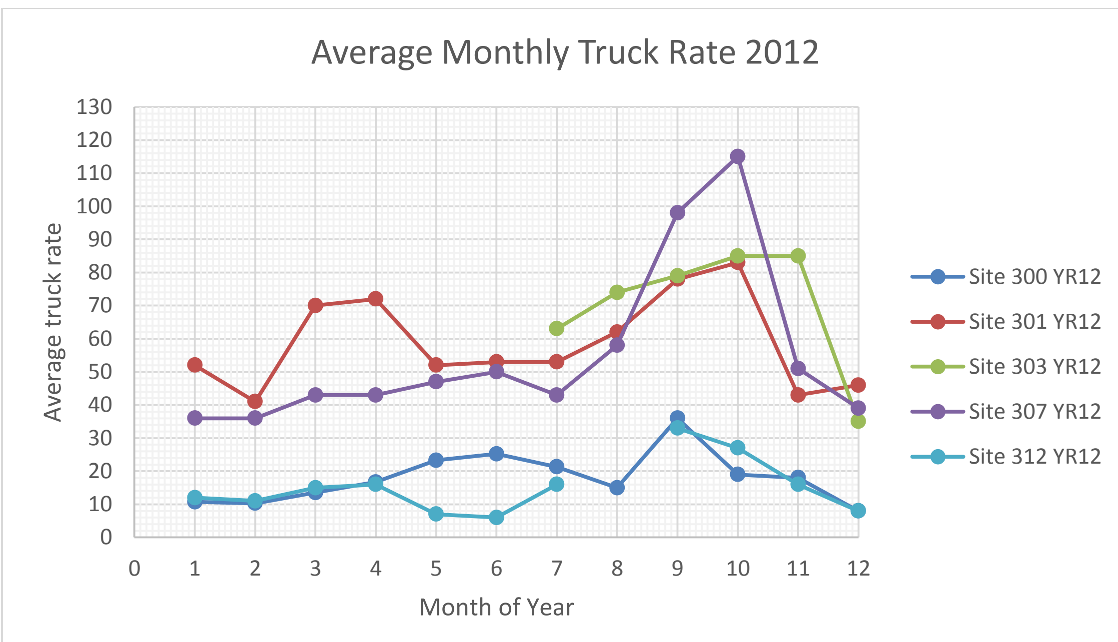
The decisions made by the county engineer regarding the roads and bridges in the county are based on expert knowledge of the area and the surroundings. No specific or systematic method is followed for this. The standard “worst-first” procedure is followed for replacement and other major works. The decisions are discussed with the Board and also with the farmers at the meetings with the Farm Bureau. So far there have been no major obstacles in communicating the decisions to the Board.

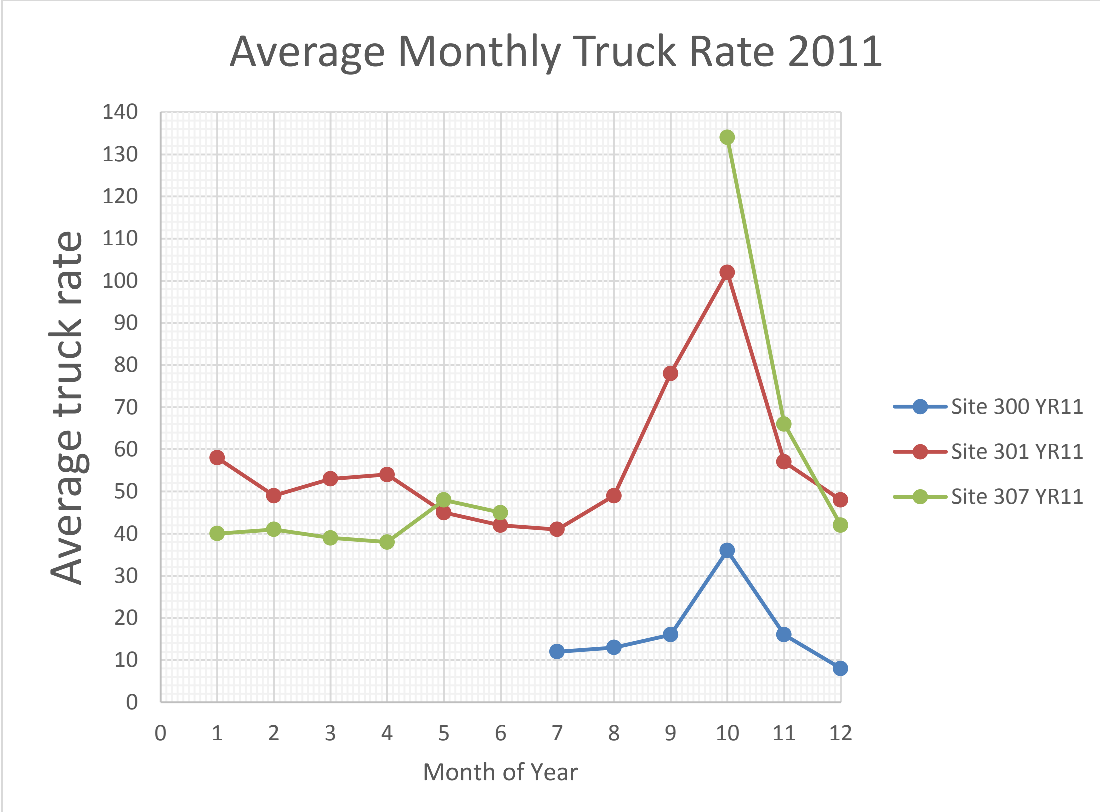
APPENDIX B. TRAFFIC COUNT DATA

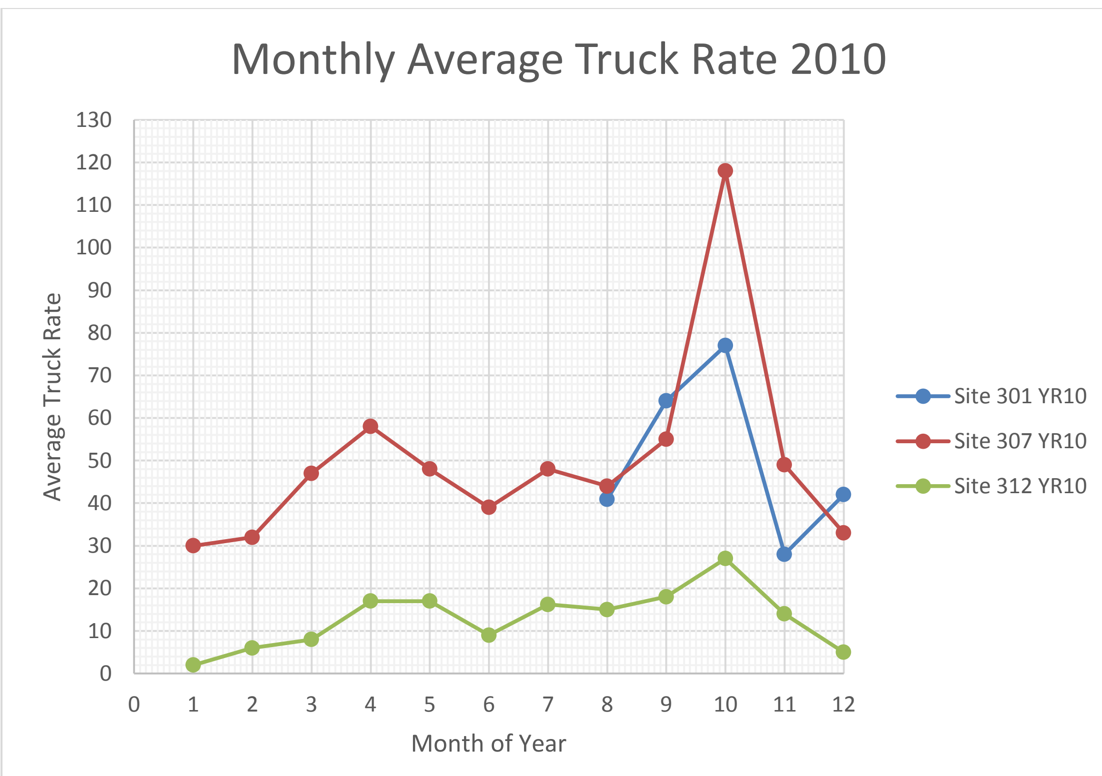
The table and graphics included in this appendix show only the actual monthly average of daily of trucks for stations 300, 301, 303, 307 and 312. Some months and years are missing information due to system failure or weather conditions.

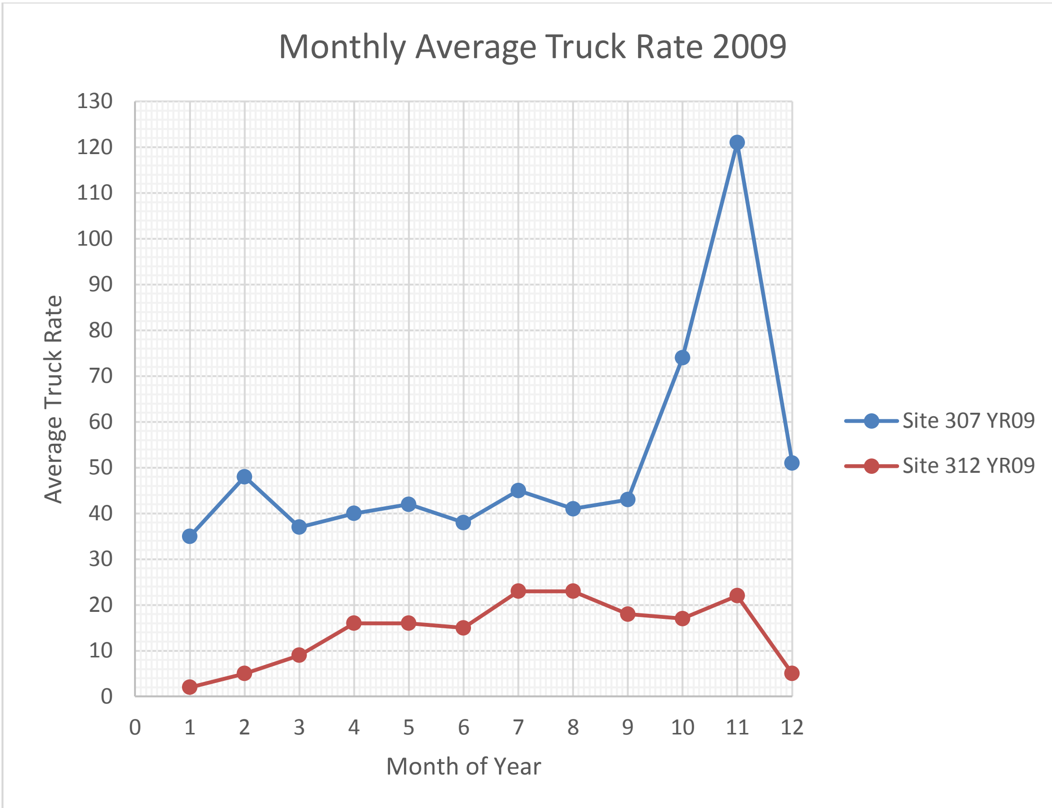
	Site 300	Site 301	Site 303	Site 307	Site 312
1/1/2012	10.71	52		36	12
2/1/2012	10.31	41		36	11
3/1/2012	13.55	70		43	15
4/1/2012	16.73	72		43	16
5/1/2012	23.29	52		47	7
6/1/2012	25.2	53		50	6
7/1/2012	21.29	53	63	43	16
8/1/2012	15	62	74	58	
9/1/2012	36	78	79	98	33
10/1/2012	19	83	85	115	27
11/1/2012	18	43	85	51	16
12/1/2012	8	46	35	39	8
1/1/2011		58		40	
2/1/2011		49		41	
3/1/2011		53		39	9
4/1/2011		54		38	
5/1/2011		45		48	
6/1/2011		42		45	
7/1/2011	12	41			
8/1/2011	13	49			
9/1/2011	16	78			
10/1/2011	36	102		134	
11/1/2011	16	57		66	19
12/1/2011	8	48		42	9
1/1/2010				30	2
2/1/2010				32	6
3/1/2010				47	8
4/1/2010				58	17
5/1/2010				48	17
6/1/2010				39	9
7/1/2010				48	16.225
8/1/2010		40.92		44	15

	Site 300	Site 301	Site 303	Site 307	Site 312
9/1/2010		64		55	18
10/1/2010		77		118	27
11/1/2010		28		49	14
12/1/2010		42		33	5
1/1/2009				35	2
2/1/2009				48	5
3/1/2009				37	9
4/1/2009				40	16
5/1/2009				42	16
6/1/2009				38	15
7/1/2009				45	23
8/1/2009				41	23
9/1/2009				43	18
10/1/2009				74	17
11/1/2009				121	22
12/1/2009				51	5




Average Monthly Truck Rate 2011
Average truck rate
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Month of Year
Site 300 YR11
Site 301 YR11
Site 307 YR11


Monthly Average Truck Rate 2010
Average Truck Rate
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Month of Year
Site 301 YR10
Site 307 YR10
Site 312 YR10


Monthly Average Truck Rate 2009
Average Truck Rate
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Month of Year
Site 307 YR09
Site 312 YR09

Estimated Daily Traffic Used In Case Studies

This table presents the actual data for Station 307 used to estimate the daily traffic for the bridges located at 360th Street and Tollman Avenue in Hamilton County, Iowa. The shaded data corresponds to data that has been estimated.

#307 Model			360th St Gravel			Tollman Ave. Paved		
Date	# Trucks	# Cars	Date	# Trucks	# Cars	Date	# Trucks	# Cars
1/1/12	2	527	1/1/11	2	9	1/1/12	2	86
1/2/12	11	644	1/2/11	11	11	1/2/12	10	105
1/3/12	86	1315	1/3/11	89	23	1/3/12	78	215
1/4/12	50	1277	1/4/11	52	23	1/4/12	45	209
1/5/12	104	1352	1/5/11	108	24	1/5/12	95	221
1/6/12	68	1543	1/6/11	71	27	1/6/12	62	252
1/7/12	12	1033	1/7/11	12	18	1/7/12	11	169
1/8/12	9	769	1/8/11	9	14	1/8/12	8	126
1/9/12	50	1280	1/9/11	52	23	1/9/12	45	209
1/10/12	52	1332	1/10/11	54	24	1/10/12	47	218
1/11/12	49	1216	1/11/11	51	22	1/11/12	45	199
1/12/12	28	1060	1/12/11	29	19	1/12/12	25	173
1/13/12	36	1039	1/13/11	38	18	1/13/12	33	170
1/14/12	4	850	1/14/11	4	15	1/14/12	4	139
1/15/12	9	687	1/15/11	9	12	1/15/12	8	112
1/16/12	50	1203	1/16/11	52	21	1/16/12	45	197
1/17/12	26	1059	1/17/11	27	19	1/17/12	24	173
1/18/12	53	1187	1/18/11	55	21	1/18/12	48	194
1/19/12	50	1230	1/19/11	52	22	1/19/12	45	201
1/20/12	28	656	1/20/11	29	12	1/20/12	25	107
1/21/12	8	743	1/21/11	8	13	1/21/12	7	121
1/22/12	4	388	1/22/11	4	7	1/22/12	4	63
1/23/12	19	696	1/23/11	20	12	1/23/12	17	114
1/24/12	33	1027	1/24/11	34	18	1/24/12	30	168
1/25/12	59	1110	1/25/11	61	20	1/25/12	54	181
1/26/12	67	1388	1/26/11	70	25	1/26/12	61	227
1/27/12	43	1275	1/27/11	45	23	1/27/12	39	208
1/28/12	13	1019	1/28/11	14	18	1/28/12	12	166
1/29/12	4	741	1/29/11	4	13	1/29/12	4	121
1/30/12	58	1329	1/30/11	60	24	1/30/12	53	217
1/31/12	36	1245	1/31/11	37	22	1/31/12	33	203
2/1/12	72	1277	2/1/11	75	23	2/1/12	66	209

#307 Model			360th St Gravel			Tollman Ave. Paved		
2/2/12	69	1358	2/2/11	72	24	2/2/12	63	222
2/3/12	50	1501	2/3/11	52	27	2/3/12	45	245
2/4/12	6	850	2/4/11	6	15	2/4/12	5	139
2/5/12	4	730	2/5/11	4	13	2/5/12	4	119
2/6/12	55	1347	2/6/11	57	24	2/6/12	50	220
2/7/12	57	1218	2/7/11	59	22	2/7/12	52	199
2/8/12	66	1202	2/8/11	69	21	2/8/12	60	196
2/9/12	53	1225	2/9/11	55	22	2/9/12	48	200
2/10/12	40	1337	2/10/11	42	24	2/10/12	36	218
2/11/12	10	1040	2/11/11	10	18	2/11/12	9	170
2/12/12	14	807	2/12/11	15	14	2/12/12	13	132
2/13/12	40	975	2/13/11	42	17	2/13/12	36	159
2/14/12	36	1197	2/14/11	37	21	2/14/12	33	196
2/15/12	37	1220	2/15/11	38	22	2/15/12	34	199
2/16/12	30	1219	2/16/11	31	22	2/16/12	27	199
2/17/12	33	1368	2/17/11	34	24	2/17/12	30	224
2/18/12	24	990	2/18/11	25	18	2/18/12	22	162
2/19/12	10	779	2/19/11	10	14	2/19/12	9	127
2/20/12	41	1230	2/20/11	43	22	2/20/12	37	201
2/21/12	49	1071	2/21/11	51	19	2/21/12	45	175
2/22/12	43	1295	2/22/11	45	23	2/22/12	39	212
2/23/12	35	1045	2/23/11	36	18	2/23/12	32	171
2/24/12	20	1174	2/24/11	21	21	2/24/12	18	192
2/25/12	10	916	2/25/11	10	16	2/25/12	9	150
2/26/12	8	781	2/26/11	8	14	2/26/12	7	128
2/27/12	55	1290	2/27/11	57	23	2/27/12	50	211
2/28/12	39	1093	2/28/11	41	19	2/28/12	35	179
2/29/12	25	867	---	26	15	2/29/12	23	142
3/1/12	54	1304	3/1/11	56	23	3/1/12	49	213
3/2/12	39	1374	3/2/11	41	24	3/2/12	35	224
3/3/12	17	980	3/3/11	18	17	3/3/12	15	160
3/4/12	9	618	3/4/11	9	11	3/4/12	8	101
3/5/12	45	1214	3/5/11	47	21	3/5/12	41	198
3/6/12	65	1357	3/6/11	68	24	3/6/12	59	222
3/7/12	54	1387	3/7/11	56	25	3/7/12	49	227
3/8/12	40	1283	3/8/11	42	23	3/8/12	36	210
3/9/12	46	1499	3/9/11	48	27	3/9/12	42	245
3/10/12	14	1049	3/10/11	15	19	3/10/12	13	171
3/11/12	43	1265	3/11/11	45	22	3/11/12	39	207
3/12/12	43	1265	3/12/11	45	22	3/12/12	39	207

#307 Model			360th St Gravel			Tollman Ave. Paved		
3/13/12	34	1366	3/13/11	35	24	3/13/12	31	223
3/14/12	57	1423	3/14/11	59	25	3/14/12	52	232
3/15/12	75	1390	3/15/11	78	25	3/15/12	68	227
3/16/12	64	1514	3/16/11	67	27	3/16/12	58	247
3/17/12	20	1166	3/17/11	21	21	3/17/12	18	191
3/18/12	19	959	3/18/11	20	17	3/18/12	17	157
3/19/12	56	1309	3/19/11	58	23	3/19/12	51	214
3/20/12	38	1368	3/20/11	40	24	3/20/12	35	224
3/21/12	48	1384	3/21/11	50	24	3/21/12	44	226
3/22/12	39	1328	3/22/11	41	23	3/22/12	35	217
3/23/12	43	43	3/23/11	45	1	3/23/12	39	7
3/24/12	15	1119	3/24/11	16	20	3/24/12	14	183
3/25/12	11	852	3/25/11	11	15	3/25/12	10	139
3/26/12	53	1295	3/26/11	55	23	3/26/12	48	212
3/27/12	51	1402	3/27/11	53	25	3/27/12	46	229
3/28/12	67	1406	3/28/11	70	25	3/28/12	61	230
3/29/12	86	1417	3/29/11	89	25	3/29/12	78	232
3/30/12	74	1596	3/30/11	77	28	3/30/12	67	261
3/31/12	16	1072	3/31/11	17	19	3/31/12	15	175
4/1/12	14	898	4/1/11	15	16	4/1/12	13	147
4/2/12	71	1410	4/2/11	74	25	4/2/12	65	230
4/3/12	81	1495	4/3/11	84	26	4/3/12	74	244
4/4/12	61	1480	4/4/11	63	26	4/4/12	56	242
4/5/12	78	1456	4/5/11	81	26	4/5/12	71	238
4/6/12	66	1411	4/6/11	69	25	4/6/12	60	231
4/7/12	23	1014	4/7/11	24	18	4/7/12	21	166
4/8/12	12	993	4/8/11	12	18	4/8/12	11	162
4/9/12	43	1297	4/9/11	44	23	4/9/12	39	212
4/10/12	46	1389	4/10/11	48	25	4/10/12	42	227
4/11/12	49	1457	4/11/11	51	26	4/11/12	45	238
4/12/12	52	1386	4/12/11	54	25	4/12/12	47	226
4/13/12	33	1483	4/13/11	34	26	4/13/12	30	242
4/14/12	8	1059	4/14/11	8	19	4/14/12	7	173
4/15/12	10	883	4/15/11	10	16	4/15/12	9	144
4/16/12	37	1364	4/16/11	38	24	4/16/12	34	223
4/17/12	47	1451	4/17/11	49	26	4/17/12	43	237
4/18/12	42	1448	4/18/11	44	26	4/18/12	38	237
4/19/12	33	1335	4/19/11	34	24	4/19/12	30	218
4/20/12	62	1617	4/20/11	64	29	4/20/12	56	264
4/21/12	27	1089	4/21/11	28	19	4/21/12	25	178

#307 Model			360th St Gravel			Tollman Ave. Paved		
4/22/12	20	890	4/22/11	21	16	4/22/12	18	145
4/23/12	76	1453	4/23/11	79	26	4/23/12	69	237
4/24/12	62	1443	4/24/11	64	26	4/24/12	56	236
4/25/12	60	1459	4/25/11	62	26	4/25/12	55	238
4/26/12	45	1464	4/26/11	47	26	4/26/12	41	239
4/27/12	58	1489	4/27/11	60	26	4/27/12	53	243
4/28/12	14	1068	4/28/11	15	19	4/28/12	13	174
4/29/12	7	844	4/29/11	7	15	4/29/12	6	138
4/30/12	47	1394	4/30/11	49	25	4/30/12	43	228
5/1/12	47	1426	5/1/11	49	25	5/1/12	43	233
5/2/12	62	1426	5/2/11	64	25	5/2/12	56	233
5/3/12	64	1447	5/3/11	67	26	5/3/12	58	236
5/4/12	58	1447	5/4/11	60	26	5/4/12	53	236
5/5/12	25	1192	5/5/11	26	21	5/5/12	23	195
5/6/12	10	848	5/6/11	10	15	5/6/12	9	139
5/7/12	55	1423	5/7/11	57	25	5/7/12	50	232
5/8/12	49	1369	5/8/11	51	24	5/8/12	45	224
5/9/12	90	1483	5/9/11	94	26	5/9/12	82	242
5/10/12	57	1548	5/10/11	59	27	5/10/12	52	253
5/11/12	51	1647	5/11/11	53	29	5/11/12	46	269
5/12/12	34	1376	5/12/11	35	24	5/12/12	31	225
5/13/12	13	1087	5/13/11	14	19	5/13/12	12	178
5/14/12	62	1483	5/14/11	64	26	5/14/12	56	242
5/15/12	39	1506	5/15/11	41	27	5/15/12	35	246
5/16/12	51	1575	5/16/11	53	28	5/16/12	46	257
5/17/12	91	1523	5/17/11	95	27	5/17/12	83	249
5/18/12	59	1704	5/18/11	61	30	5/18/12	54	278
5/19/12	24	1273	5/19/11	25	23	5/19/12	22	208
5/20/12	16	958	5/20/11	17	17	5/20/12	15	157
5/21/12	63	1518	5/21/11	65	27	5/21/12	57	248
5/22/12	41	1439	5/22/11	43	25	5/22/12	37	235
5/23/12	54	1470	5/23/11	56	26	5/23/12	49	240
5/24/12	68	1543	5/24/11	71	27	5/24/12	62	252
5/25/12	73	1609	5/25/11	76	28	5/25/12	66	263
5/26/12	9	1301	5/26/11	9	23	5/26/12	8	213
5/27/12	13	1076	5/27/11	14	19	5/27/12	12	176
5/28/12	39	1041	5/28/11	41	18	5/28/12	35	170
5/29/12	56	1467	5/29/11	58	26	5/29/12	51	240
5/30/12	59	1610	5/30/11	61	28	5/30/12	54	263
5/31/12	35	1466	5/31/11	36	26	5/31/12	32	240

#307 Model			360th St Gravel			Tollman Ave. Paved		
6/1/12	59	1712	6/1/11	61	30	6/1/12	54	280
6/2/12	22	1211	6/2/11	23	21	6/2/12	20	198
6/3/12	19	919	6/3/11	20	16	6/3/12	17	150
6/4/12	61	1511	6/4/11	63	27	6/4/12	56	247
6/5/12	60	1525	6/5/11	62	27	6/5/12	55	249
6/6/12	72	1567	6/6/11	75	28	6/6/12	66	256
6/7/12	55	1471	6/7/11	57	26	6/7/12	50	240
6/8/12	66	1690	6/8/11	69	30	6/8/12	60	276
6/9/12	22	1319	6/9/11	23	23	6/9/12	20	215
6/10/12	15	1033	6/10/11	16	18	6/10/12	14	169
6/11/12	44	1474	6/11/11	46	26	6/11/12	40	241
6/12/12	44	1418	6/12/11	46	25	6/12/12	40	232
6/13/12	72	1563	6/13/11	75	28	6/13/12	66	255
6/14/12	61	1536	6/14/11	63	27	6/14/12	56	251
6/15/12	75	1578	6/15/11	78	28	6/15/12	68	258
6/16/12	31	1103	6/16/11	32	20	6/16/12	28	180
6/17/12	23	952	6/17/11	24	17	6/17/12	21	156
6/18/12	66	1515	6/18/11	69	27	6/18/12	60	248
6/19/12	60	1534	6/19/11	62	27	6/19/12	55	251
6/20/12	65	1535	6/20/11	68	27	6/20/12	59	251
6/21/12	56	1526	6/21/11	58	27	6/21/12	51	249
6/22/12	95	1626	6/22/11	99	29	6/22/12	86	266
6/23/12	24	1166	6/23/11	25	21	6/23/12	22	191
6/24/12	29	1030	6/24/11	30	18	6/24/12	26	168
6/25/12	74	1598	6/25/11	77	28	6/25/12	67	261
6/26/12	59	1543	6/26/11	61	27	6/26/12	54	252
6/27/12	42	1577	6/27/11	44	28	6/27/12	38	258
6/28/12	62	1589	6/28/11	64	28	6/28/12	56	260
6/29/12	52	1523	6/29/11	54	27	6/29/12	47	249
6/30/12	15	1085	6/30/11	16	19	6/30/12	14	177
7/1/12	21	942	7/1/11	22	17	7/1/12	19	154
7/2/12	40	1398	7/2/11	42	25	7/2/12	36	228
7/3/12	68	1538	7/3/11	71	27	7/3/12	62	251
7/4/12	16	863	7/4/11	17	15	7/4/12	15	141
7/5/12	56	1466	7/5/11	58	26	7/5/12	51	240
7/6/12	38	1477	7/6/11	40	26	7/6/12	35	241
7/7/12	23	1261	7/7/11	24	22	7/7/12	21	206
7/8/12	18	1049	7/8/11	19	19	7/8/12	16	171
7/9/12	61	1415	7/9/11	63	25	7/9/12	56	231
7/10/12	51	1528	7/10/11	53	27	7/10/12	46	250

#307 Model			360th St Gravel			Tollman Ave. Paved		
7/11/12	66	1567	7/11/11	69	28	7/11/12	60	256
7/12/12	51	1565	7/12/11	53	28	7/12/12	46	256
7/13/12	62	1538	7/13/11	64	27	7/13/12	56	251
7/14/12	12	1226	7/14/11	12	22	7/14/12	11	200
7/15/12	24	1021	7/15/11	25	18	7/15/12	22	167
7/16/12	61	1482	7/16/11	63	26	7/16/12	56	242
7/17/12	52	1405	7/17/11	54	25	7/17/12	47	230
7/18/12	43	1321	7/18/11	45	23	7/18/12	39	216
7/19/12	47	1452	7/19/11	49	26	7/19/12	43	237
7/20/12	54	1488	7/20/11	56	26	7/20/12	49	243
7/21/12	12	1192	7/21/11	12	21	7/21/12	11	195
7/22/12	22	958	7/22/11	23	17	7/22/12	20	157
7/23/12	74	1452	7/23/11	77	26	7/23/12	67	237
7/24/12	42	1369	7/24/11	44	24	7/24/12	38	224
7/25/12	52	1446	7/25/11	54	26	7/25/12	47	236
7/26/12	48	1500	7/26/11	50	27	7/26/12	44	245
7/27/12	77	1500	7/27/11	80	27	7/27/12	70	245
7/28/12	20	980	7/28/11	21	17	7/28/12	18	160
7/29/12	23	822	7/29/11	24	15	7/29/12	21	134
7/30/12	47	1288	7/30/11	49	23	7/30/12	43	210
7/31/12	54	1441	7/31/11	56	25	7/31/12	49	235
8/1/12	59	1414	8/1/11	61	25	8/1/12	54	231
8/2/12	61	1393	8/2/11	63	25	8/2/12	56	228
8/3/12	90	1474	8/3/11	94	26	8/3/12	82	241
8/4/12	17	1087	8/4/11	18	19	8/4/12	15	178
8/5/12	21	998	8/5/11	22	18	8/5/12	19	163
8/6/12	92	1435	8/6/11	96	25	8/6/12	84	234
8/7/12	97	1424	8/7/11	101	25	8/7/12	88	233
8/8/12	71	1387	8/8/11	74	25	8/8/12	65	227
8/9/12	116	1395	8/9/11	121	25	8/9/12	106	228
8/10/12	71	1556	8/10/11	74	28	8/10/12	65	254
8/11/12	28	1270	8/11/11	29	22	8/11/12	25	207
8/12/12	22	824	8/12/11	23	15	8/12/12	20	135
8/13/12	50	1525	8/13/11	52	27	8/13/12	45	249
8/14/12	74	1554	8/14/11	77	27	8/14/12	67	254
8/15/12	57	1507	8/15/11	59	27	8/15/12	52	246
8/16/12	66	1459	8/16/11	69	26	8/16/12	60	238
8/17/12	63	1596	8/17/11	65	28	8/17/12	57	261
8/18/12	22	1181	8/18/11	23	21	8/18/12	20	193
8/19/12	23	938	8/19/11	24	17	8/19/12	21	153

#307 Model			360th St Gravel			Tollman Ave. Paved		
8/20/12	63	1449	8/20/11	65	26	8/20/12	57	237
8/21/12	57	1364	8/21/11	59	24	8/21/12	52	223
8/22/12	51	1499	8/22/11	53	27	8/22/12	46	245
8/23/12	60	1339	8/23/11	62	24	8/23/12	55	219
8/24/12	76	1517	8/24/11	79	27	8/24/12	69	248
8/25/12	21	1103	8/25/11	22	20	8/25/12	19	180
8/26/12	28	927	8/26/11	29	16	8/26/12	25	151
8/27/12	51	1375	8/27/11	53	24	8/27/12	46	225
8/28/12	64	1522	8/28/11	67	27	8/28/12	58	249
8/29/12	73	1503	8/29/11	76	27	8/29/12	66	246
8/30/12	58	1445	8/30/11	60	26	8/30/12	53	236
8/31/12	101	1725	8/31/11	105	31	8/31/12	92	282
9/1/12	24	1204	9/1/11	25	21	9/1/12	22	197
9/2/12	17	956	9/2/11	18	17	9/2/12	15	156
9/3/12	11	856	9/3/11	11	15	9/3/12	10	140
9/4/12	46	1499	9/4/11	48	27	9/4/12	42	245
9/5/12	62	1511	9/5/11	64	27	9/5/12	56	247
9/6/12	94	1396	9/6/11	98	25	9/6/12	86	228
9/7/12	75	1627	9/7/11	78	29	9/7/12	68	266
9/8/12	52	1067	9/8/11	54	19	9/8/12	47	174
9/9/12	24	909	9/9/11	25	16	9/9/12	22	149
9/10/12	73	1483	9/10/11	76	26	9/10/12	66	242
9/11/12	79	1538	9/11/11	82	27	9/11/12	72	251
9/12/12	79	1470	9/12/11	82	26	9/12/12	72	240
9/13/12	46	1490	9/13/11	48	26	9/13/12	42	243
9/14/12	123	1591	9/14/11	128	28	9/14/12	112	260
9/15/12	94	1202	9/15/11	98	21	9/15/12	86	196
9/16/12	66	1002	9/16/11	69	18	9/16/12	60	164
9/17/12	86	1414	9/17/11	89	25	9/17/12	78	231
9/18/12	145	1491	9/18/11	151	26	9/18/12	132	244
9/19/12	175	1577	9/19/11	182	28	9/19/12	159	258
9/20/12	164	1684	9/20/11	171	30	9/20/12	149	275
9/21/12	201	1589	9/21/11	209	28	9/21/12	183	260
9/22/12	144	1193	9/22/11	150	21	9/22/12	131	195
9/23/12	42	982	9/23/11	44	17	9/23/12	38	160
9/24/12	157	1615	9/24/11	163	29	9/24/12	143	264
9/25/12	178	1527	9/25/11	185	27	9/25/12	162	249
9/26/12	234	1584	9/26/11	243	28	9/26/12	213	259
9/27/12	163	1561	9/27/11	169	28	9/27/12	148	255
9/28/12	149	1759	9/28/11	155	31	9/28/12	136	287

#307 Model			360th St Gravel			Tollman Ave. Paved		
9/29/12	86	1264	9/29/11	89	22	9/29/12	78	207
9/30/12	45	1012	9/30/11	47	18	9/30/12	41	165
10/1/12	173	1489	10/1/11	180	26	10/1/12	157	243
10/2/12	127	1520	10/2/11	132	27	10/2/12	116	248
10/3/12	123	1582	10/3/11	128	28	10/3/12	112	258
10/4/12	117	1405	10/4/11	122	25	10/4/12	106	230
10/5/12	97	1549	10/5/11	101	27	10/5/12	88	253
10/6/12	57	1198	10/6/11	59	21	10/6/12	52	196
10/7/12	46	898	10/7/11	48	16	10/7/12	42	147
10/8/12	97	1466	10/8/11	101	26	10/8/12	88	240
10/9/12	74	1498	10/9/11	77	26	10/9/12	67	245
10/10/12	165	1527	10/10/11	172	27	10/10/12	150	249
10/11/12	69	1511	10/11/11	72	27	10/11/12	63	247
10/12/12	115	1557	10/12/11	120	28	10/12/12	105	254
10/13/12	15	1003	10/13/11	16	18	10/13/12	14	164
10/14/12	10	850	10/14/11	10	15	10/14/12	9	139
10/15/12	184	1459	10/15/11	191	26	10/15/12	167	238
10/16/12	197	1443	10/16/11	205	26	10/16/12	179	236
10/17/12	200	1492	10/17/11	208	26	10/17/12	182	244
10/18/12	188	1396	10/18/11	195	25	10/18/12	171	228
10/19/12	178	1671	10/19/11	185	30	10/19/12	162	273
10/20/12	16	1029	10/20/11	17	18	10/20/12	15	168
10/21/12	15	882	10/21/11	16	16	10/21/12	14	144
10/22/12	206	1472	10/22/11	214	26	10/22/12	187	240
10/23/12	178	1377	10/23/11	185	24	10/23/12	162	225
10/24/12	232	1386	10/24/11	241	25	10/24/12	211	226
10/25/12	155	1392	10/25/11	161	25	10/25/12	141	227
10/26/12	179	1578	10/26/11	186	28	10/26/12	163	258
10/27/12	13	1115	10/27/11	14	20	10/27/12	12	182
10/28/12	11	954	10/28/11	11	17	10/28/12	10	156
10/29/12	188	1454	10/29/11	195	26	10/29/12	171	238
10/30/12	60	1503	10/30/11	62	27	10/30/12	55	246
10/31/12	71	1501	10/31/11	74	27	10/31/12	65	245
11/1/12	71	1488	11/1/11	74	26	11/1/12	65	243
11/2/12	94	1649	11/2/11	98	29	11/2/12	86	269
11/3/12	25	1143	11/3/11	26	20	11/3/12	23	187
11/4/12	51	1314	11/4/11	53	23	11/4/12	46	215
11/5/12	92	1411	11/5/11	96	25	11/5/12	84	231
11/6/12	67	1349	11/6/11	70	24	11/6/12	61	220
11/7/12	102	1502	11/7/11	106	27	11/7/12	93	245

#307 Model			360th St Gravel			Tollman Ave. Paved		
11/8/12	87	1542	11/8/11	90	27	11/8/12	79	252
11/9/12	68	1624	11/9/11	71	29	11/9/12	62	265
11/10/12	44	1155	11/10/11	46	20	11/10/12	40	189
11/11/12	10	769	11/11/11	10	14	11/11/12	9	126
11/12/12	47	1244	11/12/11	49	22	11/12/12	43	203
11/13/12	78	1435	11/13/11	81	25	11/13/12	71	234
11/14/12	70	1469	11/14/11	73	26	11/14/12	64	240
11/15/12	38	1426	11/15/11	40	25	11/15/12	35	233
11/16/12	52	1559	11/16/11	54	28	11/16/12	47	255
11/17/12	12	1014	11/17/11	12	18	11/17/12	11	166
11/18/12	13	840	11/18/11	14	15	11/18/12	12	137
11/19/12	61	1371	11/19/11	63	24	11/19/12	56	224
11/20/12	55	1453	11/20/11	57	26	11/20/12	50	237
11/21/12	62	1536	11/21/11	64	27	11/21/12	56	251
11/22/12	9	1001	11/22/11	9	18	11/22/12	8	164
11/23/12	22	1117	11/23/11	23	20	11/23/12	20	182
11/24/12	18	1040	11/24/11	19	18	11/24/12	16	170
11/25/12	6	895	11/25/11	6	16	11/25/12	5	146
11/26/12	70	1325	11/26/11	73	23	11/26/12	64	216
11/27/12	47	1307	11/27/11	49	23	11/27/12	43	214
11/28/12	45	1424	11/28/11	47	25	11/28/12	41	233
11/29/12	67	1486	11/29/11	70	26	11/29/12	61	243
11/30/12	50	1541	11/30/11	52	27	11/30/12	45	252
12/1/12	15	1057	12/1/11	16	19	12/1/12	14	173
12/2/12	19	880	12/2/11	20	16	12/2/12	17	144
12/3/12	48	1412	12/3/11	50	25	12/3/12	44	231
12/4/12	49	1389	12/4/11	51	25	12/4/12	45	227
12/5/12	78	1456	12/5/11	81	26	12/5/12	71	238
12/6/12	52	1454	12/6/11	54	26	12/6/12	47	238
12/7/12	50	1672	12/7/11	52	30	12/7/12	45	273
12/8/12	19	1083	12/8/11	20	19	12/8/12	17	177
12/9/12	8	751	12/9/11	8	13	12/9/12	7	123
12/10/12	40	1304	12/10/11	42	23	12/10/12	36	213
12/11/12	59	1419	12/11/11	61	25	12/11/12	54	232
12/12/12	71	1539	12/12/11	74	27	12/12/12	65	251
12/13/12	60	1456	12/13/11	62	26	12/13/12	55	238
12/14/12	95	1582	12/14/11	99	28	12/14/12	86	258
12/15/12	11	1076	12/15/11	11	19	12/15/12	10	176
12/16/12	10	792	12/16/11	10	14	12/16/12	9	129
12/17/12	80	1347	12/17/11	83	24	12/17/12	73	220

#307 Model			360th St Gravel			Tollman Ave. Paved		
12/18/12	85	1332	12/18/11	88	24	12/18/12	77	218
12/19/12	79	1385	12/19/11	82	24	12/19/12	72	226
12/20/12	3	280	12/20/11	3	5	12/20/12	3	46
12/21/12	33	1112	12/21/11	34	20	12/21/12	30	182
12/22/12	6	1024	12/22/11	6	18	12/22/12	5	167
12/23/12	5	807	12/23/11	5	14	12/23/12	5	132
12/24/12	13	946	12/24/11	14	17	12/24/12	12	155
12/25/12	5	698	12/25/11	5	12	12/25/12	5	114
12/26/12	61	1269	12/26/11	63	22	12/26/12	56	207
12/27/12	69	1235	12/27/11	72	22	12/27/12	63	202
12/28/12	39	1235	12/28/11	41	22	12/28/12	35	202
12/29/12	15	911	12/29/11	16	16	12/29/12	14	149
12/30/12	6	780	12/30/11	6	14	12/30/12	5	127
12/31/12	28	1141	12/31/11	29	20	12/31/12	25	186
Total	**20110**	**468855**		**20908**	**8292**	**29200**	**18298**	**76602**

APPENDIX C. BIBLIOGRAPHY OF JOURNAL PAPERS

This appendix contains a bibliography of the journal papers that were submitted and published or are currently in press.

Miller, M. C., and Gransberg D. D. Integrating Social Impact to Bridge's Asset Management Plans. Institution of Civil Engineering (UK), *Journal of Infrastructure Asset Management*. March 2015.

Miller, M. C., and Gransberg, D. D. Social Return on Investment as an Asset Management Metric. *Transportation Research Board: 2014 Annual Meeting Compendium of Papers* Paper 14-0399, National Academies, January 2014.

Miller, M. C., and Gransberg D. D. Measuring Users' Impact to Support Economic Growth Through Transportation Asser Management Planning. *Public Works Management and Polices Journal*, (Submitted for publication in 2014).

Miller, M. C., Rueda, J. A. and Gransberg D. D Applying SROI to Risk-Based Transportation Asser Management Plans in Low-Volume Bridges. Presented at 11th International Conference on Low-Volume Roads, Pittsburgh, PA, and publication in *Transportation Research Record, Journal of the Transportation Research Board*, National Academies in 2015.

APPENDIX D. ASSET MANAGEMENT WHITE PAPERS

This appendix contains copies of the white papers produced during Phases I and II of this project.

IOWA DEPARTMENT OF TRANSPORTATION

Transportation Asset Management for the Iowa DOT

Office of Systems Planning

July 2011

What is Asset Management?

The American Association of State Highway and Transportation Officials (AASHTO) defines Asset Management as "a strategic approach to managing transportation infrastructure [and] at its core, a process of resource allocation and utilization." The Federal Highway Administration defines Asset Management as follows:

> *"Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading and expanding physical assets effectively throughout their lifecycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision-making based upon quality information and well-defined objectives."*

A transportation agency's infrastructure includes not only linear assets like roadways and bridges, but also non-linear assets such as facilities and fleets. Asset Management is a way to strategically manage infrastructure with decision-making processes that are supported by economic, engineering, and organizational principles.

With the realities of an aging infrastructure system, Asset Management enables an agency to allocate insufficient resources in order to provide the public with the most cost-effective transportation system and an acceptable level of service. Resource allocation is not strictly based on the financial operations. Although Transportation Asset Management (TAM) focuses on the integration of cost/benefit analysis and life-cycle costs into an agency decision-making process, equally important is the data used to make such judgments. The availability and accessibility of data and reliable measures of system performance should be a priority for any TAM process.

TAM is about more than simply the preservation of infrastructure assets. AASHTO clarifies TAM as "more than just tools…it represents the integration of tools with organization, leadership, people, and business processes." Staff and organizational alignment along specific and clear policies should be a focal point of TAM, especially as this relates to implementation.

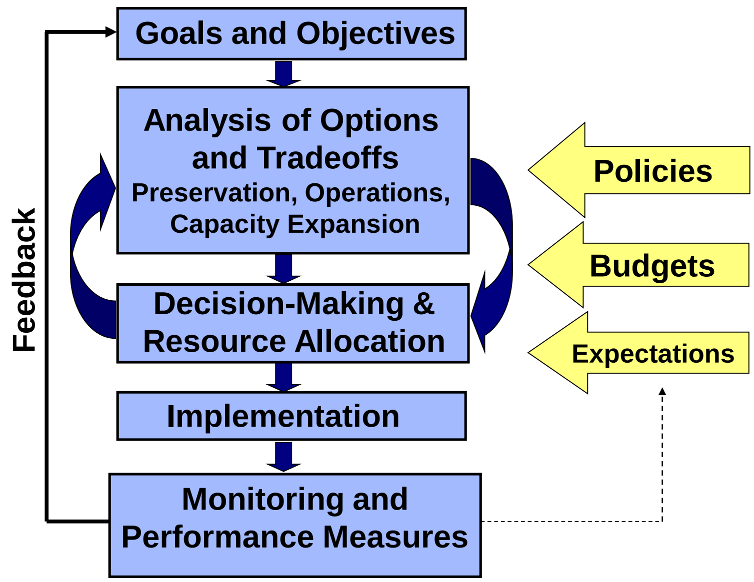
One significant benefit of TAM is the capacity to connect an agency's administrative processes to strategic goals. Performance measures quantify progress towards self-determined goals such as a desired level of service, safety benchmark or pavement condition. For instance if an agency determines that bridge maintenance is a strategic goal then a performance measure could show the number of deficient bridges, or forecast bridge conditions into the future based on current maintenance practices.

Most agencies already have some components of Asset Management in place so the implementation of TAM can actually be quite easy. However, the implementation process can become more complex and require constant attention, depending on the need to modify organizational structures or decision-making frameworks. In either case, TAM should not be perceived as a single massive project with a defined end date, but rather an iterative process in which administrators should be continually looking for ways to improve how an agency does business.

Perspectives

AASHTO and FHWA

Figure 1 - Transportation Asset Management Framework
(Basics of Asset Management, Thomas Van, FHWA [2008])



Both AASHTO and FHWA have worked to advance the culture of Asset Management within DOTs. Asset Management evolved from the earlier development of Pavement, Bridge, and Maintenance Management. Lately, there has been focus on using these tools to measure system performance and to determine how well assets are performing against targets. These measures can then be used by agencies to adjust costs, maintenance schedules, investments, etc. in order to meet strategic goals. However, Asset Management should not be viewed as a competing system to current DOT practices, but rather a framework for incorporating all of these management systems. Most importantly it allows management *across* assets; giving practitioners the tools to compare costs and trade-offs between different major asset categories. AASHTO provides an overall operational framework (Figure 1) for TAM:

> **Policy Goals and Objectives** - Policies in Asset Management have to be realistic; they have to be clear and have to have "buy-in" from all who are responsible for implementing them. They are supported by quantifiable performance measures and service levels used to guide the overall resource allocation and program delivery processes.

> **Analysis of Options and Trade-offs** - This includes examination of options *within* each investment area, as well as trade-offs *across* different investment areas that support the agency's policies, goals and objectives. The definition of investment areas is flexible and needs to be tailored to

how an individual agency does business. Option analysis and trade-off analysis are often facilitated by economic analysis methods.

Decision-making and Resource Allocation - These decisions are the critical allocations of resources to different strategies, programs, projects or asset classes within the organization. Once an Asset Management System is in place, decisions are informed by the results of the proactive analysis of the options and trade-offs and cover all investment areas and focus directly on performance goals and service levels with life cycle performance considerations. Also, customer expectations must be factored into the decision process.

Implementation and Program Delivery - Programs need to be accomplished in the most cost-effective manner that can meet the performance targets. It may involve consideration of different delivery options, such as using contractors, interagency agreements or design-build projects. Program delivery also means having a systematic way to monitor actions taken, costs, efficiency and lessons learned to guide future decisions and analyses (on time and within budget).

Monitoring System Conditions and Performance Measures - This is the monitoring and the all-important feedback portion of Asset Management that measures the extent to which established performance objectives are being addressed. This information has to be objective, current and targeted toward the goals, objectives and priorities set by the agency.

(Basics of Asset Management, Thomas Van, FHWA [2008])

FHWA and Asset Management

The FHWA motives for implementing Asset Management in transportation agencies is a result of "increasing pressure from Congress and state legislatures to demonstrate results, accountability and transparency." And because of the fact that most transportation projects are funded solely by federal and state monies this concern is understandable. The accountability aspect of Asset Management was first developed with the Governmental Accountability Standards Board Statement 34 (GASB 34). It should also be noted that Asset Management could be an area of focus in the next federal transportation reauthorization. Similar to the AASHTO definition, FHWA describes Asset Management by being:

- Policy-driven – Resource allocation decisions are based on a well-defined set of policy goals and objectives.

- Performance-based – Policy objectives are translated into system performance measures that are used for both day-to-day management and strategic management.

- Analysis of Options and Tradeoffs – Decisions on how to allocate funds within and across different types of investments (e.g. preventative maintenance versus rehabilitation, pavements versus bridges) are based on an analysis of how different allocations will affect achievements of relevant policy objectives.

- Decisions Based on Quality Information – The merits of different options with respect to an agency's policy goals are evaluated using credible and current data.

- Monitoring Provides Clear Accountability and Feedback – Performance results are monitored and evaluated for both efficiency and effectiveness.

Both FHWA and AASTHO describe the tenants of Asset Management. By using self-assessment/gap analysis process for Asset management, Iowa DOT could begin to review current practices to see how they can be improved. Iowa DOT's first step is to develop goals for the condition of pavements or safety of highway system users. This can be an extensive process and often must include an honest assessment of all agency activity.

The TAM Plan

The TAM plan outlines how an agency can fully implement Asset Management principle into all aspects of operation and policy. The TAM plan can be one master plan focused on implementation or multiple documents focused perhaps on performance measures and cost/benefit analysis for assets. AASHTO emphasizes that a TAM plan can originate at any level within an agency but must be embraced by the "highest appropriate organizational level."

It should be mentioned that two different DOT's TAM plans may not look similar to one another. This is due to TAM being, at its core a method to improve and maintain Asset Management policies and principles within an agency. Since DOTs can be at different stages of enabling Asset Management processes and tools, it follows that their TAM plans would be comparatively distinct.

TAM Benefits

TAM also provides management benefits to policy-makers and DOT executives. Many of these benefits can be used to achieve the strategic goals of an agency, whether these are have been previously determined or were determined through the TAM gap-analysis. According to AASHTO these benefits include:

- **Long-Term View** – The benefit of a long-term view can help agencies realize that assets are just that ("property in the hands of an heir, executor, or administrator") which must be managed for the long-term, from decades to even centuries.

- **Clear Relationships, Transparency, and Accountability** – a TAM plan can provide the benefit of showing employees, executives and legislatures the results of investment in transportation assets.

- **Provides the Desired Levels of Service (LOS)** – TAM provides the desired LOS which is representative of legislation and regulatory requirements.

- **Plans for Growth** – TAM allows the integration of growth forecasts and future effects into the management of assets.

- **Maximizes the Benefits of Infrastructure** – By stressing the importance of life-cycle planning and cost, and placing agreed levels of service at the core of the asset management process, TAM helps to ensure that the benefits delivered by the network are maximized while the costs of providing, maintaining, and using it are minimized.

Enabling Performance Measures and Targets

A vital component of Asset Management is the measurement of the performance of assets. Within Iowa DOT performance measurements and targets are already used, so rationally we should build upon these frameworks and also expand them to all operations. As an example, a step-by-step process for enabling a performance measure, whether for pavement or signage, could resemble this:

1. A target level of service or performance goal for the asset (bridges) is set after determining the current condition (percentage of structurally) based on reliable data from management systems
2. Inventory of the asset is compiled, if one does not already exist or a more reliable one is needed, and current conditions are assessed against the desired targets
3. Economic tradeoff analysis is conducted

4. Rational analysis to allocate funds among various needs, preferably for highest Return On Investment (ROI). [Engineering judgment and past experience can be used if formal analysis is not possible]
5. Application of maintenance or construction would be scheduled at a time that provides the lowest-cost
6. Once performance measurements are at an acceptable level, a preventative maintenance schedule would be implemented
7. Asset performance is then assessed annually and adjustments are made to the schedule
8. If performance levels cannot be maintained, an in-depth analysis would be done to indentify the causes of the poor performance and corrective action would be taken
9. Finally, performance and costs would be input to the overall system for that particular asset to determine if goals were met

Why is TAM Necessary for Iowa DOT?

The purpose of this paper is to increase awareness of Asset Management in Iowa DOT. It is important to have a coordinated effort when creating and implementing a TAM plan, and requires department-wide involvement. However, this is not to say that a TAM plan would drastically change how Iowa DOT operates. A TAM plan would be a framework for improving how Iowa DOT operates and the services it provides. It would build off of current practices while enhancing their efficiency and value.

A TAM plan can also assist Iowa DOT in achieving its strategic goals as outlined in the most recent strategic plan. One of the core functions of the Iowa DOT Strategic Plan (2008-2012) is physical assets management. Some of the "weaknesses/challenges" listed in the plan can also be directly addressed with asset management. One weakness mentioned states that the Iowa DOT does "not adequately integrate and utilize available information for decision-making and monitoring progress toward our vision and mission." Another concern was that there is "an ongoing expectation of citizens, businesses and elected officials for increasing levels of quality, efficiency and responsiveness. (4)"

Another benefit of TAM is that it can simultaneously address both community and political needs. A TAM plan creates accountability and transparency, two important factors in the politics of funding and taxpayer opinions.

Current Status of Asset Management in Iowa DOT

Iowa DOT has many Asset Management processes already established. Currently, data systems provide volumes of information about Iowa DOT linear assets.

According to the Self-Assessment the respondents believe planning and programming and program delivery to be overall performing well.

Self-Assessment Results

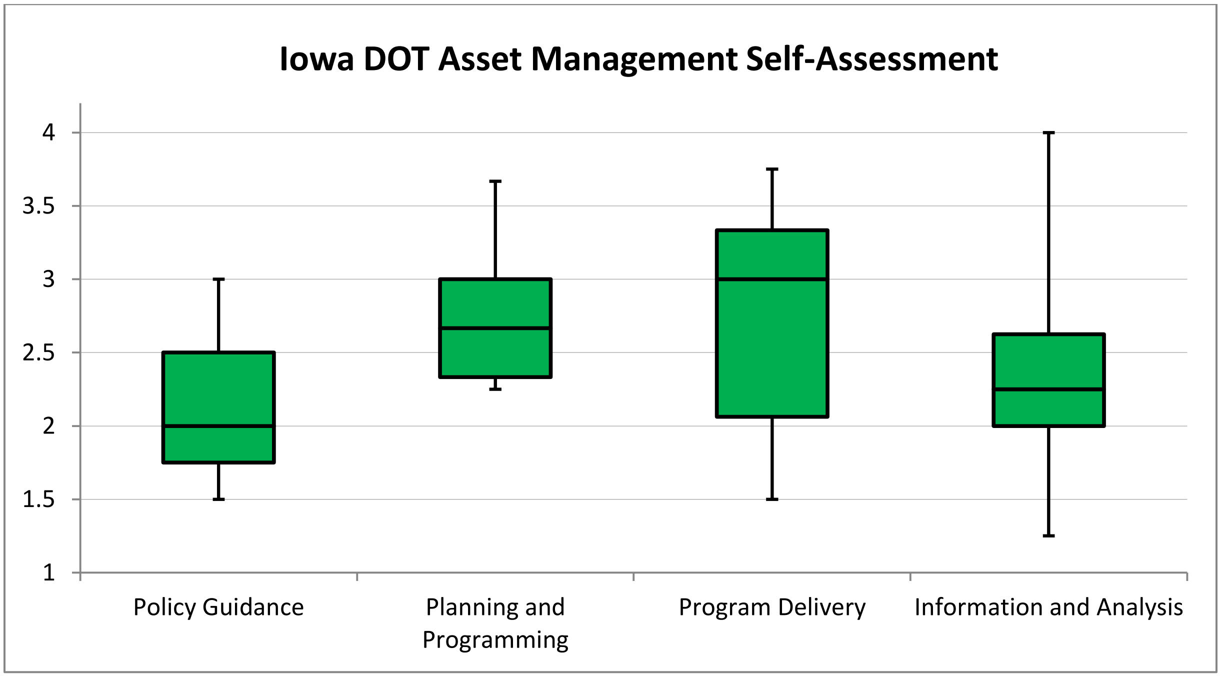
Iowa DOT performed the AM self-assessment using the questionnaire from the AASHTO Transportation Asset Management Guide (2002). This is the first step for an agency to identify their current asset management practices. Once the questionnaire is completed and the results are tallied, the overall self-assessment process continues with the gap analysis (which will be addressed later). Think of the self-assessment questionnaire as a quick diagnostic tool while the gap analysis is a performance tool used to specifically target asset management strategies.

Respondents were asked to rate the extent to which they agreed with statements, using a scale of 1 to 4. The questionnaire asks about a series of topics focusing on four areas of Asset Management:

- Policy, Goals and Objectives;
- Planning and Programming;
- Program Delivery; and
- Information and Analysis.

All responses were averaged for each question (Table 1), then for each policy area and also for each of the four topics of AM (Figure 2). These illustrations provide an overall picture of how Iowa DOT is currently performing, and will be used later in the TAM plan for gap analysis, identifying performance measures and targets, and designing a framework of comprehensive asset management.

Figure 1 – Self-Assessment Results



Next Steps

Iowa DOT must incorporate Asset Management practices in order to prepare Iowa's transportation system for the future. AASHTO has compiled the "Transportation Asset Management Guide: A Focus on Implementation" as a manual for implementing a TAM plan. The overall goal for Iowa DOT is to expand Asset Management processes and tools to all departments. The good news is that the often expensive and time-consuming aspects of implementing TAM have already been developed, namely Iowa DOTs vast data systems. The Gap-Analysis is the next step in the self assessment process and through this Iowa DOT can build on its solid foundation. The Gap-Analysis also provides guidance in defining goals for the TAM plan and suggestions for policy. Once the self-assessment is completed the writing of the TAM plan can begin.

Iowa DOT Asset Management Self-Assessment Results

3.2.1 PART A. POLICY GUIDANCE

How Does Policy Guidance Benefit from Improved Asset Management Practice? *1 = Strongly Disagree - 4 = Strongly Agree*

		Maintenance	Bridge	OLE	Systems Planning	Average
A1	Policy supports preservation	2.0	2.0	3.0	3.0	2.5
A2	Policy based on cost-effectiveness	2.0	1.0	2.0	2.0	1.8
A3	Policies support life-cycle approach	2.0	1.0	2.0	2.0	1.8
A4	Policy considers customer perceptions	2.0	3.0	4.0	3.0	3.0
A5	Our customers contribute to formulation of policy goals	2.0	2.0	2.0	3.0	2.3
A6	Performance-based approach for resource allocation	2.0	1.0	2.0	1.0	1.5
A7	Our agency well defined strategic plan	2.0	2.0	2.0	2.0	2.0
A8	Our agency goals linked to performance measures	2.0	2.0	1.0	2.0	1.8
A9	Our agency estimates resources needed	2.0	3.0	2.0	2.0	2.3
A10	Our agency communicates policy accomplishments to stakeholders	2.0	2.0	1.0	2.0	1.8
A11	Our agency communicates budget consequences with stakeholders	4.0	3.0	2.0	3.0	3.0

3.2.2 PART B. PLANNING AND PROGRAMMING

Do Resource Allocation Decisions Reflect Good Practice in Asset Management? *1 = Strongly Disagree - 4 = Strongly Agree*

		Maintenance	Bridge	OLE	Systems Planning	Average
B1	Our agency's long-range plan includes capital, operational, modal alternatives	-	4.0	4.0	3.0	3.7
B2	Capital versus maintenance expenditure tradeoffs for pavement etc	-	2.0	3.0	2.0	2.3
B3	Capital versus operations tradeoffs for traffic improvements	-	2.0	2.0	3.0	2.3
B4	Our agency's long-range plan consistent with policy goals and objectives	-	3.0	3.0	3.0	3.0
B5	Our agency's long-range plan is consistent with plausible projections of future revenues	3.0	3.0	2.0	3.0	2.8
B6	Our agency's long-range plan has guidance for capital program development process	-	1.0	-	2.0	1.5

		Maintenance	Bridge	OLE	Systems Planning	Average
B7	Our agency updates planning and programming methods...	2.0	2.0	2.0	1.0	1.8
B8	Criteria used to set program priorities, select projects, and allocate resources are consistent with stated policy objectives and defined performance measures	-	2.0	2.0	2.0	2.0
B9	Our agency's programs are consistent with projections of future revenues	3.0	3.0	4.0	3.0	3.3
B10	Our agency's programs based on realistic estimates of costs, benefits, and impacts on system performance	-	3.0	2.0	2.0	2.3
B11	Project selection based on an objective ability to meet performance targets	-	3.0	3.0	2.0	2.7
B12	The preservation program budget is based upon analyses of least life-cycle cost	2.0	1.0	1.0	1.0	1.3
B13	A maintenance quality assurance study has been implemented to define levels of service for transportation system maintenance	-	1.0	2.0	1.0	1.3

3.2.3 PART C. PROGRAM DELIVERY

Are Appropriate Program Delivery Processes that Reflect Industry Good Practices Being Implemented?

1 = Strongly Disagree - 4 = Strongly Agree

		Maintenance	Bridge	OLE	Systems Planning	Average
C1	Our agency periodically evaluates the use of alternative delivery options	2.0	1.0	2.0	2.0	1.8
C2	Our agency has an incentive program for improving upon schedule, quality, and cost objectives	2.0	2.0	1.0	2.0	1.8
C3	Our agency solicits input to ensure that project scope is consistent with objectives	-	3.0	4.0	3.0	3.3
C4	Our agency uses program delivery measures to track adherence to project scope, schedule, and budget	-	3.0	4.0	3.0	3.3
C5	Our agency has a functioning process to approve project changes and program adjustments	3.0	3.0	4.0	3.0	3.3
C6	When adding projects or changing project schedules, our agency considers effects on the delivery of other projects in the program	3.0	3.0	4.0	3.0	3.3

		Maintenance	Bridge	OLE	Systems Planning	Average
C7	Projects with significant changes to scope, schedule, or cost are reprioritized to ensure that they are still competitive in cost and performance	2.0	1.0	1.0	2.0	1.5
C8	Agency executives and program managers are regularly kept informed of program delivery status	3.0	4.0	4.0	4.0	3.8
C9	External stakeholders and policy-makers feel that they are sufficiently updated on program delivery status	-	-	4.0	3.0	3.5
C10	Our agency maintains and uses information on the full unit costs of construction activities	3.0	4.0	2.0	2.0	2.8
C11	Our agency maintains and uses information on the full unit costs of maintenance activities	1.5	4.0	2.0	2.0	2.4

3.2.4 PART D. INFORMATION AND ANALYSIS

Do Information Resources Effectively Support Asset Management Policies and Decisions?

1 = Strongly Disagree - 4 = Strongly Agree

		Maintenance	Bridge	OLE	Systems Planning	Average
D1	Our agency has a complete and up-to-date inventory of our major assets	2.0	4.0	3.0	4.0	3.3
D2	Our agency regularly collects information on the condition of our assets	1.5	4.0	3.0	4.0	3.1
D3	Our agency regularly collects information on the performance of our assets	3.0	3.0	3.0	2.0	2.8
D4	Our agency regularly collects customer perceptions of asset condition and performance.	2.0	2.0	2.0	2.0	2.0
D5	Our agency continually seeks to improve the efficiency of data collection	-	4.0	4.0	4.0	4.0
D6	Agency managers and staff at different levels can quickly and conveniently obtain information they need about asset characteristics, location, usage, condition, or performance.	2.0	3.0	1.0	1.0	1.8

		Maintenance	Bridge	OLE	Systems Planning	Average
D7	Our agency has established standards for geographic referencing that allow us to bring together information for different asset classes.	2.0	4.0	1.0	2.0	2.3
D8	Our agency can easily produce map displays showing needs/deficiencies for different asset classes and planned/programmed projects.	-	3.0	1.0	2.0	2.0
D9	Our agency has established data standards to promote consistent treatment of existing asset-related data and guide development of future applications.	2.0	3.0	2.0	3.0	2.5
D10	Information on actual work accomplishments and costs is used to improve the cost-projection capabilities of our asset management systems.	2.0	3.0	2.0	2.0	2.3
D11	Information on changes in asset condition over time is used to improve forecasts of asset life and deterioration in our asset management systems.	2.0	3.0	2.0	1.0	2.0
D12	Calculate and report actual system performance	3.0	2.0	3.0	2.0	2.5
D13	Identify system deficiencies or needs	3.0	3.0	3.0	2.0	2.8
D14	Rank candidate projects for the capital program	-	1.0	3.0	1.0	1.7
D15	Forecast future system performance given a proposed program of projects	2.0	1.0	2.0	1.0	1.5
D16	Forecast future system performance under different mixes of investment levels by program category.	2.0	1.0	1.0	1.0	1.3
D17	Our agency monitors actual system performance and compares these values to targets projected for its capital preservation program.	-	2.0	2.0	2.0	2.0
D18	Our agency monitors actual system performance and compares these values to targets projected for its capital improvement program.	-	2.0	2.0	2.0	2.0
D19	Our agency monitors actual system performance and compares these values to targets projected for its maintenance and operations program.	3.0	2.0	2.0	2.0	2.3
D20	We periodically distribute reports of performance measures relevant to customer/stakeholder satisfaction with transportation system and services.	2.0	3.0	-	2.0	2.3

WHITE PAPER

Asset Management Program Enhancement Plan: Baseline Assessment

Iowa DOT RT 393/Addendum 432

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Integrating Key Performance Indicators for Transportation Assets Management

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March 29, 2013

IOWA STATE UNIVERSITY
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CONSTRUCTION MANAGEMENT AND TECHNOLOGY

Integrating Key Performance Indicators for Transportation Assets Management

One of the key components in operation and maintenance phase of a highway project life cycle is pavement management. The aim of pavement management is to preserve, rehabilitate reconstruct, and/or maintain the highway network to increase road users' safety and meet transportation goals. During this process, Department of transportations' (DOTs) perform multiple decisions at various levels of their program in order to sustain the network. Some of the key decisions range from evaluation of system performance to setting policies and objectives at strategic level; Rehabilitation, Restoration and Resurfacing (3R) fund distribution to allocation of budgets forecasting short-term and long-range plans at network level; and evaluation and prioritization of pavements/projects to treatment selection (improvement strategy) at project level. These decisions are supported through various data, information and knowledge that incorporates asset management inventory (condition data, structural history of pavement, traffic data and roadway data), external information (such as public input, expert opinion, safety data and environmental data) and performance analysis (life cycle cost analysis, cost/benefit analysis, deterioration curves, etc.) to address the technical-social-economic-environmental-political aspects on highway projects. Figure 1 shows pavement-management decision hierarchy.

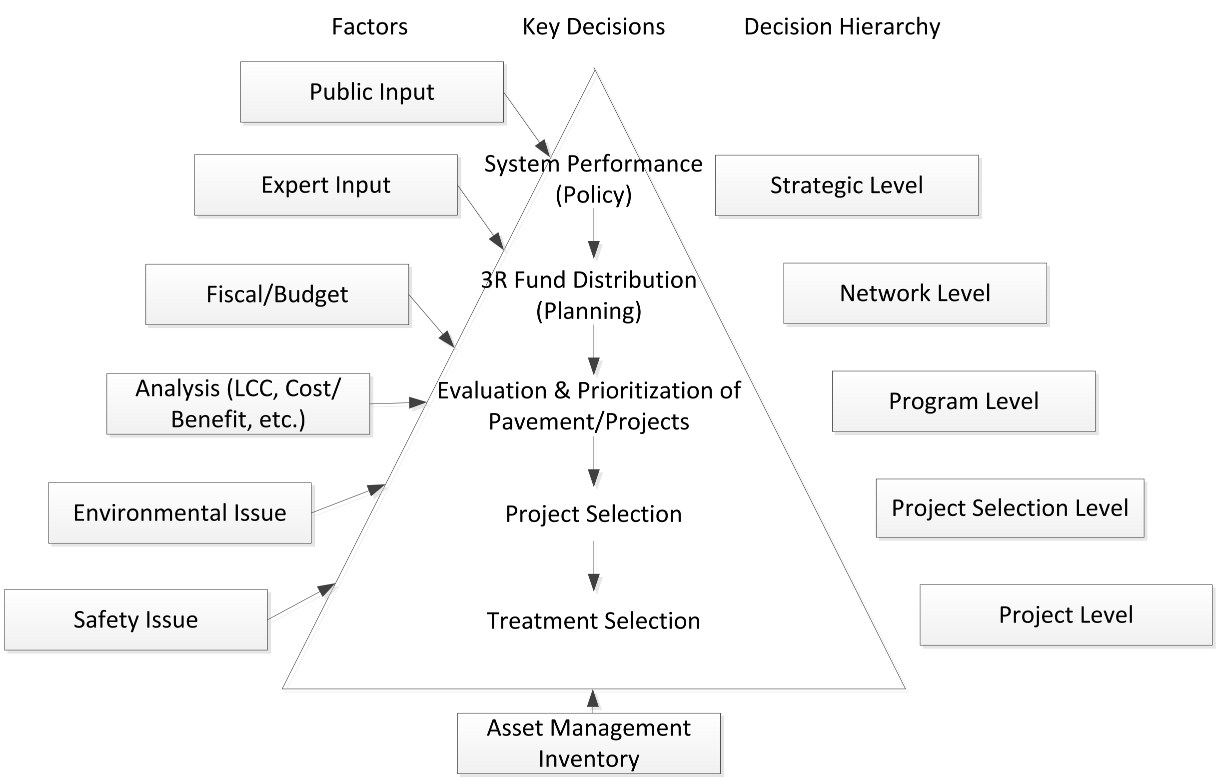

Figure 1 Pavement Management Decision Hierarchy

Currently, state DOT pavement management programs collect and store large amounts of technical data and information as part of their asset management program. For instance, there are approximately 1.5 million pavement condition records in the Oklahoma DOT database. The Iowa DOT pavement management program (IPMP) has a pavement management system (PMS) that approximately 38,000 km (23,500 miles) of roadway network (Smadi, 1998). The program uses automated data collection system to collect data on the condition of roads (distress data collection). This distress data collection is conducted on bi-annually basis for federal aid eligible roadways in the state until 2006 when the data collection effort was left for individual Metropolitan Planning Organizations (MPO) and Rural Planning Agencies (RPO) decision. Figure 2 shows MPOs and RPAs who participated in the data collection effort in 2010.

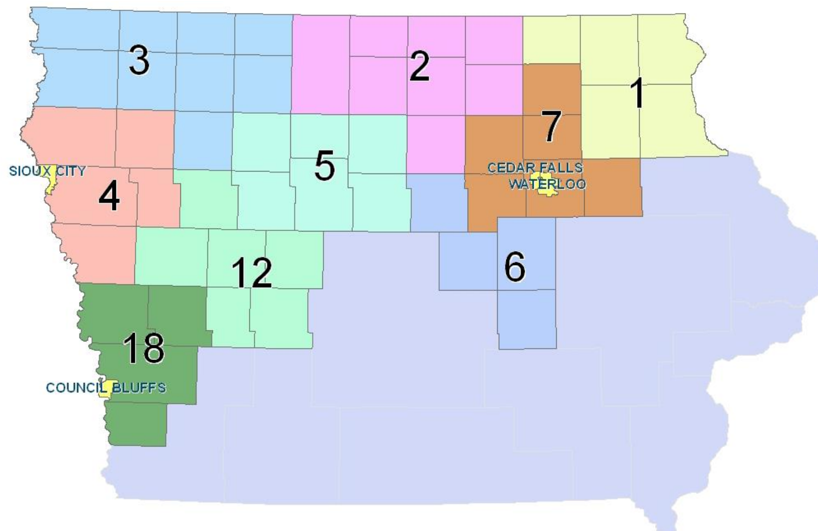

Figure 2 Data Collection Effort (IDOT, 2010)

However, one of the main concerns in the current practice is whether the data currently being collected provides the right information needed for decision-making. There are questions if these data and information are meaningful and interpreted in the same manner, if they reflect the details of the original observation, or if they are recorded in consistent manner or if the information includes all the relevant and necessary data to support decision-makings. In addition, there are concerns in regards to fulfilling various decision-makers' needs and utilizing the right type of information/analysis, as data and information are collected in qualitative and quantitative manner. Therefore, there is a need to identify the current level of data usage and information requirements to integrate them to support decision-making and achieve the return on the data collection investment.

The Iowa DOT often utilizes pavement condition data such as pavement condition index (PCI) and international roughness index (IRI) in construction and maintenance project selection. In many cases, the indices are used for comparing the performance of competing roadway sections. The comparisons in turn help prioritize which sections are selected for treatment. However, the indexes are not comprised of discrete values that facilitate a "yes/no" decision on whether a specific treatment should be used. For instance, Iowa DOT has set treatment selection criteria (treatment triggers) for their primary road system based on pavement condition indexes and other performance criteria (Table 1). However, it is difficult to furnish a rational justification for the accuracy of the selection criteria (triggers). This issue leads to the following unanswered questions that are necessary to make authoritative decisions:

Does PCI value greater than 50 and pavement age greater than 10 years, a real indicator for a pavement to be replaced?

Should additional data and/or information be incorporated for replacing a pavement?

Does the PCI have any significant relationship with other pavement condition data or key performance indicators?

At what level of rutting should a trigger be developed to recommend a treatment strategy?

At what IRI level do we say the ride is poor and rehabilitation is needed? Is there a level of cracking amount, severity, or a combination of both that would trigger different treatment strategies?

Table 1 IDOT Primary System Pavement Treatment Strategy (IDOT, 2012)

Treatment Strategy	Criteria							
	PCI	Rutting	Roughness (Faulting)	Age	Structure	D-Cracking	T-Cracking	Fatigue Cracking
Replacement (NHS & Non-NHS)	< 50	-	-	> 10 years	-	-	-	-
Structural Overlays (4", 6")	> 10	> 0.5" (for milling)	-	-	≥ 1.32	-	-	-
Functional Overlays (2"- 4")	> 10	> 0.5" (for milling)	> 2.5	-	< 1.32	-	-	< 20% Coverage
Crack and Seal (6'-9" Type I)	> 10	-	> 2.5 or > 3.0	-	-	NHS-3, Non-NHS - 5 to 8 joints/100m test section	-	-
Rubberized (6'-9", Type I)	> 10	-	> 2.5 or > 3.0	-	-	NHS-4 or 5, Non-NHS>10joints/100m test section	-	-
Cold-In-Place Recycling, CIPR (2"-4", Types III & IV)	> 10	-	> 2.5 or > 3.0	-	< 2	-	(Low +1.5 Moderate + 3 Severe) > 50% Coverage	-

Pavement condition data is the primary source of the information (key performance indicator) utilized in pavement operation and maintenance decision-making such as treatment strategy selection. In addition, pavement history, roadway inventory and traffic are used as supporting tools for pavement performance analysis. Pavement history is used to understand previous treatment applications in terms of pavement surface type, thickness, composition and treatment cost. Roadway inventory incorporates pavement classification, pavement type, section, length, width, etc., while traffic data incorporates the traffic profile or growth, annual average daily traffic (AADT) and traffic year to determine the structural capacity of existing and future pavement. Pavement condition data combines functional and structural aspects of a pavement. Functional aspects are pavement rutting, roughness, friction, ride quality, etc., while the structural aspects are pavement distress data and stiffness such as longitudinal cracking, transverse cracking, fatigue (alligator cracking) etc. The functional data contains one record for each 100th mile of roadway surface condition. Structural data mainly contains one record per 100th mile of structural layer information while the analysis produces condition indices on structurally homogeneous segments of roadway.

A 3-tiered hierarchical framework is developed to match and convert data into meaningful information to support the decision-making process across the life cycle of highway projects (Figure 3). The framework consists of raw data (Tier I), information (Tier II) and decision-making (Tier III). The framework will integrate and map these three entities based on the decision-makers requirement. Mapping these three-tiered components using hierarchical dependency and inclusive relationships will help identify three types of paths. The first path is an active path that indicates active use of data currently employed as information in support of decision-making. The second path, an inactive path meaning that there are currently available data but it is not utilized in decision-making. The third path is a non-existing path indicating that there is not available data to generate required information to support specific decisions and information extraction method is not known.

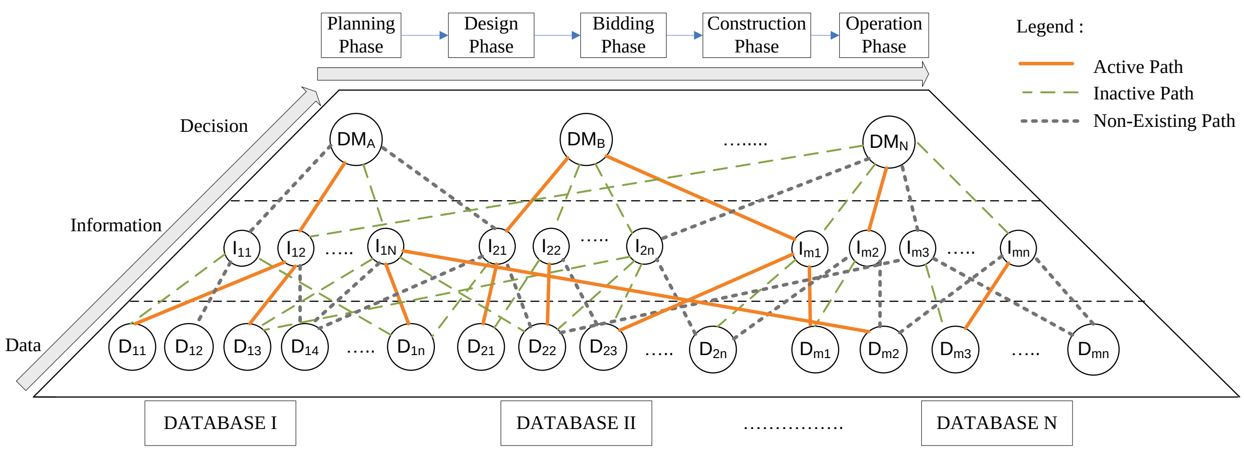

Figure 3 3-Tiered Hierarchical Framework

As mentioned earlier, based on asset management inventory of existing databases, currently available raw data have been identified as pavement condition data, pavement history data, roadway inventory data and traffic data (Tier I). Tier II is the information level where as key performance indicators and analysis are used to support decision-makings (Tier III). Key performance indicators such as pavement condition indices are treated as information since it incorporates one or more raw data points to obtain pavement performance measures. For instance, PCI is 0 - 100 rating used to measure the condition of pavements without the consideration of geometry, safety or congestion. However, Iowa DOT has developed PCI equations based on pavement roughness, faulting and cracking. Currently, PCI is used in fund distribution at a network level, project prioritization and treatment strategy selection at program level and project level respectively. IRI is information developed to measure the ride quality based on the roughness of a pavement utilized in treatment selection and project selection. It should be noted that some raw data can be treated as information as long as they are directly utilized in decision-making.

Figure 4 illustrates a prototype three-tier technical data and information decision framework for highway operation and maintenance phase. For project selection, the district staff primarily develop a list of candidate projects based on staff input, input from the public, and pavement condition data (often PCI and IRI). Then, the district staff reviews the road performances and prioritizes the projects accordingly. Using available funding levels, the districts will develop a 3R program for 3 to 5 years into the future. Pavement treatment selection is another key decision made at project level. Pavement treatment selection considers PCI (as information); age, roughness, rutting, fault, and crack data (as pavement condition data/information); structure and pavement type (as structural data/ information); highway class and pavement length (as roadway inventory data) and AADT (traffic inventory). PCI is a combination of roughness, faulting, and cracking. Other decisions made in the pavement management could include selection of type of pavement (asphalt, concrete or combination) or thickness of pavement for new or rehabilitation projects.

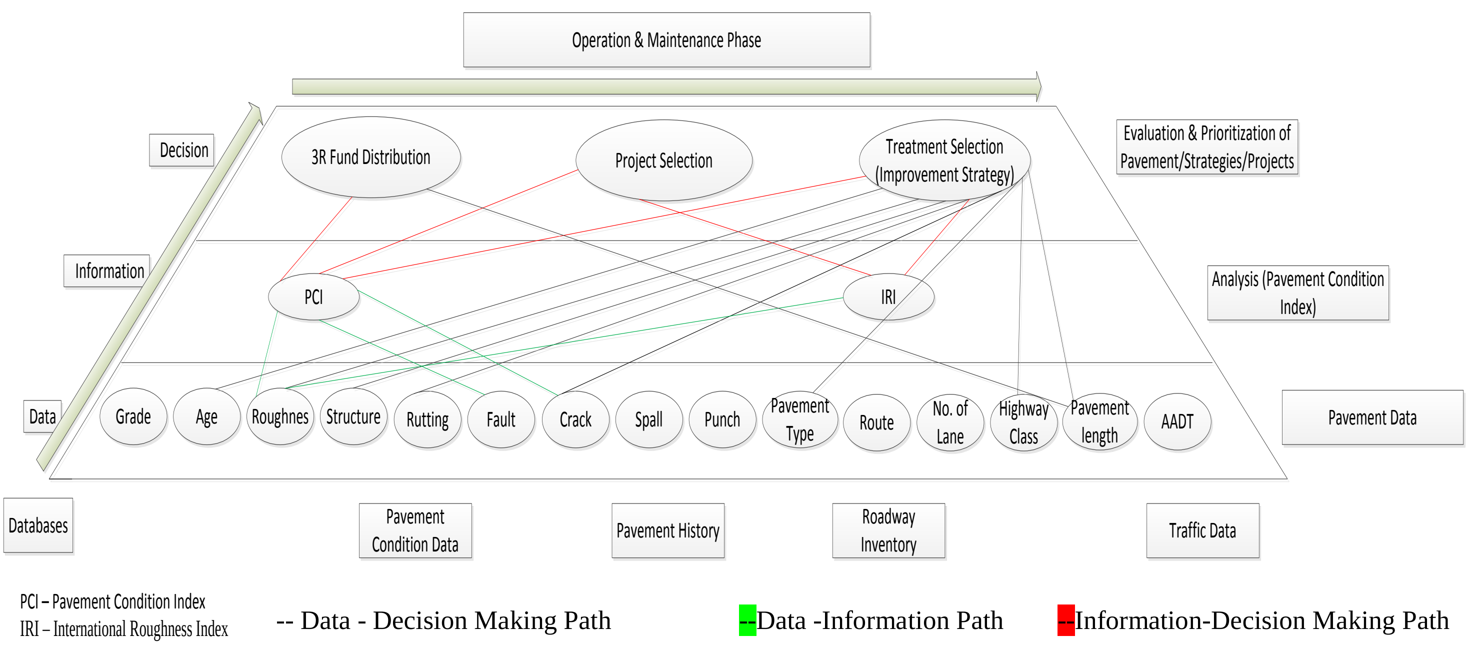

Figure 4 3-Tier Pavement Management Data-Information-Decision Framework

This prototype framework only maps the active path of the current data and information utilization in the pavement decision-making process. However, the inactive path and no path should be investigated to identify the gap in data and information integration. In addition, an Asset Management Plan involves more than the physical or technical condition of the roads. Selecting the optimum maintenance treatment implies a comprehensive understanding of the impact of the assets on the stakeholders. Other inputs such as risk analysis and social impact must be integrated with the physical condition. This way the output will identify the need for maintenance due to normal deterioration as well as the need for maintenance due to the actual use and socioeconomic impact, in other words, going from a prioritization system based on "worst first" to as "as needed" system. Once risk assessment and socioeconomic impact have been added to the analysis, integration becomes a little more complex. Ending up with heterogeneous range of data, the goal is to be able to compare and analyze relevant data and information to allow decision makers allocate the resources based on needs in selecting the most efficient maintenance treatment. Figure 5 shows an overall asset management framework.

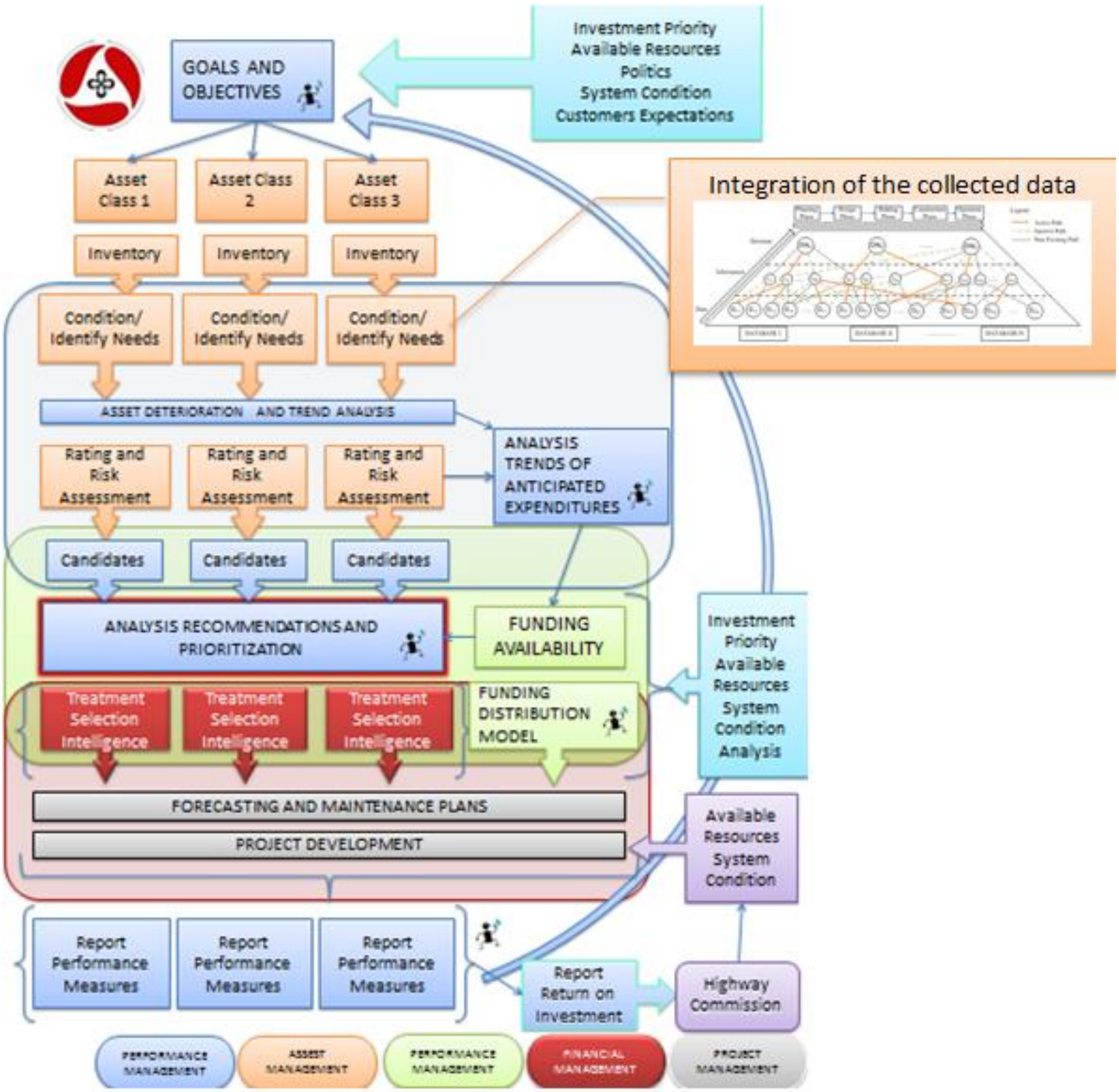

Figure 5 Asset Management Framework

Often the most widely used pavement management KPIs in decision-makings are PCI and IRI. These are sometimes used in a quantitative decision process like 3R fund distribution, but more often in a qualitative decision analysis. Iowa DOT utilizes dTIMS™ pavement management software program to develop inventory of physical assets and perform life cycle cost analysis to support their pavement management plan. dTIMS™ allows generation of projects by year, recommended treatments by project and year, and overall summaries of condition, backlog, treatment cost, and treatment length (IDOT, 2012). The program is set up to provide assistance to districts in the selection and prioritization of rehabilitation and reconstruction projects. It also has capabilities in doing network level analysis of the condition of the system and the funding levels needed to maintain status quo or improve the system. However, it has been used in a limited extent for both of these purposes and there is need to utilize the huge amount of data and information collected in State DOTs to support the decision making process. Therefore, a framework should be developed to integrate the data and key performance indicators (information) beyond the technical aspects to effectively manage highway projects, increase the return on investment and meet transportation asset management goals.

Table 2 Summary of Asset Management Performance Measures in Use in the USA and Internationally.

TECHNICAL-MEASURE	Int'l	USA	TECHNICAL-MEASURE	Int'l	USA
International Roughness Index	21	2	Raveling and Potholes	2	2
Ruth Depth	10	1	Signs	1	-
Cracking	8	1	Lighting	1	-
Friction	8	-	Average Speed	1	-
Pavement Surface Condition	6	-	Facility Condition Index	1	1
Pavement Condition Index	5	3	Accident Risk	1	-
Paved Shoulders	5	-	Structural Index	1	1
Pavement Performance	4	-	Foreign Object Debris Index	1	-
Plastic Deformation	4	-	Bearing capacity	1	-
Macro Texture	4	1	Smoothness travel	1	1
Micro Texture	3	-	Texture Depth	1	-
Pavement Maintenance Score	2	-	Visual Condition Index	1	-

FINANCIAL-MEASURE	Int'l	USA	SAFETY-MEASURE	Int'l	USA
Road Maintenance Cost	15	-	Fatalities Per 100,000 People	8	-
Warranty Costs	6	1	Fatalities	5	3
Allocation level for the Road fund	5	-	Present Serviceability Index	4	-
Asset Utilization	2	-	Car accidents per 100,000 people	2	2
Pavement Asset Value	2	-	Road Accidents	1	-
User Cost	1	-	Road Accidents Costs	1	1
Detour Cost	1	-	Deaths per age group	1	-
Accrued Depreciation	1	-	Accidents per 1 million vehicles	1	-
Gross Replacement Cost	1	-	Accidents per 100 million vehicle km	1	-
Transportation Fee	1	-	Fatality Risk	1	-

WHITE PAPER

Asset Management Program Enhancement Plan: Baseline Assessment

Iowa DOT RT 393/Addendum 432

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Asset Management: Performance Measures

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March 29, 2013

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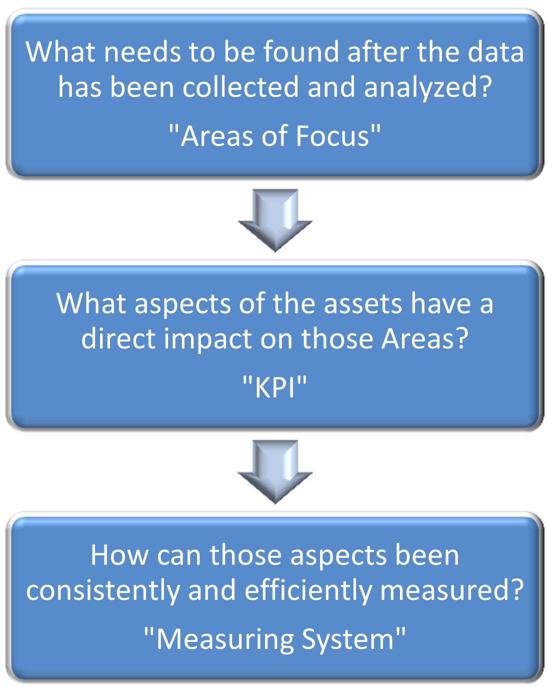
CONSTRUCTION MANAGEMENT AND TECHNOLOGY

Asset Management: Performance Measures

By Catalina Miller

Introduction One of the elements for a successful Assets Management Program is to identify the Key Performance Indicators (KPI) and how they will be measured so that the output responds to the needs of the state agency. Thus it is important to align them with the strategic plan and goals for each specific Department of Transportation (DOT).

In order to have an efficient set of performance indicators the following conditions need to be identified:



Iowa DOT Each state agency has different needs driven by their internal organization, financial conditions, and stakeholders' demands. In order to identify the areas of focus, the annual Strategic Plan should be reviewed. For this scenario three focus areas have been identified based on the Iowa Department of Transportation 2012-2013 Strategic Plan:

- To understand the status of their transportation system, so it can be enhanced;
- To obtain tools that support investment decisions and resource allocation; and
- To ensure accountability and responsiveness to stakeholders.

KPI Within a wide range of key performance indicators, it is imperative to select the aspects that directly impact each of the above areas. In other words, once the areas of focus have been identified, the agencies can target the data collection efforts more efficiently. Not only will the quality of the data improve, but also the communication and decision making will also be simplified. From a practical point of view, the data collectors will be more motivated to do their job if they understand the reason for their scope and can tangibly see its application.

Status of the Transportation System KPI:

Historically, the state DOTs have been collecting technical data for roads. Even though there is not a uniform system across the states to collect and integrate data, there is a wide range of performance indicators that are commonly been used to measure the condition of the roads and bridges.

It is important to indicate that for ancillary infrastructure like lighting, culverts, and signs the deterioration models are not as structured as for roads and bridges; however, some models have been developed (see measurement systems).

Table 1 compares the different systems used by some DOTs, and the KPI that better describe the condition of the roads.

Table 1

Measuring System	KPI used	Examples
PCI (pavement condition index)	Cracks and rutting (pavement surface distresses)	IADOT
	Smoothness and ride comfort	
PSI & PSR (Pavement Serviceability Rating and index)	Slope variance	DCDOT
	Ruth depth	
	Cracking & patching	
IRI (International roughness index)	Profile of Pavement Surface	ARDOT, OKDOT
PACES Computerized Pavements Condition Evaluation Systems	Load Cracking	GDOT
	Block Cracking	
	Raveling	
	Reflective Cracking	
	Loss Section	
	Bleeding	
	Corrugation	
	Patch Areas	
	Edge Distress	
	Rutting	
Drainage Conditions	Ditching	GDOT
	Shoulder Clipping	
	Shoulder Rebuilding	
	Slope Repairs	
Day Inspections	Potholes	GDOT
	Vegetation Issues	
	Edge Ruts	
Night Inspections	Retro-Reflectivity of Signs	GDOT
	Raised Pavement Marking (RPMs)	
Skid Testing	Friction	GDOT, ODOT
CRS Condition Rating Survey	Pavement distress (cracks & spalling)	IL DOT
RQI Ride Quality Index	Pavement Roughness	MNDOT, MIDOT
SR Surface Rating	Pavement Distress	MNDOT, MIDOT
PQI Pavement quality Index	Pavement Quality	MNDOT
Distress Index (DI)	Pavement distress (cracks & spalling)	MIDOT
PSC Pavement Structural Condition	Similar to PCI	WADOT

Support investment decisions and resource allocation KPI:

An Assets Management Program cannot just focus on the technical aspects of the assets. Decision makers must have a comprehensive understanding of how the assets impact the institution and the community. In order to measure this impact and to be able to make strategic investments, two KPIs have been identified:

- Level of Return on Investment (ROI): At this point is necessary to assign a value to the assets and analyze their life cost cycle which involves maintenance cost, as well as the monetized impact that the assets have to the financial aspects of the institution (e.g. Road accidents cost, serviceability cost).

  Internal Rate of Return (IRR) is one of the many ways ROI can be measured. One can think of IRR as the rate of growth a project is expected to generate.
  NPV= Net present value of the investment
  I= the projected cash flow in years 0, 1, and 2
  r = rate of growth
  (Solving for "r" when NPV is zero)

$$NPV = I_0 + \frac{I_1}{1+r} + \frac{I_2}{(1+r)^2} + \ldots + \frac{I_n}{(1+r)^n}$$

- Level of Social Return on Investment (SROI): If an asset is not working at full potential, how does this economically and personally affect the routine users? One indicator that could potentially be quantified is the detour cost, wish involves time, miles/gallon and transportation fee. SROI is especially important when the final decision on resource allocation is based on the number of users impacted instead of the value of the impact. This could cause low populated areas, such as agricultural or industrial zones, to receive less maintenance resources possibly altering the economy of the state in the future.

$$SROI = \frac{\text{Program Benefits} - \text{Program Cost}}{\text{Program Costs}} \times 100$$

Ensure accountability and responsiveness to stakeholders:

What needs to be measured in this area must be directly related to the expectations and needs of the stakeholders. The "Transportation Assets Management Guide" describes these measurements as "performances that are important to public but may have no discernible impact on agency operation", called "comfort/convenience", in other words these are subjective impressions of transportation system users. (ASSHTO, 2011)

Potential KPI have been classified in two main categories: safety and mobility.

- Safety KPI: The following are possible options for measuring the levels of safety in the roads:
  - Number of Car accidents per 100,000 people;
  - Number of Fatalities Per 100,000 People;
  - Number of Road Accidents per road section;
  - Deaths per age group;
  - Number of Accidents per 1 million vehicles;
  - Fatality Risk; and
  - Perception of safety and security, related to visible elements such a aesthetic of the assets such as the condition of the bridges (which doesn't necessarily imply a poor performance), and the presence of surveillance and law enforcement.

- Mobility KPI: Some of these aspects could also have been addressed in the technical data of the assets. Some of the following indicators will help collect customers' perceptions of asset condition and performance:
  - Average Speed;
  - Comfort of ride or road roughness: For example, measures of pavement ride quality or serviceability could be used to gauge smoothness of ride, some agencies are typically using the International Roughness Index (IRI)
  - Sign visibility or reflectivity;
  - Assets utilization and fluctuation;
  - ADT (Average Daily Traffic) used by Georgia DOT GDOT;
  - Effectiveness of signage (navigation); and
  - Effectiveness of maintenance operations such as snow removal, grass mowing, and pothole filling.

Measurement

Systems: Table 1 shows a summary of different measuring systems for roads. Unlike roads, bridges have a more standardized system used across the states. The Bridge Health Index (BHI) provides a ratio of the current condition of each of the bridge's elements.

Georgia DOT addresses pavement conditions via a rating system based on type and severity of identified distresses call Computerized Pavements Condition Evaluation Systems (COPACES). Simple numeric averages for each distress are used instead of prorating in this rating system. The averages are computed by totaling the values for each type of distress and dividing by the number of rating segments. After the average values are computed for each distress for the project, deduction points are determined for the extent and severity of each distress. These deduction points are totaled and subtracted from 100 to determine the project rating. (GADOT, 2011)

Some other deterioration models have been developed as presented by Salem, Sakman, and Najafi in their report about "Culvert Asset Management Practices and Developing a Deterioration Model for Metal Culverts". In their model, they use "binary logistic regression in development of a deterioration model, which can be used to predict the probability associated with a circular metal culvert to reach a condition state that will require repairing" (Salem, 2012).

The methods described above use data from observation of the current conditions, and unlike safety, mobility, ROI, and SROI would need historical observation to find the trends. Regardless of how data is gathered, it is important to understand unusual factors that could have altered the information collected. For instance, a secondary road could present an increase in normal traffic volume due to construction on the main road; therefore, the deterioration cycle of the secondary road could appear accelerated. If decisions are made based on the data collected during the construction period, and not linked to other factors, the result could be the wrong allocation of resources. On the opposite side, a road could have a permanent increase in traffic due to new developments along the road that if not considered could suggest the wrong allocation of the resources as well.

Conclusion: The selection of the performance measurements should be the result of a diligent study of the needs of the institutions as well as the expectations of the stakeholders; this will ensure that the measuring efforts match what is important for them. On the other hand, the analysis of the data collected, or KPI, should predict the performance level of the assets based on their full design intent. Managerial decisions made to demote or maintain the original design intent of an asset, as would be the case of posted bridges, should be the result of integrating and evaluating all areas of focus to better respond to the agency's strategic plan.

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WHITE PAPER

Asset Management Program Enhancement Plan: Baseline Assessment

Iowa DOT RT 393/Addendum 432

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Data Collection

Initial implementation of asset management requires concentrated efforts on the development and implementation of road, bridge, traffic, sewer, electrical, vehicles and geographic information data collection. Assets fixed within the right of way and unfixed and fixed assets outside the right of way need to be collected. Typical assets include: pavements, bridges, drainage structures, land & landscaping/vegetation, grading (cut/fill), maintenance depots (regional/district buildings, salt sheds, fuel tanks, etc.), buildings (central offices), material stockpiles, laboratories, communication equipment, computer hardware, vehicles and equipment, and parts inventory. Other non-physical assets identified in the TAC report include human resources, intellectual property (i.e. software, libraries, manuals, procedures and data), organization/management structure, image/goodwill and cash/liquidity [TAC 2001]. These are important assets in any organization, whether it is a road agency, contractor or Public Private Partnerships (P3) and require similar management tools.

Importance of the Database in Asset Management

An integration platform is the mechanism by which the various assets are linked through the agency's corporate database (which addresses the key question of "What assets do we have?"). The essential requirement is location referencing (which addresses the question of "Where are the assets?"). Other integration features, such as asset value, level of service provided and risk exposure, can also be included (which addresses the questions of "What condition are they in or what is their value, and how much money is required to maintain the assets in this condition?"). An integration platform allows for road asset types and condition to be linked to a specific location. The complementary decision support process as part of the framework provides the necessary analysis and reporting tools such as graphs, tables, forecasts, recommendations, etc. appropriate to all three levels. Alignment with the organization's business plan implies recognition of the social, economic, political and financial environment within which these systems operate and the need to consider stakeholder interests. Any system should be flexible to incorporate unplanned activities/events and/or the evaluation and impact associated with changes to agency business practices [TAC 2013].

Asset inventory is the key building block for asset decision making. For ease of management, transportation inventory is typically divided into five asset classes. The major assets in the overall asset management plan include:

- Pavements
- Structures
  - Bridges and major retaining walls
  - Major culverts and tunnels
  - Major sign structures
- Drainage features
- Electrical systems

Safety and other features

Each asset is usually subdivided into a number of uniform sections or elements. Logical subsections include location and geometry of the asset section, construction history, properties of the asset, and asset performance data. The primary objectives of the asset management system are to provide a practical and useable tool that:

- Provides a database inventory for transportation assets
- Contains information on these key asset features
    - Asset location
    - Construction history
    - Asset condition
    - Past asset condition
    - Future asset condition
- Predicts future performance of the assets
- Contains cost information to predict future maintenance and rehabilitation expenditures
- Has procedures for prioritizing and optimizing future maintenance and rehabilitation expenditures
- Provides tools to effectively report asset condition and management information.

Developing the Database

Asset management can be carried out in-house, or contracted out to a consultant. In any case, a hierarchical framework is applicable, where the policy objectives are derived from the agency's mission statement and consider a range of relevant factors such as stakeholder considerations, social, political and economic considerations [TAC 2013].

Effective asset management requires Key Performance Indicators (KPIs) which should be objectively based, consistent, quantifiable and sensitive to changes in technology or policy. Thus the importance of objective and high quality data is critical to this. The KPI's should incorporate institutional, economic, environmental, safety, user expectations and technical and functional considerations.

These are mainly applicable to larger road networks and do not include KPIs related to human resource or corporate goals such as worker safety, timely response to public inquiries, etc. Other references are available to help agencies define their KPIs [Cook 1999, Keehley 1997, NAMS 2006]. Performance measures must align with corporate goals in order to fulfill the requirement of strategic level management. An example includes Alberta Transportation, which has a mission to "contribute to Alberta's prosperity and quality of life by providing and supporting a safe, innovative, and sustainable provincial transportation system…" [AT 2010].

Asset Management Database Integration

Asset management involves data integration from multiple applications and databases. Agencies are increasingly adopting an enterprise approach to asset management implementation. Enterprise systems are generally large scale integrated systems that support multiple functions within an organization through shared databases, data analytical tools and business information processes. These systems can be uniquely designed for each agency (as in the case of Alberta's Transportation Infrastructure and Management System (TIMS) shown in Figure 1) or through the modification of commercial off-the-shelf (COTS) applications. Some agencies, such as the British Columbia's Ministry of Transportations Roadway Management System, combine both approaches by buying the COTS application and then using it to build a corporate database. Regardless of which approach is taken, the ultimate goal is to provide a common data warehouse from which data can be extracted for reporting and analysis.

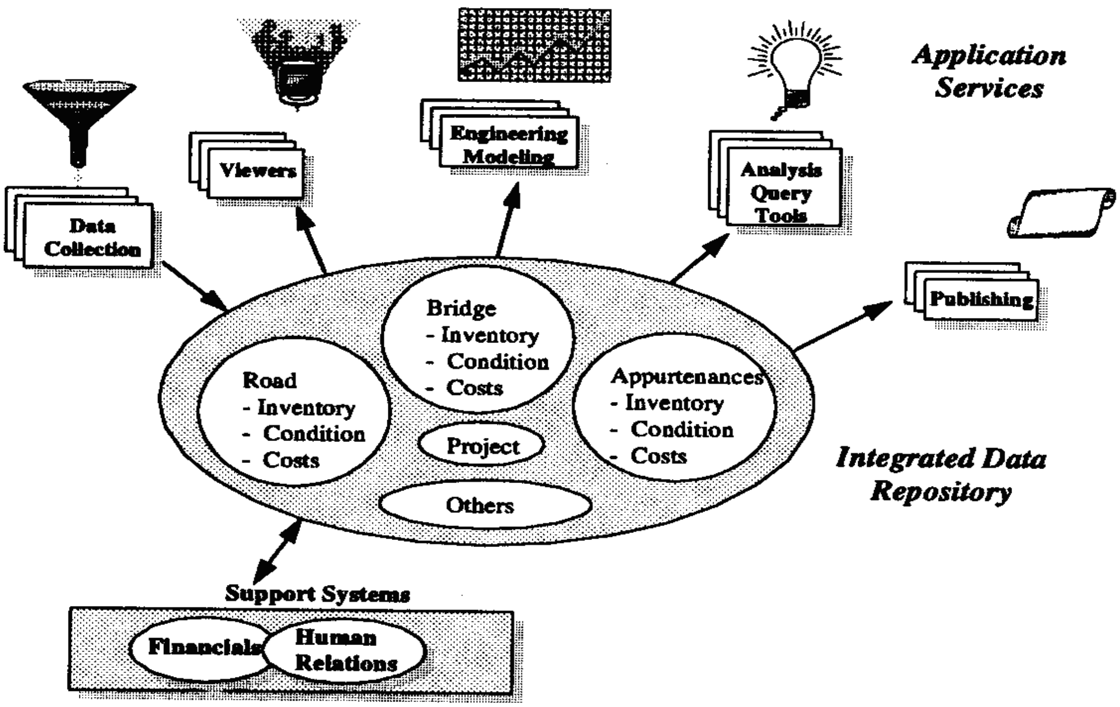

Figure 1 Alberta Transportation Information Measurement System (TIMS) conceptual application architecture after [Cheetham 2000]

Key Elements of a System

Key attributes of enterprise wide systems are [TAC 2013]:

- Common analytical modules (e.g. condition analysis, treatment selection and programming/planning) for each asset in the system. This enables expansion of the system as asset categories are added.
- Common location referencing, which acts as an integration mechanism for linearly referenced assets such as roads and point-referenced assets such as bridges or sign structures, and integration to a Geographic Information System (GIS).

- Common database warehouse, from which data is stored, retrieved, analyzed and returned. Many agencies have individual databases for each asset category and one of the great challenges of asset management implementation is the integration of these databases into one coordinated database.
- Common language within and across asset categories.
- Clear protocols on reporting detailed and aggregated indicators.
- Standardization of data collection and processing.
- Defined levels and/or quality of service within and across asset categories.
- Defined data cycles and reporting timeframes.

Building Tangible Assets Inventories and Asset Valuation

Asset registries (or inventories) and condition assessment are cornerstones of the accounting process. Asset registries contain many elements of an infrastructure assets database, the main differences being that registries include expected useful life, and asset valuation elements. The CICA suggests including these items in the asset registry [CICA 2007]:

Name of asset
Physical description
Serial number
Date of acquisition
Location
Person/position responsible for custody and maintenance of asset
Due date for replacement
Expected useful life
Original life
Expired life
Remaining life
Date asset life last reviewed
Any evidence of impairment
Historic cost (or initial valuation if historical cost is not known)
Amortization method, rate and amount
Book value
Date of disposal

The asset registry does not include detailed condition data on the asset but indirectly considers performance by including the due date for replacement, expected useful life and remaining life.

Summary Comments

The backbone to a good asset management system is high quality data. The data needs to be reliable, repeatable, and reproducible. This brief summary has considered the key aspects of the database.

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WHITE PAPER

Asset Management Program Enhancement Plan: Baseline Assessment

Iowa DOT RT 393/Addendum 432

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Asset Management Reporting and Communication

Asset management should provide the following direct and indirect benefits in facilitating the foregoing decisions [TAC 1999]:

- Effective tools for communication, coordination and information exchange within the agency and between management levels and asset types.
- Use of objective, measurable Key Performance Indicators (KPIs) for level of service, condition, safety, efficiency and productivity.
- Ability to estimate the impacts of different funding levels, or different standards, on level of service, condition and safety of the assets.
- A corporate database with access to data and information as needed.
- Use of state-of-the-art technologies and processes.
- An environment for innovation, skills development and ongoing training.

These benefits will accrue to the agency and stakeholders only if the asset management system is implemented, periodically evaluated and updated, and fully supported. As well, it is essential that the asset management system be aligned with the agency's business practices.

Overall, the asset management should provide answers to the various questions as noted in Figure 1.

Individual road agencies might use only a subset of KPIs depending on their resources, size, location and specific conditions or requirements. Some agencies, such as the City of Edmonton [Edmonton 2010], have grouped performance indicators into three categories: condition, utilization and functional adequacy. These KPIs are an important for both reporting and communicating. These KPIs enable agencies to report on the various asset categories and allows for facilitated communications and trade-off analyses at the strategic level. The KPIs for the city agency are asset specific and each KPI category falls into one of five definitions of levels of service (LOS). Various examples of KPIs are presented in Table 1.

Robust temporal data is required so that realistic implementation targets can be set. Targets are not fixed and should be revisited periodically to ensure that they remain not only realistic, but relevant to agency operations. A loss of credibility in the process and a loss of momentum in the implementation can occur if the targets are difficult to achieve [TAC 2013].

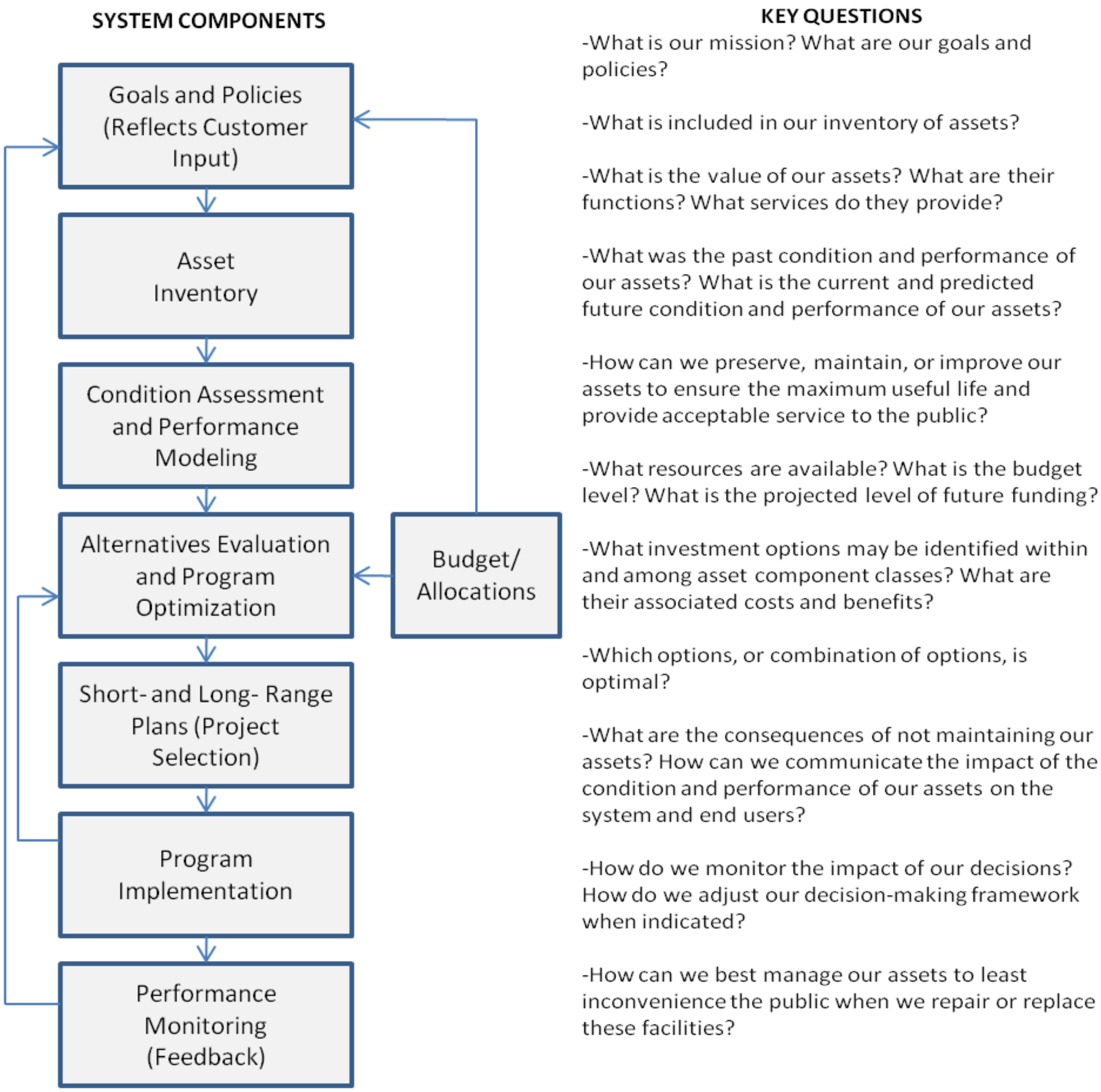

Figure 1 Asset management system components and overview [US DOT 1999]

Table 1 Examples of institutional policy objectives, KPIs and implementation targets [TAC 2013]

Policy Objectives	Key Performance Indicators	Implementation Targets
Level of service	• Network level of service (smoothness, functionality and utilization) - network condition • Provision of mobility (average travel speed by road class)	• Maintain 90% or greater of network in fair or better category (e.g. IRI≤2) • Rush hour traffic average speed minimum of 50% of posted speed limit
Safety	• Accident reductions (percent) • Bridges (% of number with reduced load postings)	• Reduction of fatalities and injuries by 1% or greater annually • Number of reduced load postings to less than 5% of the network
Asset preservation	• Asset value of road network ($)	• Annual increase in written down replacement cost by 0.5% or greater.
Sustainability	• Recycling of reclaimed materials (asphalt, concrete, etc) – % • Emissions levels	• Maintain at 90% or greater • Maintain at levels <90% of standards

Individual road agencies might use only a subset of KPIs depending on their resources, size, location and specific conditions or requirements. Some agencies, such as the City of Edmonton [Edmonton 2010], have grouped performance indicators into three categories: condition, utilization and functional adequacy. This has enabled the reporting of more than a dozen asset categories and has facilitated communications and trade-off analyses at the strategic level. The KPIs for the city agency are asset specific and each KPI category falls into one of five definitions of levels of service (LOS).

Building Tangible Assets Inventories and Asset Valuation for Reporting Purposes

Asset registries (or inventories) and condition assessment are cornerstones of the asset management accounting process. Asset registries contain many elements of an infrastructure assets database, the main differences being that registries include expected useful life, and asset valuation elements [NAMS 2006].

Various reporting agencies require that asset values be recorded and reported. There are several ways of actually calculating asset value within these approaches, and they can lead to substantially different values [Cowe Falls 2005]. Table 2 lists the various methods for reporting asset values.

Table 2 Basic definitions of asset valuation methods [TAC 2001]

Asset Valuation Methods	
Book value	Current value based on historical cost adjusted for depreciation (commonly used for financial accounting purposes). Historical cost is the original purchase price or as-built cost.
Written down replacement cost	Current value based on replacement cost depreciated to current condition of the asset (commonly used for management accounting purposes).
Replacement cost	Current value based on cost of replacing/rebuilding the asset.
Market value	Value of the asset based upon the price agreed upon in an open and unrestricted market.

Providing Data for Communication

There is also a need to integrate and manage across asset classes in part based on the geospatial proximity of one asset class to another. This has forced an emphasis on geospatial location referencing of pavement related data and this in turn has led to a shift towards a geospatial emphasis in roadway related data collection practices and in asset management database design and development. Figure 2 provides an example of how the various databases in the asset management system are integrated to provide data for reporting and communication.

Almost all large agencies have implemented GIS for roadway data management. One example is Alberta Transportation's (AT) Transportation Infrastructure and Management System (TIMS). TIMS is a sophisticated web based system that allows efficient user interaction with fully integrated data, information and expertise through any internet enabled computer or wireless device. The system uses a central data repository containing current and historical information which is complete and correctly referenced. Data is accessed by both internal and, in some cases external clients, using 25 integrated web based input, query, and analysis applications (see Figure 3). This enterprise GIS provides a single consolidated data warehouse architecture and provides the ability for clients (internal or external) to dynamically segment the roadway network based on any attribute(s) or performance criteria, query the database, and report the results.

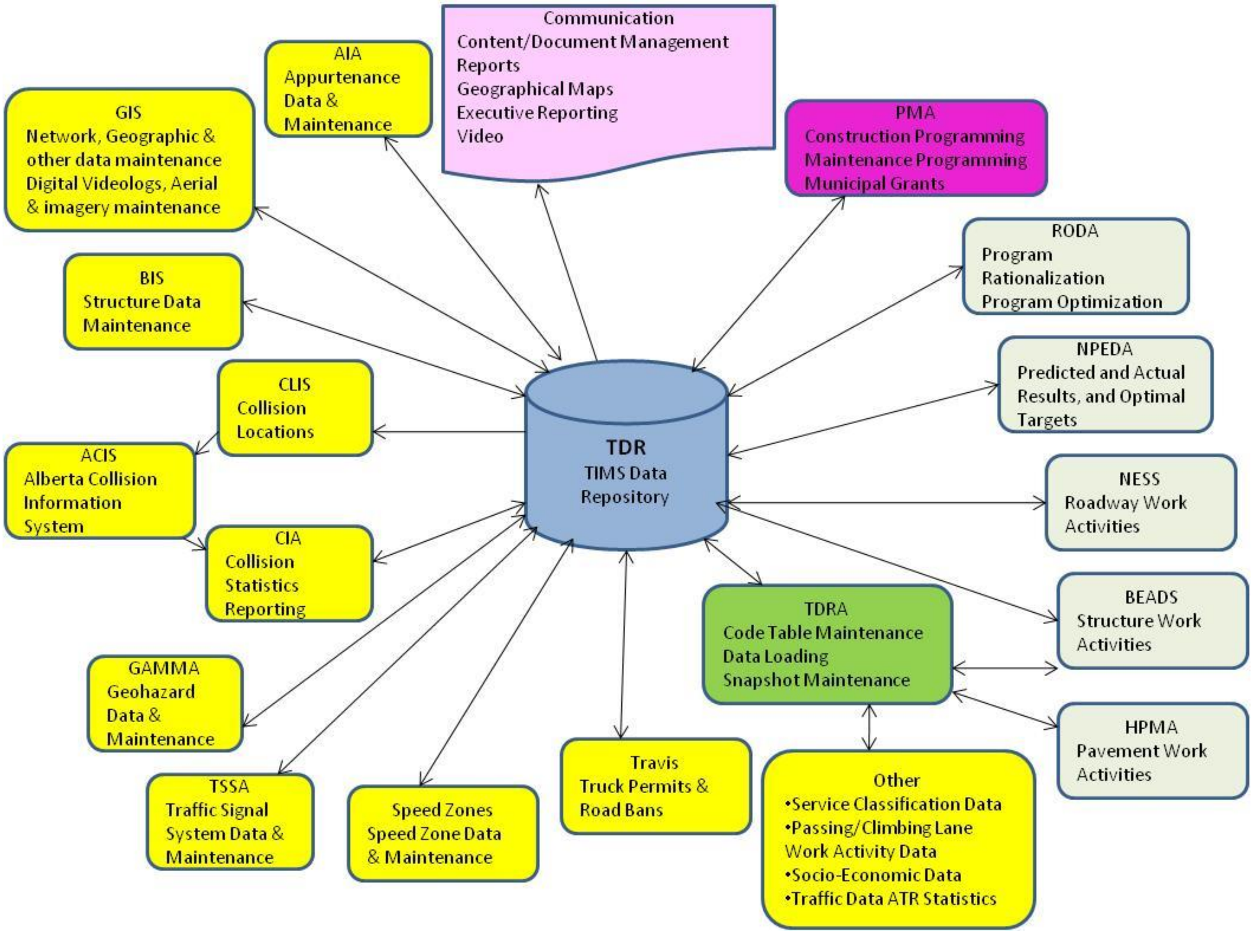

Figure 2 TIMS Information Management System [Alberta Transportation 2010]

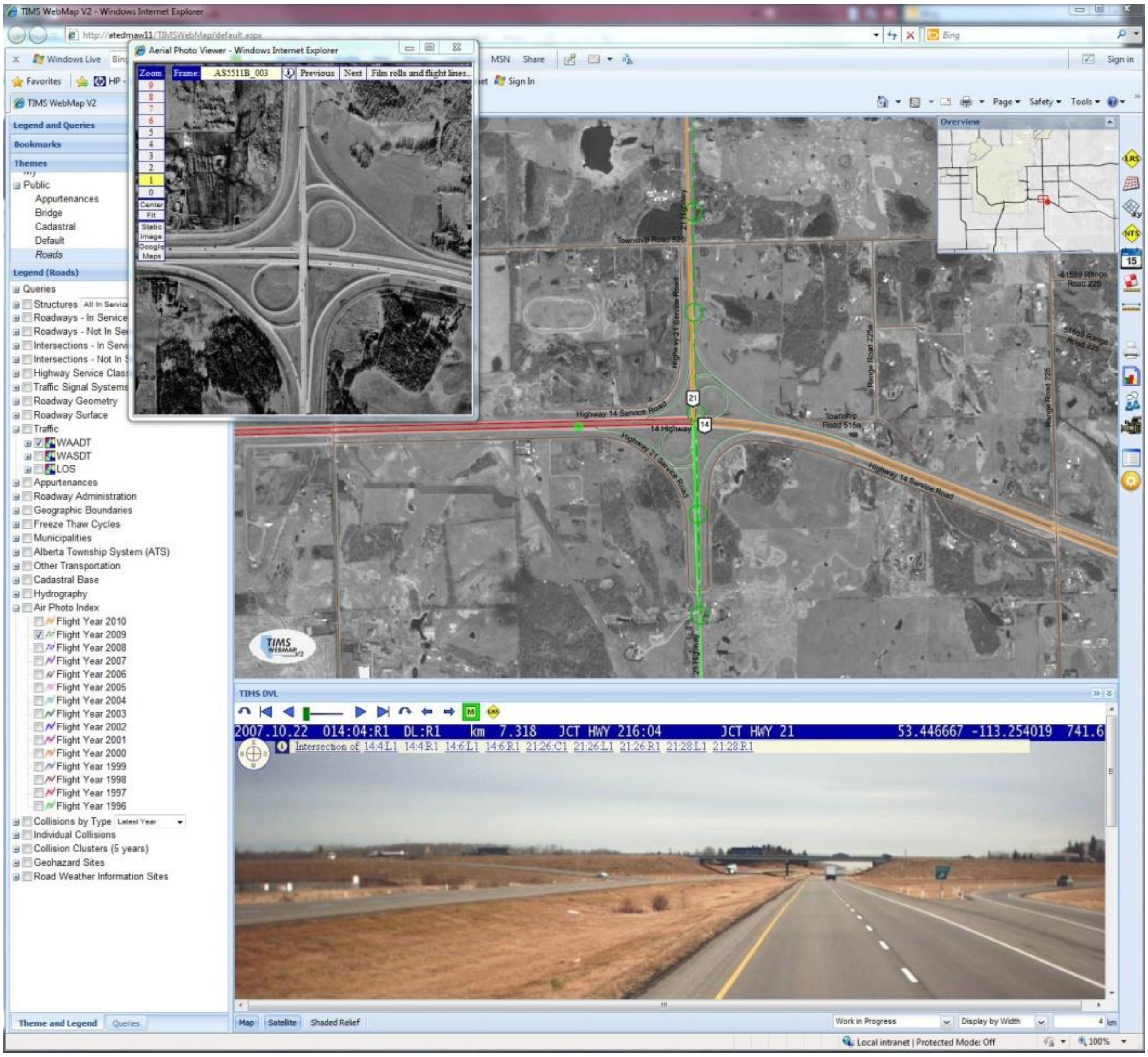

Figure 3 TIMS interactive Web environment

At the municipal level, the GIS is rapidly becoming the user interface for all infrastructure related asset data with the data either as Open Database Connectivity (ODBC) links to the GIS's underlying database engine or incorporated directly.

Summary Comments

Asset management require appropriate and effective KPIs for reporting and communication.

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Asset Management Program Enhancement Plan: Baseline Assessment

Iowa DOT RT 393/Addendum 432

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Financial Trends Monitoring Analysis for the Iowa Transportation System

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Financial Trends Monitoring Analysis for the Iowa Transportation System

Maria Catalina Miller

Introduction

The purpose of this paper is to apply the Financial Trends Monitoring System (FTMS) to the Iowa transportation system with special emphasis on the rural areas. The environmental, Organizational and Financial indicators that are been considered are shown in figure 1.

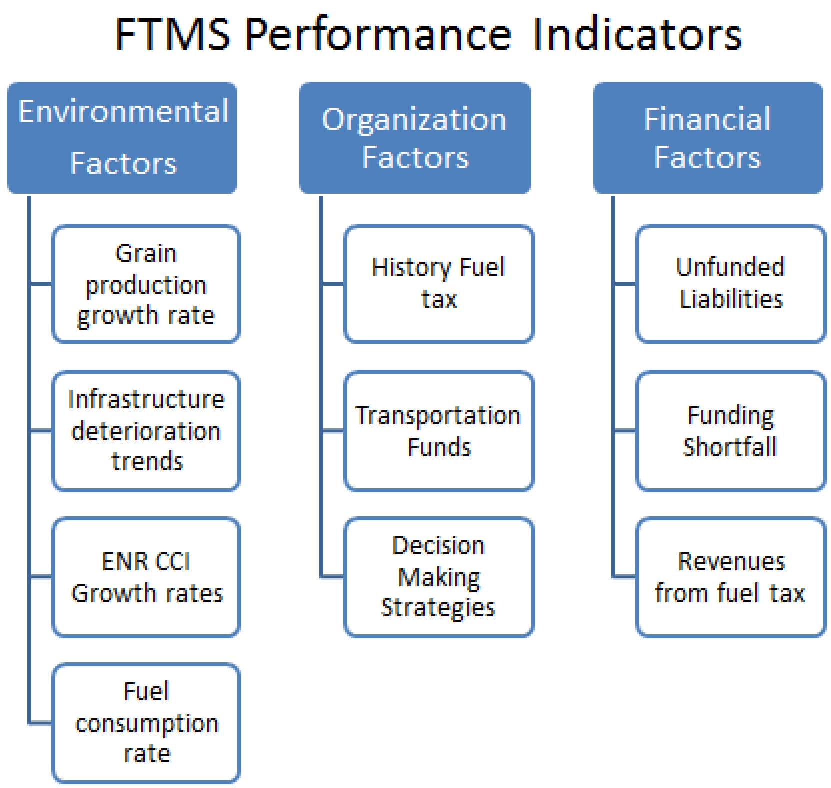

Figure 1. Financial Trends Monitoring System

This study was motivated by the current prospect of raising more revenue for Iowa's transportation infrastructure by increasing motor fuel taxes, this bill is known as the House Study Bill (HSB) 514 (The Iowa Legislature, 2014) and has been approved by the House of Representative as on January 29 2014. The analysis includes the identification of the motivations that drove legislators to make this polemic proposal, and the ways how these funds are and will be allocated, and consequently evaluate whether the expected impact aligns with the needs and interested of the taxpayers.

Iowa transportation funding structure is based on the annual strategic plan. One of the objectives at the federal and state level is to support regional economic growth as shown on the MAP 21 provisions as well as DOT's annual strategic plans (FHWA-2, 2012) (IADOT, 2012-2013). Therefore and based on the great impact that agriculture has in the economy of Iowa and the poor condition of the rural infrastructure the author will primarily look at how the fuel tax is been distributed to try to evaluate whether the new revenue created by the increased in fuel taxed will fulfill the expectations of the proponents.

Iowa Agricultural Economic Trends

In Iowa, the economy is based on agriculture and dependent on the transportation network's ability to deliver those commodities to market. Thus, equitable distribution of funds becomes more complex. If low volume roads do not receive sufficient funding to cover adequate maintenance and timely repair, rehabilitation, and replacement, a negative impact on the State's agricultural economy occurs. *The Economist* (Belmond, 2007) highlights how the local farmers in remote areas could not get the top prices for corn because of the high cost of transporting it to the market. Similar issues apply to other commodities like soybeans and corn across Iowa as shown in Figure 2.

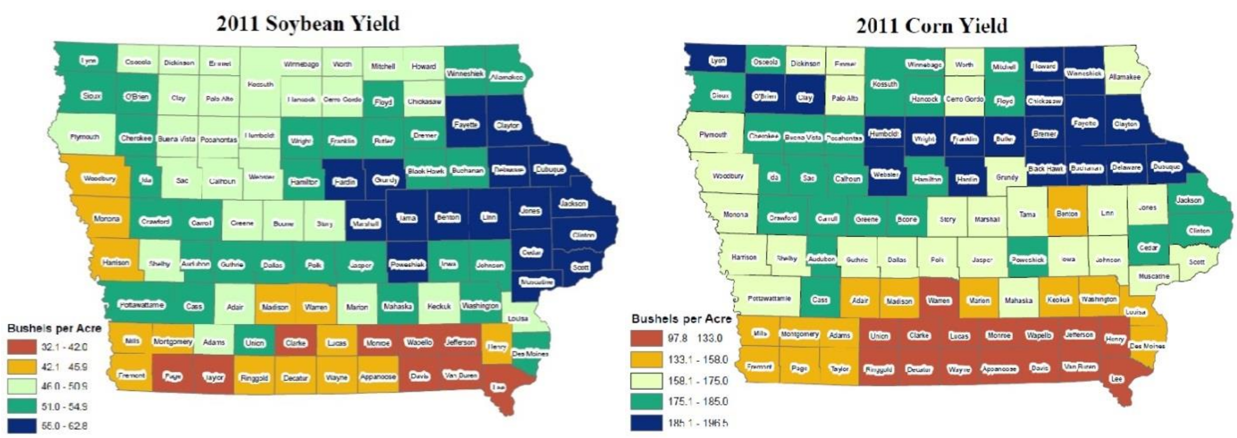

Figure2. 2011 Soybean and Corn Yield by counties in Iowa (Ford, 2012)

Moreover, agricultural products are a big part of the country's economy; the US provides nearly half of world grain exports, Iowa ranks first among the state in production of corn and soybeans (USDA 2013). Iowa alone has gone from producing 12,200,000 bushels of all purposes corn in 1998 to produce 2,161,500,000 bushels in 2013. (USDA, 2014)

Iowa Transportation Infrastructure Condition

According to the study shown in Table 1 (Transportation for America, 2013), Iowa ranks third nationwide among states with the highest percentage of deficient bridges. However, 77% of all bridges nationwide and 63.5% of all structurally deficient bridges are located in the rural areas illustrating the potential that inadequate construction and maintenance funding to keep those rural bridges operating at their current structural load capacities could have an enormous economic impact on the Iowa economy. Furthermore, the forecast is not promissory considering that the life span of a bridge is 50 years and the current average age of American bridges is 42 years (Transportation for America, 2013).

Table 1. Ranking of Structurally Deficient Bridges (adapted from (Transportation for America, 2013))

State	Rank	2013% deficient	Total bridges	Deficient Bridges 2013	Deficient Bridges 2011 (FHWA)	Change in Deficient Bridges Over 2011	Percent Change in Deficient Bridge total	Average Daily traffic on deficient bridges
Pennsylvania	1	24.5	22,667	5,543	6,043	-500	-8.3% better	18,994,224
Oklahoma	2	22.6	23,778	5,382	5,305	+77	15% worse	7,236,161
Iowa	3	21.2	24,465	5,191	5,440	-249	-46% better	1,728,828
South Dakota	5	20.6	5,869	1,208	1,198	+10	0.8% worse	354,303

Added to the rapid deterioration of the transportation system, the means and methods use for farmers to plant and harvest grain has been evolving throughout the last century, machinery has get more efficient allowing farmers to plant and harvest largest extension of cropland and shorter periods of time and with greater yield as shown in figure 3 (USDA 2, 2013), farming equipment has gotten larger in volume and in weight capacity. Iowa roadways have lacked to keep up with the evolution of farming and the current infrastructure lacks of adequate capacity to meet user’s expectation and full capacities.

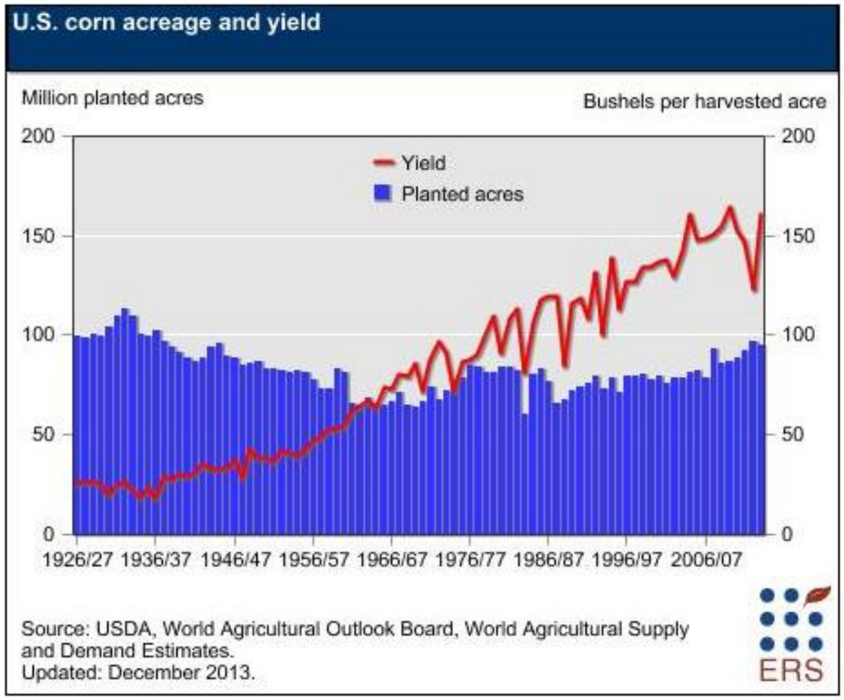

Figure 3. U.S. corn acreage and yield from 1926 to 2007 (USDA 2, 2013)

According to the Iowa Department of Transportation (IADOT) 42% of Iowa's major locally and state maintained roads and highways are either in poor or mediocre condition, 27% of Iowa bridges are in need of repair, improvement or replacement. (TRIP, 2013).

Furthermore, it is imperative to recognize that as shown in Figure 4 the distribution of structurally deficient bridges across the U.S. shows that 63.5% of these bridges are located in rural counties where the economy depends on them to carry the nation's food supply to market. (Daily Yonder, 2011)

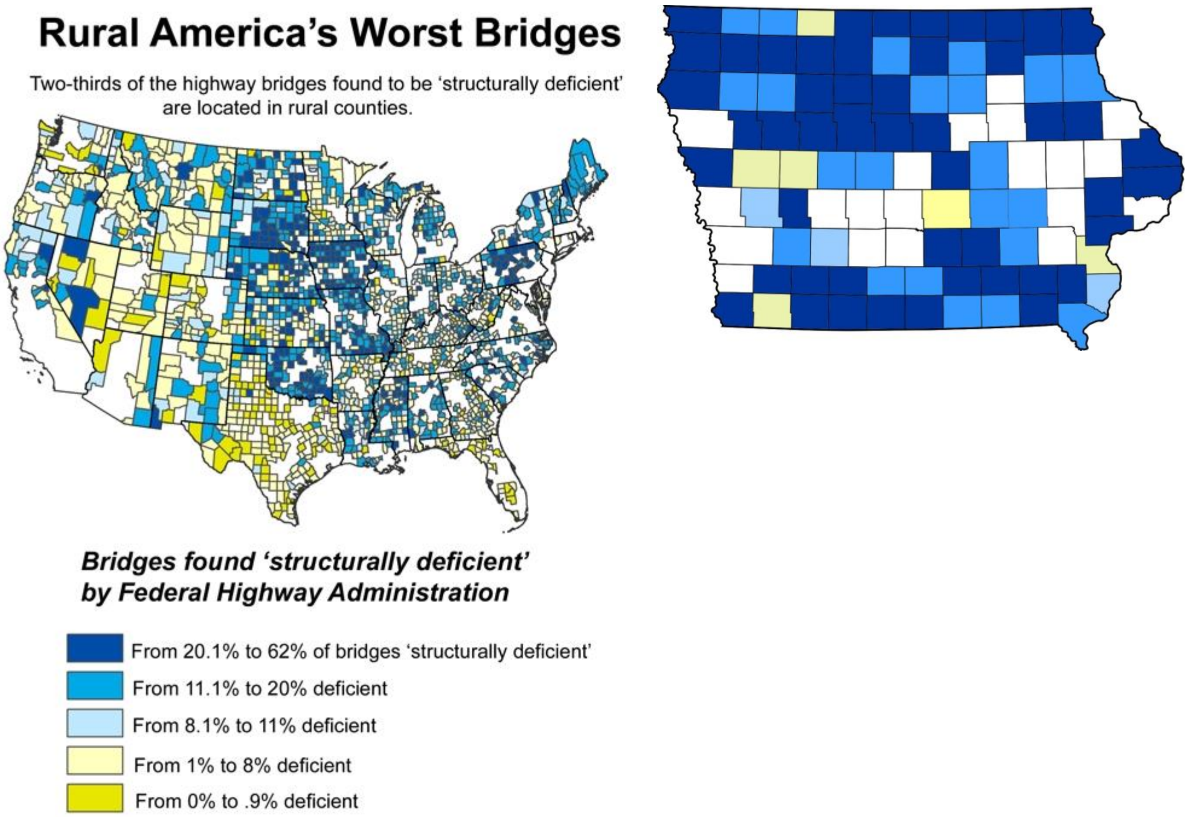

Figure 4. Distribution of Rural Structurally Deficient Bridges (adapted from (Daily Yonder, 2011))

Table 2. Iowa Rural Counties with the Worst Bridges- National Rank (Adapted from (Transportation for America, 2013))

National Rank	County	Total Bridges	Bridges needing repair	Percent of bridges needing repair	2011 Soybean Yield Bushels/acre	2011 Corn Yield Bushels/acre
7	Allamakee	202	94	46.50%	51.0-54.9	158.1-175
11	Winneshiek	111	49	44.10%	51.0-54.10	185.1-196.5
13	Decatur	210	91	43.30%	42.1-45.9	97.8-133
19	Lyon	203	79	38.90%	51.0-54.9	185.1-196.5
20	Pocahontas	535	208	38.90%	46.0-50.9	175.1-185.0
22	Kossuth	209	80	38.30%	46.0-50.10	175.1-185.1
23	Union	255	96	37.60%	51.0-54.9	97.8-133

Returning to the Iowa context, Allamakee County is ranked seventh in the nation for the worst bridges in the rural counties, at the same time Allamakee is within the counties with high production (Figures 2, Table 2) of corn and soy. Comparing the soy and corn yield data with the county's overall bridge condition leads to the conclusion that an agricultural state like Iowa needs to build a function that portrays the needs of its agricultural industry for the transportation network into its Transportation Asset Management to ensure that the infrastructure needs of the state's economy are kept in a condition that supports rather than retards growth.

Engineering News Records Construction Cost Index (ENR CCI)

The Engineering News Records (ENR) publishes a Construction Cost Index (CCI) that is widely used in the construction industry as in indicator of inflation. Unlike Consumer Price Index (CPI) which uses indicators such as goods and services that the average person acquire, CCI uses materials and labor components used in the construction industry, therefore this index is a better indicator of the inflation to analysis trends and forecast funding needs related to the transportation infrastructure. The ENR CCI is volatile to the price of commodities such as petroleum, steel, concrete, among others. (ENR)

The ENR CCI has grown at an annual average rate of 3.6% in the last 10 years, this growth shows a lineal trend which allows as to forecast a continuous growth in the years to come. (EGWS)

Iowa Tax Gas

The Iowa motor fuel tax is imposed on each gallon of fuel sold in Iowa for use in motor vehicles or aircraft. Motor vehicle fuel includes gasoline, diesel fuel, liquefied petroleum gas, compressed natural gas, aviation fuel, and ethanol blended gasoline. The current Iowa's motor fuel tax for gasoline consists of an excise of 21 cents per gallon plus 1 cent per gallon for environmental fees (FTA). In Iowa the Diesel excise rate has stay unchanged since 1989 at 22.5 cents per gallon of Diesel, and the gasoline's excise has fluctuated between 20 and 21 cents per gallon in the same period of time (IA Department of Revenue). This shows a growth rate of 0% for diesel and 5% for gasoline in 28 years.

One of the current challenges that the government has been facing is due to the gas tax not been applied to the final sale price therefore the revenues do not increased with inflation, instead, it is applied to the amount of gallon consumed. Based on the Retailers Motor Fuel Gallons Annual report from 1999 to 2013 provided by the Iowa Department of Revenue (Figure 5) (IA Department of Revenue, 2013) one could observe a decrease trend in fuel consumption through the last 3 years that could be explained by the fact that the efficiency of the vehicles is improving at the same time that more hybrids and electric cars are being commercialized, but it could also represent a transitory economic downfall similar to what is seen in between 2008 and 2010. If the amount of gallons of motor fuel decreased, the revenue of the states decreased.

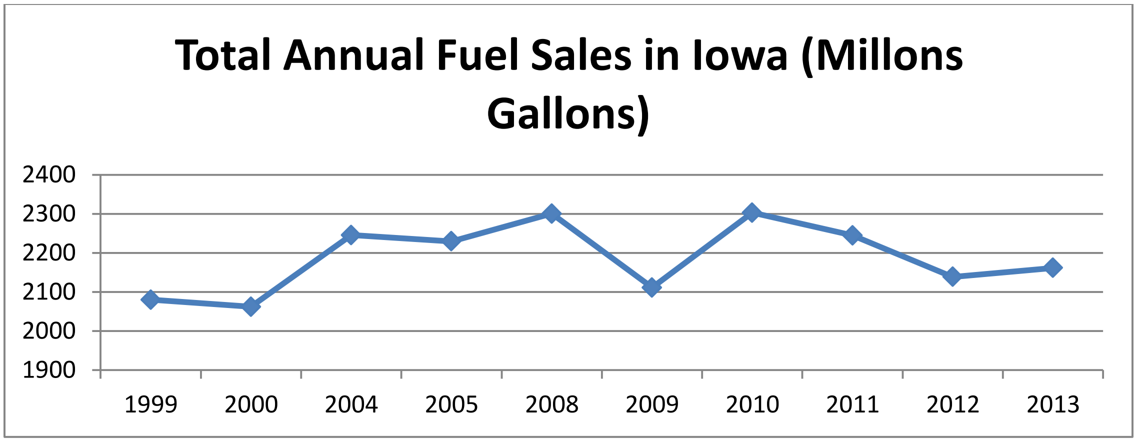

Figure 5. Iowa Annual Retailers Motor Fuel Gallons Report (IA Department of Revenue, 2013)

Tax Increased Bill

In Iowa the Motor Fuel tax can only be changed with legislation but this is a very controversial decision and not very popular between politicians. The state's cultural perception on increasing these taxes has prevented the state of Iowa from having an increased on the motor fuel tax rates since 1986 (Lynch, 2014). Throughout the years it has been believed that the shortfall in transportation infrastructure can be overcome by different means.

Some of administrative officials such as the director of IADOT Paul Trombino III, when been approached about the gas tax increase, have stated that there is "not going to be one single fix. When it comes to funding, diversity is the best", some of Trombino's ideas include a higher tax on the sale of automobiles and to cut tax-free fuel for farm equipment. At the same time State Sen. Jeff Danielson believe that a fuel tax increase "make sense today, and that every other option but gas tax is worse in our current environment". (Wiser, 2014)

Early 2014, a bipartisan subcommittee in the Iowa House of Representatives passed legislation to increased 10 cents for gallon to the state's fuel tax during the next 3 years , 3 cents in 2014, 6 cents in 2015 and 10 cents in 2016. This initiative is part of the House Study Bill (HSB), this act increases the rate of the excise taxes on motor fuel and certain special fuel used in motor vehicles and provides for the use of revenues resulting from the increase. (The Iowa Legislature, 2014)

But this won't be an easy race, opponents such as The Republican Party, and the advocacy group Iowans for tax Relief have already expressed disapproval and have created a movement call "Help Us Stop the Gas Tax" (Wiser, 2014)

The American Association of Civil Engineers (ASCE) have launched a campaign to encourage their member to contact the state legislator in support for the legislation HSB 514, the reasons to support the bill mentioned by the ASCE in their website are as follow:

- The American Society of Civil Engineers 2013 Report Card for America's infrastructure reported that 21.2 percent of Iowa's bridges were structurally deficient in addition to the 5.2 percent of the state's bridges that are functionally.
- The same report found that around 46 percent of Iowa's roads are in need of some sort of repair, whether it be potholes or road cracks.
- Continually ignoring these problems will cost Iowans $756 million annually in vehicle-repair costs, around $351 per driver
- Alongside this report, the federal government ranked the state 38th in the nation in terms of road conditions, not necessarily the state's most flattering ranking.
- The tax, which currently stands at 22 cents per gallon, hasn't been raised in 24 years. Data suggest that raising the tax would generate $230 million annually, money that can be used to substantially upgrade Iowa's roadways and would close the state's $215 million annual shortfall in road funds. (ASCE, 2014)

Iowa Transportation Funding Strategies:

Iowa fuel taxes represent the 38% of the total State Road Use Tax Fund (RUT). From the RUT, two specify funds provide resources to County roads and one to city and county bridges; 22% of the total Rut is allocated to the Secondary Road Funds, 5% to the Farm-to-Market Road Funds, and 0.2% to the City and County Bridges Program. The 27% of the RUT allocated to county roads represents the 92% of the total state found allocated to the 99 counties in Iowa, the other 8% comes from the TIME-21 Fund which collects revenues from Registration, Title and Trailer Fees (Figure 6). (IADOT, 2013)

In summary 92% of the counties revenues (state funds) comes from RUT which is 38% founded by fuel taxes.

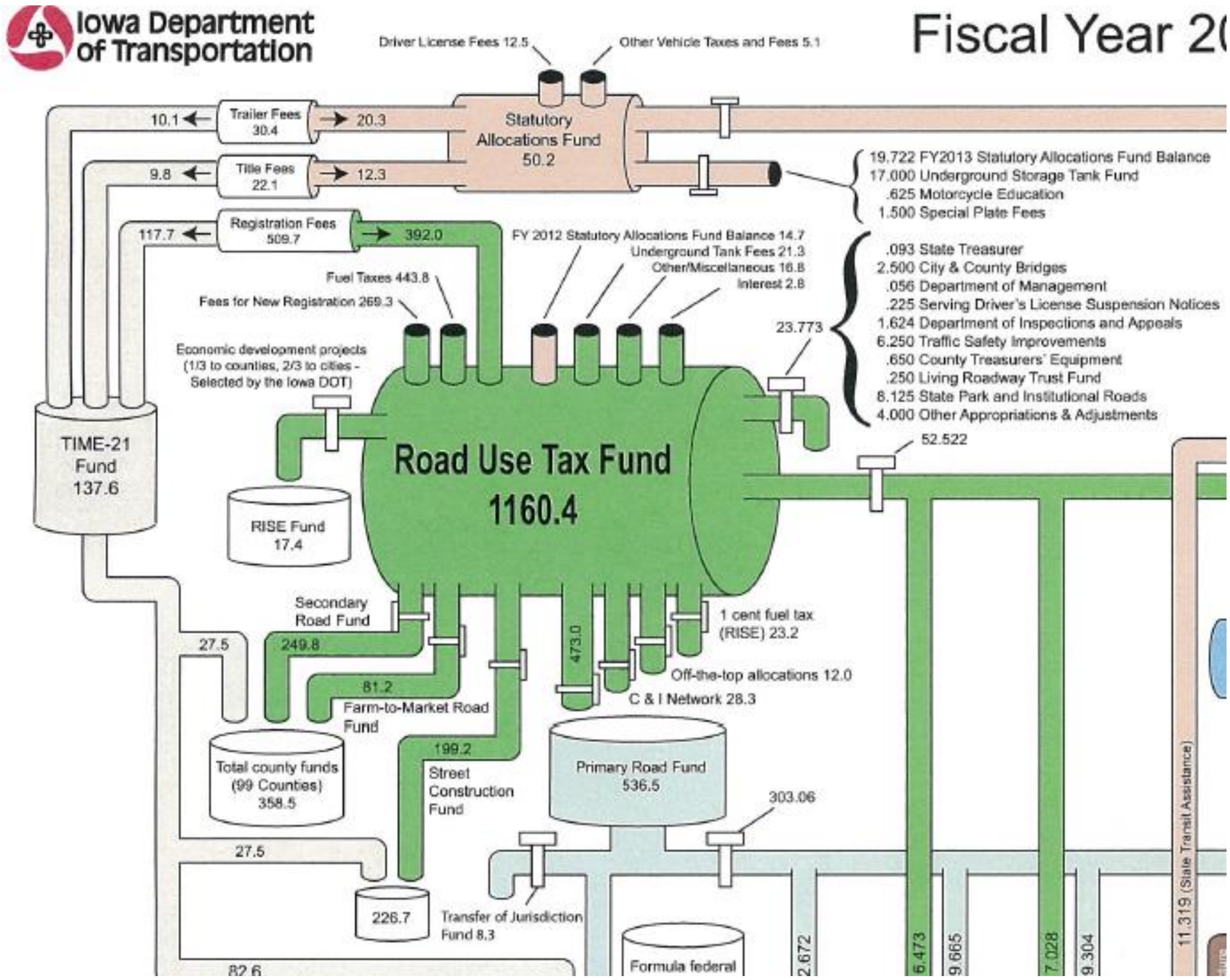

Figure 6. Iowa 2013 Transportation Founds Pipeline Chart. (IADOT, 2013)

Decision Making and Prioritization Process:

Funding replacement, rehabilitation, and maintenance projects on low volume roads has always been problematic (Raballand, Macchi, & Petracco, 2010). One study cited the prevailing concept that "using these [state and federal construction and maintenance] funds on projects other than major highways will result in crippling gridlock" (Gann, et al. 2012).

The problem of programs such as City and County Bridges is that the counties are required to match 20 percent of the total cost of the replacement or rehabilitation project, and based on interviews with County Engineers in Iowa, the cost of some bridges can reach up to $5millon for which the 20% that the county would have to match represents a significant percentage of total annual budget of the county's maintenance and /or capital funds. In addition, this project limits the total available funds to $2 million per year for county bridges, to be spent following a prioritization list, so depending of the cost of the bridges the fund may only impact 3 to 4 county bridges a year across the State. (IADOT 2, 2014)

On the other hand the Secondary Roads and Farm to Market Roads Funds are equally split within the 99 counties. This generates an equal distribution of the resources but it does not represent equality on the allocation of resources based on needs. For small counties with limited local revenues it is hard to found big projects so instead of doing maintenance to bridges based on needs they have to consider the available resources and rehabilitate the less costly projects even thou they have lower social cost benefit rates.

The Federal and State DOT's had developed a Transportation Asset Management (TAM) framework to prioritize and effectively distribute available construction and maintenance funds, this methodology encourages the allocation of resources based on business intelligence as well as cost benefit impact, and discourage the prioritization process based on worse first scenarios which is at some level still been used in the state of Iowa at local levels. (AASHTO, 2011)

Financial Factors

The state of Iowa is currently facing an annual transportation funding shortfall of $215 million in order to meet the state's most critical public roadway needs, (TRIP, 2013)
In an interview to IADOT bridge engineer Scott Neubauer done by a local news broadcaster he mentions that out of 24,000 bridges in Iowa more than 5,000 are rated as structurally deficient, he also states that with $200 million over the next five years, 50 more state bridges will be repaired or replaced but that still leaves more than 5,000 county bridges in poor condition. Polk County Engineer Kurt Baileys said "That is not enough to keep up with inflation let alone the cost of construction that we are seeing. We are basically flat in road use tax and it is tough to keep the system up as costs increase every year," (McIntosh, 2013)

"The Federal Highway Administration estimates that each dollar spent on road, highway and bridge improvement results in an average benefit of $5.20 in the form of reduced vehicle maintenance costs, reduced delays, reduced fuel consumption, improved safety, reduced road and bridge maintenance costs, and reduced emissions as a result of improved traffic flow" (TRIP, 2013)
The ASCE report suggests that raising the tax would generate $230 million annually, money that can be used to substantially upgrade Iowa's roadways and would close the state's $215 million annual shortfall in road funds. (ASCE, 2014)

FTMS Analysis

Figure 7 shows the growth rate during the last 12 years of the different indicators that could play an important role on understanding the needs for an increase on the motor fuel tax rates in the state of Iowa. It is clear that inflation has directly impacted the cost of delivering infrastructural projects to the community. While the construction cost index increased year by year, the motor fuel tax excite has stay unchanged, the 22.5 cent per gallon of 12 years ago are equivalent to $15.8 cents in 2012 or a growth rate of -30% if we compare it in real value between 2002 and 2012.

In addition to the inflation, the revenue received by the government is showing a small decreased in the last 4 years due to the amount of gasoline and diesel that has been consume annually, and it could potentially become a trend thanks to new technologies that make vehicles more efficient. And because the taxes are applied to each gallon sold and not the price this is feeding the financial crisis that transportation infrastructure is facing.

The annual production of all purposes corn during the last 12 years does not show a representative growth, Figure 3 could give a better explanation of the needs for infrastructure to support economic grow of the region.

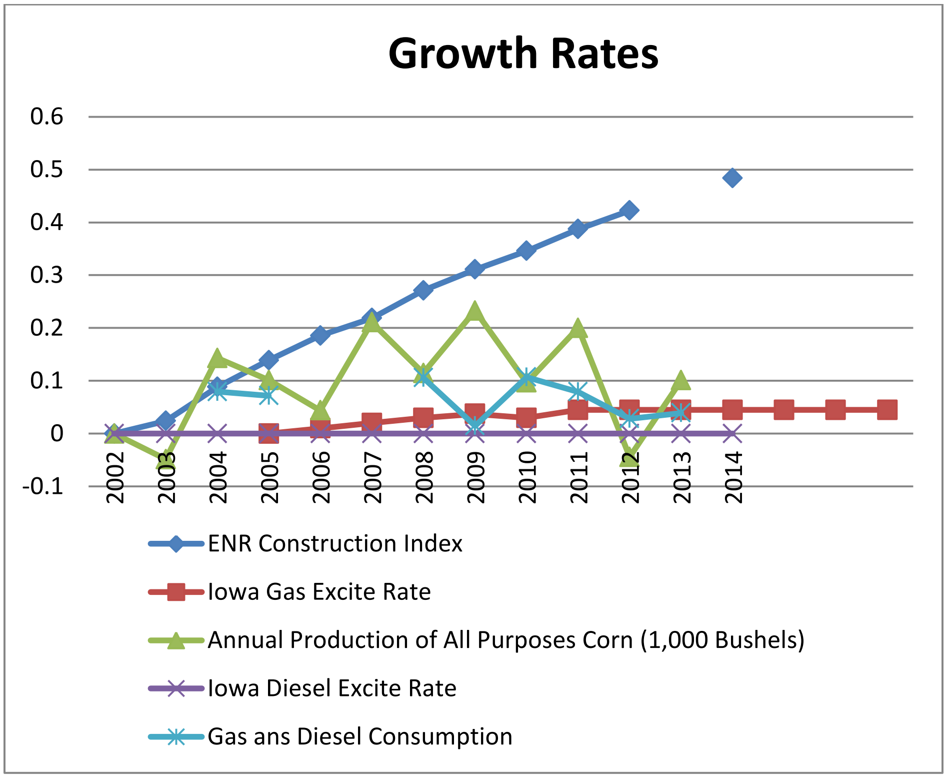

Figure 7. Summary of Growth Rates

Projecting in to the future, a forecasted value of the ENR CCI for 2016 could be expected to be around 10411 by using an average annual growth rate of 3.6%. Using this index to compare the expected new proposed excite rate for 2016 (32.5 cents per gallon of diesel) in real value, the tax rate would be 20.4 cents per gallon using 2002 as the base year. In summary looking at real values, the new fuel tax rate in 2016 would still have a negative growth of -9% compared with the tax rate of the last 24 years.

Conclusion

The need for an increased on the motor fuel tax in Iowa seems to be valid considering the negative growth rate in real value throughout the last year and the increase on liabilities and users demands.

At the same time, increase on the excite rate may not satisfies all the expectations of the proponents. Comparing the real values of the tax rate we can see a negative increased even after the proposed increased.

Infrastructure such as bridges have a very extend life span, the average Iowa bridge is 40 years old and with good maintenance they could last between 75 and 100 years. But maintenance funds have to be obligated through the life cycle of the structure. If 22.5 cents per gallon wasn't enough to maintain Iowa's transportation system in the last 24 years, to the point that the state is now third in the nation with the greatest percentage of structurally deficient bridges, it is unrealistic to believe that 20.4 cents (in real value) could heal the current deficiencies.

New and more creative alternatives are going to have to come to the table. The new TAM plan is a great commencement to be more efficient in the allocation of resources and prioritization process. But in order to support the economic grow of the region, some of the funding programs would need to be revised so the money gets allocated where the greatest social and economic impact happens instead of dissipating the resources across the state which prevents costly projects from been executed.

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APPENDIX E. ASSET MANAGEMENT WORKSHOP MATERIALS

This appendix contains copies of the slides and handout materials developed for the workshops conducted during this project.

Asset Valuation & Asset Management Decision Tools

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Outline

- Asset Valuation in TAM
- Valuation Methods
- An Example!
- Decision Tools
  - Performance Measures
  - Key performance indicators

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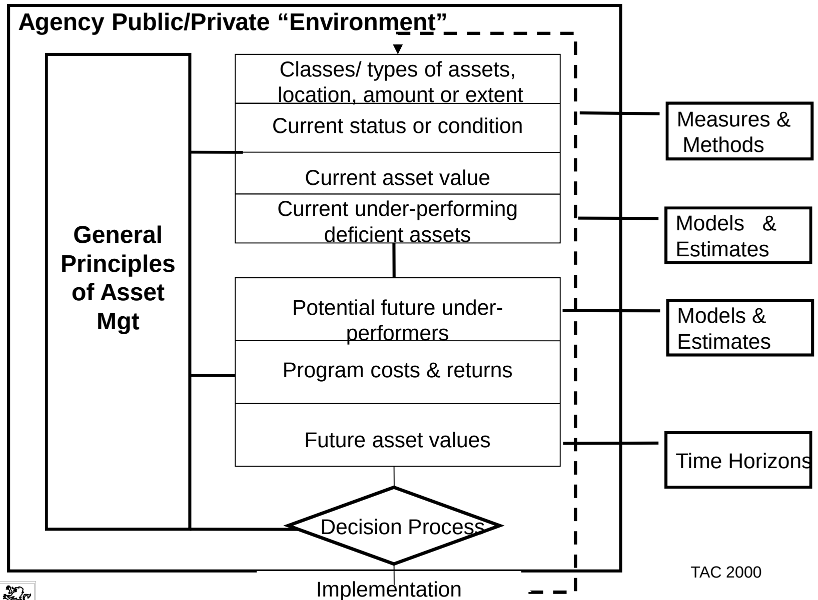

3

Essential Questions for Asset Valuation

- What assets do we have?
- What asset classes do they fit in?
- What is their condition and/or status?
- What are the assets worth?

4

Issues & Questions

- Deterioration = Depreciation??
- What is the valuation method for each asset?
- How to account for assets that improve?
- Where is asset value reported?
- How to deal with complex assets?

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Components of Asset Valuation System

- Asset classification system
- Deterioration models
  - Current condition
  - Trigger points
  - Estimate remaining service life
- Valuation algorithm
  - Portrays "true" value to agency & public
  - Can be quantified for all assets in a given class.

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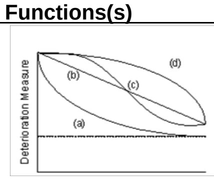
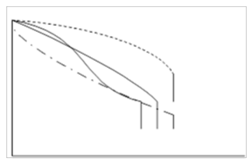
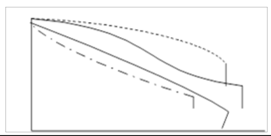
What condition are they in?

Asset Type	Functions(s)	Remarks
Pavements		• Function can be concave up or down, straight or sigmoidal. • Level of acceptability is dashed line
Bridges		• Function varies with component element (material, structural etc.) • Level of acceptability varies with element. • Step function applies to sudden failure
Drainage Structures		• Function varies with material or structure. • Step function applies to breakdown (pipe blockage).

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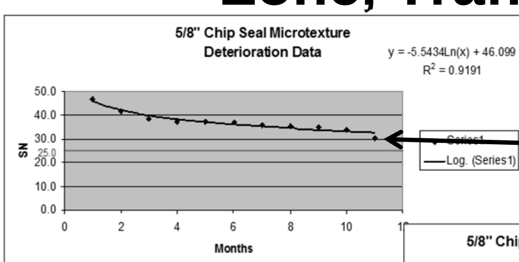
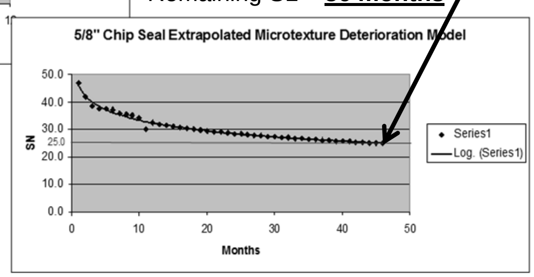
Local Models by District, Zone, Traffic, etc.



Based on a Failure Criteria of SN < 25 – This road has the following remaining service life:
Age @ last data point = 11 months
Projected failure = 47 months
Remaining SL = **36 months**



If it takes 12 months to program a resurfacing project, then the trigger point is:
36 mo – 12 mo = **24 mos** from last data point

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What are they worth?

Book value: Current value based on historical cost adjusted for depreciation.

Written Down Replacement cost: Current value based on replacement cost depreciated to current condition of the asset.

Replacement cost: Cost to replace item.

Market value: Estimate of price buyer is willing to pay

Equivalent present worth in place: Historic cost adjusted for inflation and wear; i.e., the worth "as is".

Productivity realized value: Net present value of benefit stream for remaining service life; i.e., the worth "in use" .

After Lemer, 1998

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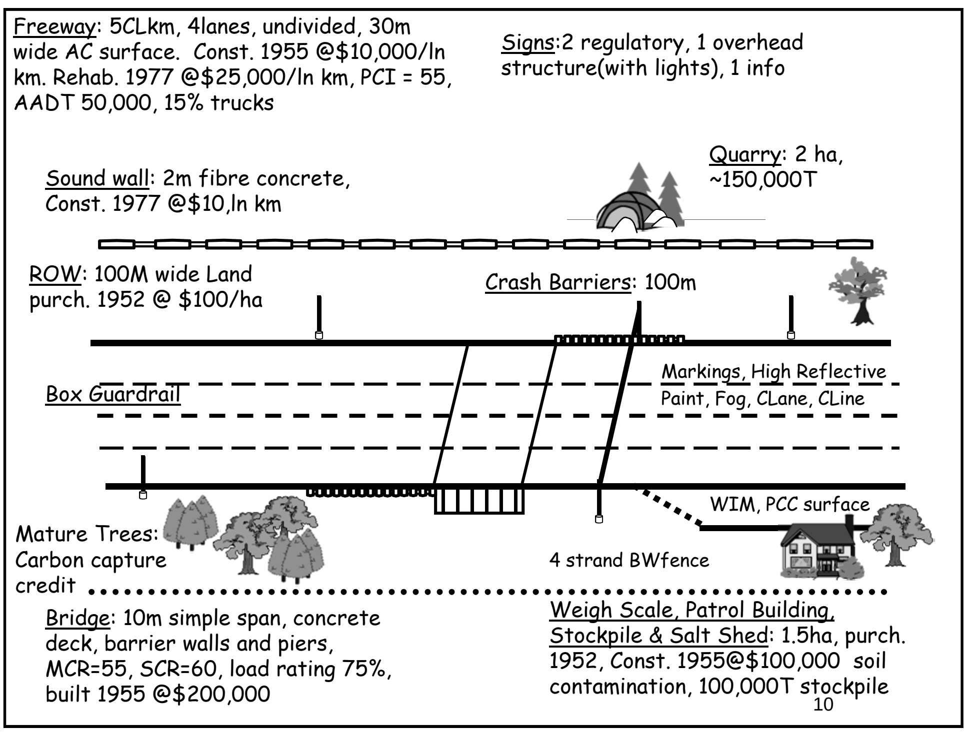

What is each asset worth?

What is the probability that my estimate of worth will change in the period preceding the decision?

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Stochastic Estimates of Asset Value

- Recognizes uncertainty
- Allows for some commodities to be more uncertain than others
- Utilizes historic bid tab data to quantify uncertainty for each commodity
- Uses cost model simulation to allow contingencies to be established statistically.

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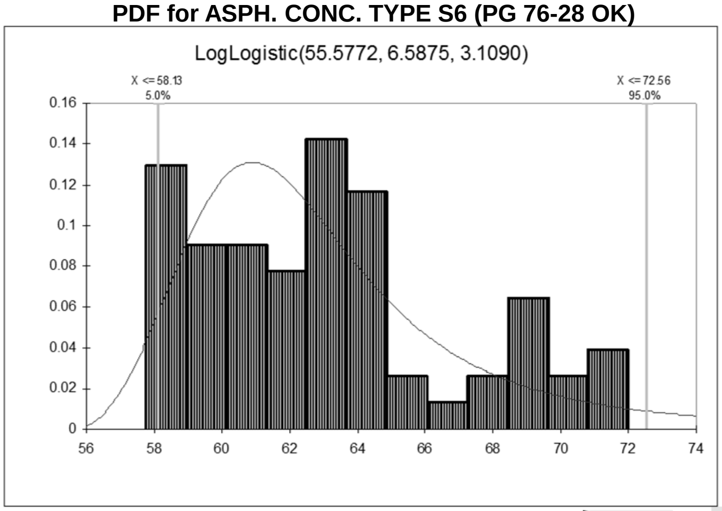
Commodity Curve Fit



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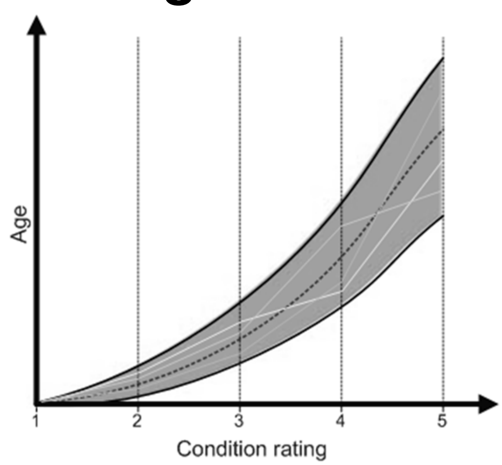
Dynamic Deterioration Modeling

Permits an allowable variance to include different assets in the same class. Allows a generalization to be made for the class.



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Simulation Spreadsheet

Rehab. Bridge No. 13.08B and 13.37B				Asphalt										
H.E. Bailey Turnpike				Aggregates										
Bid Opening: 3/7/2006 10:00a.m.				Cement			$0.15			0.327		0.04905		
				Diesel										
PART A - ALTERNATE BID				Steel										
				Engineer's Est. - W2M		Means Mat'l %	Fuel @ 15% of Means Equip Cost					Commodity		
ITEM NO.	ITEM DESCRIPTION	UNIT	QTY	Est. Unit Cost	Est. Total	Material	Equip	Material	Equip	Deterministic	Total	Means Equipment Percentage		
104	Maintenance of detour	LSUM	1.00	$80,000.00	$80,000.00					$80,000				
106	Quality control and acceptance	LSUM	1.00	$50,000.00	$50,000.00					$50,000				
201	Clearing and grubbing	LSUM	1.00	$30,000.00	$30,000.00	0.00%	4.91%	$0	$1,472	$28,529	$30,000	diesel	02230 200 0010	
202(A)	Unclassified excavation	CY	3690.00	$11.00	$40,590.00	0.00%	8.70%	$0	$3,531	$37,059	$40,590	diesel	02315 430 0100	58.00%
202(G)	Earthwork	LSUM	1.00	$50,000.00	$50,000.00	0.00%	9.75%	$0	$4,875	$45,125	$50,000	diesel	02300 250 0020	65.00%
230(A)	Solid slab sodding	SY	18000.00	$2.25	$40,500.00					$40,500				
303	Aggregate base	CY	75.00	$70.00	$5,250.00	100.00%	0.00%	$5,250	$0	$0	$5,250	Agg	03060 110 0850	0.00%
307(A)	Lime	TON	28.00	$145.00	$4,060.00					$4,060				
307(B)	6" Lime treated subgrade	SY	1680.00	$16.00	$26,880.00	0.00%	1.89%	$0	$508	$26,372	$26,880	diesel	02720 200 1511	12.59%
403(A)	Traffic bound surface course - Type A	TON	65.00	$45.00	$2,925.00	70.13%	1.05%	$2,051	$31	$843	$2,925	Asph/diesel	02740 300 0810	6.99%
407	Tack coat	GAL	705.00	$6.00	$4,230.00	25.64%	5.19%	$1,085	$220	$2,926	$4,230	Asph/diesel	02785 500 3200	34.62%
408	Prime coat	GAL	909.00	$6.00	$5,454.00	85.29%	0.45%	$4,652	$24	$778	$5,454	Asph/diesel	02700 200 0800	2.99%
411(A)	(SP) Asph. Conc. Type A (PG 64 22 OK)	TON	1253.00	$70.00	$87,710.00	68.67%	1.17%	$60,230	$1,028	$26,452	$87,710	Asph/diesel	02740 300 0850	7.81%
411(B)	(SP) Asph. Conc. Type B (PG 64 22 OK)	TON	1185.00	$80.00	$94,800.00	72.15%	1.03%	$68,398	$973	$25,429	$94,800	Asph/diesel	02740 300 0852	6.84%
413(A)	Rumble strip - method AC-CON	LF	8562.00	$2.00	$17,124.00					$17,124				
414(A1)	9" P.C. dowel jointed concrete pavement	SY	2973.00	$70.00	$208,110.00	84.85%	0.34%	$176,581	$709	$30,820	$208,110	cement	02750 100 0200	2.27%
417	Cold milling bituminous pavement	SY	2164.00	$4.50	$9,738.00	0.00%	9.15%	$0	$891	$8,847	$9,738	diesel	02785 500 5280	61.02%
419	Concrete joint rehabilitation	LF	1600.00	$12.00	$19,200.00	0.00%	1.59%	$0	$304	$18,896	$19,200	diesel	03930 300 0100	10.57%
425	Diamond grinding concrete pavement	SY	1000.00	$11.00	$11,000.00					$11,000				
501(B)	Substructure excavation common	CY	670.00	$18.00	$12,060.00	0.00%	7.10%	$0	$856	$11,204	$12,060	diesel	02315 400 0250	47.31%
501(F)	Granular backfill	CY	210.00	$40.00	$8,400.00	46.67%	0.43%	$3,920	$36	$4,444	$8,400	agg	02315 505 1100	2.86%
504(A)	Approach slab	SY	813.90	$140.00	$113,946.00	32.17%	0.65%	$36,656	$742	$76,548	$113,946	cement	03310 240 2950	4.34%
504®	(PL) Silicone expansion joint	LF	445.92	$90.00	$40,132.80					$40,133				
504(F)	Concrete parapet	LF	2711.40	$45.00	$122,013.00	39.34%	1.41%	$48,000	$1,717	$72,296	$122,013	cement	03470 600 0550	9.38%
506(A)	Structural steel	LB	745610.00	$1.85	$1,379,378.50	64.89%	1.28%	$895,079	$17,608	$466,692	$1,379,379	steel	05120 260 5400	8.51%
509	(PL) Special concrete finish	SY	444.50	$55.00	$24,447.50	50.57%	0.00%	$12,363	$0	$12,084	$24,448	cement	02750 100 1000	0.00%
509(A)	Class AA concrete	CY	1192.90	$400.00	$477,160.00	90.63%	0.00%	$432,450	$0	$44,710	$477,160	cement	03310 220 0100	
509(B)	Class A concrete	CY	24.20	$650.00	$15,730.00	91.03%	0.00%	$14,319	$0	$1,411	$15,730	cement	03310 220 0200	
509(D)	Class C concrete	CY	65.30	$275.00	$17,957.50	90.51%	0.00%	$16,253	$0	$1,704	$17,958	cement	03310 220 0412	
511(B)	Epoxy coated reinforcing steel	LB	307440.00	$0.80	$245,952.00	90.83%	0.00%	$223,398	$0	$22,554	$245,952	steel	03210 100 0162	

Deterministic Value = $4,450,000

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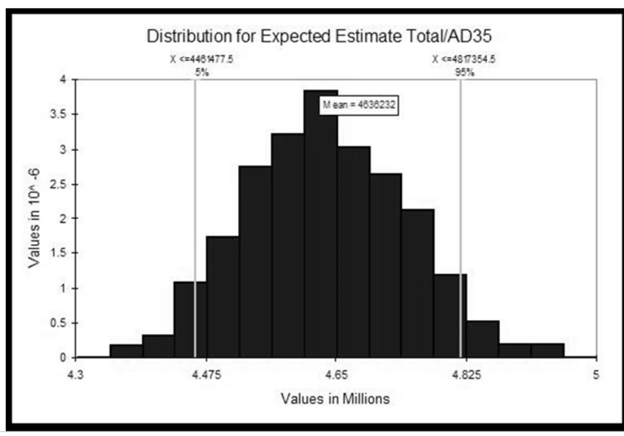
Stochastic Asset Value



Expected Value: EV 95% = $4,820,000

$370,000 or 8.3% more than the deterministic value

Iowa Department of Transportation

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Decision Tools

- Appropriate for asset class
- Time horizon matches expected service life of asset
- More than one alternative available
- Stochastic life cycle cost can be computed using the change to asset value of each alternative
- Example – Structurally sound pavement with SNs approaching trigger point.

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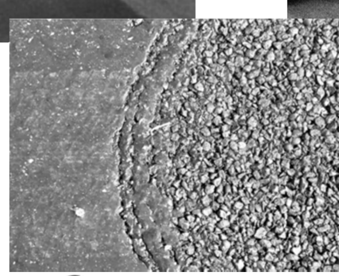
Alt 1: Strip Seal Wheel Paths to Regain SN

Alternative 2: Watercutter Retexturizing



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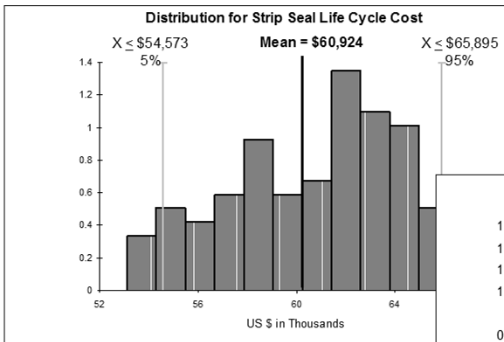
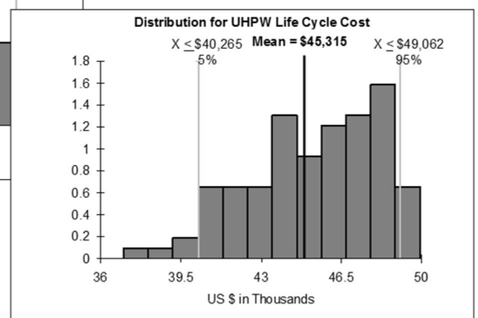
Asset Treatment Alternative Decision



WC EV 95% = $49K
SS EV 5% = $55K
or 95% > $55K
WC is preferred treatment



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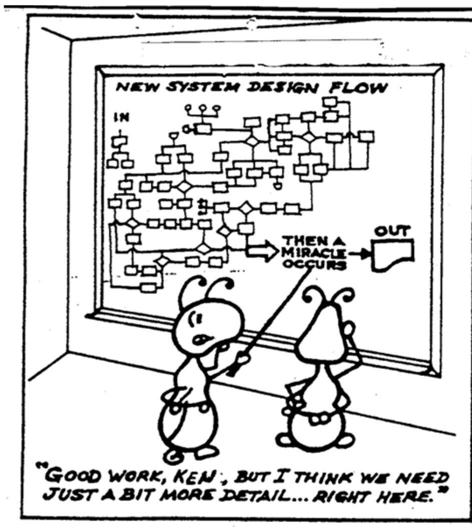
Lots of work to do!!



Iowa Department of Transportation

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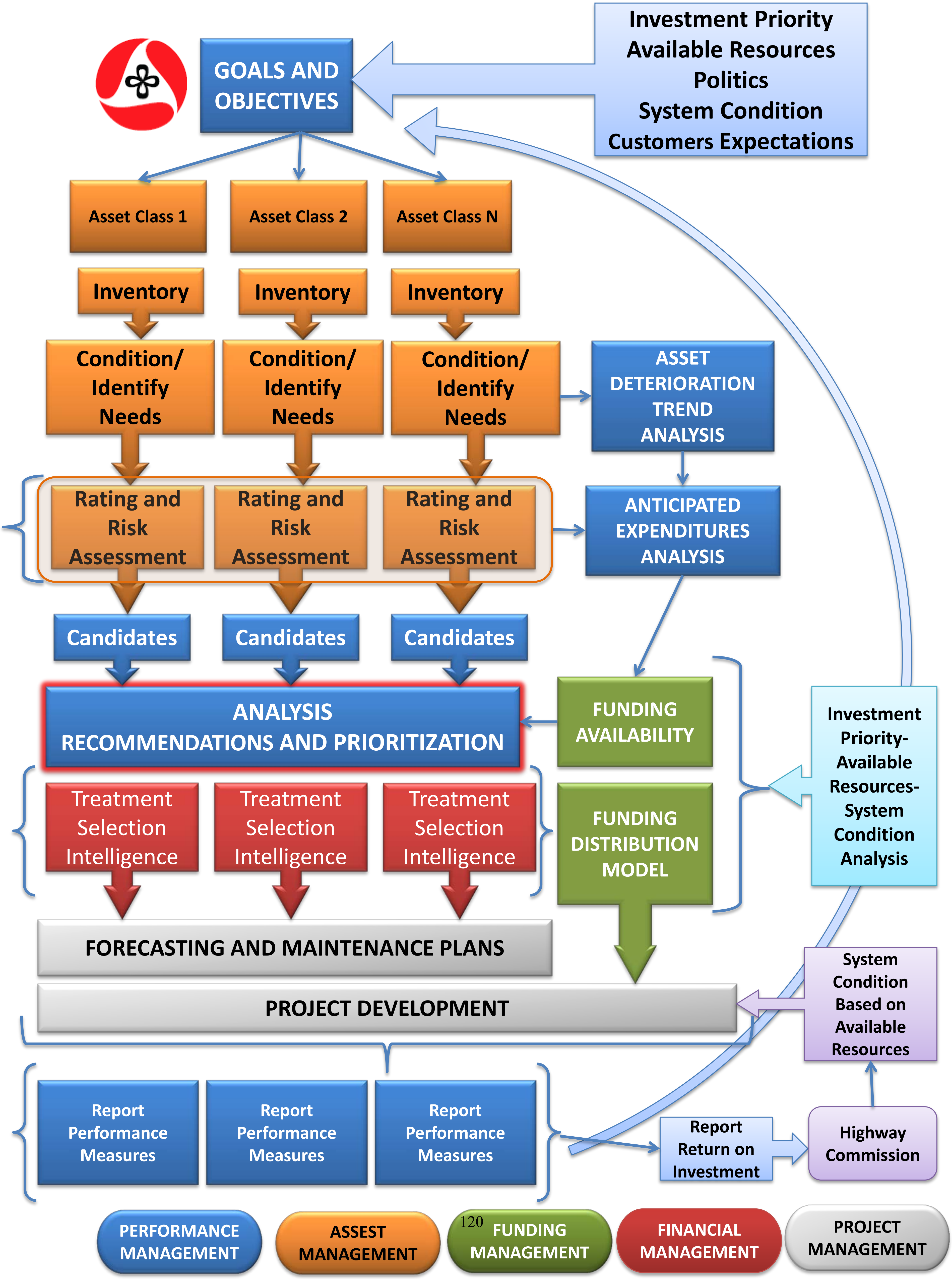
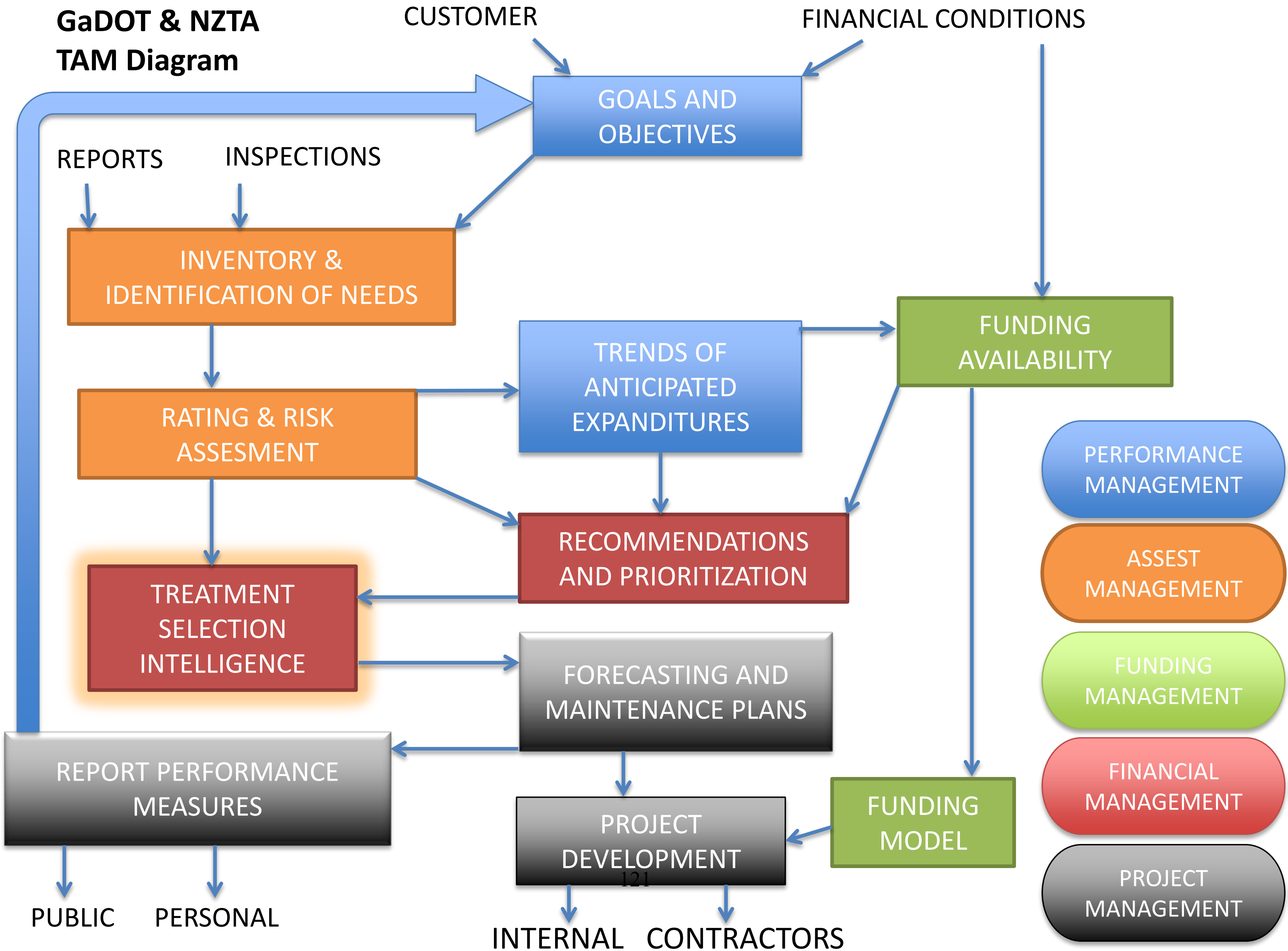


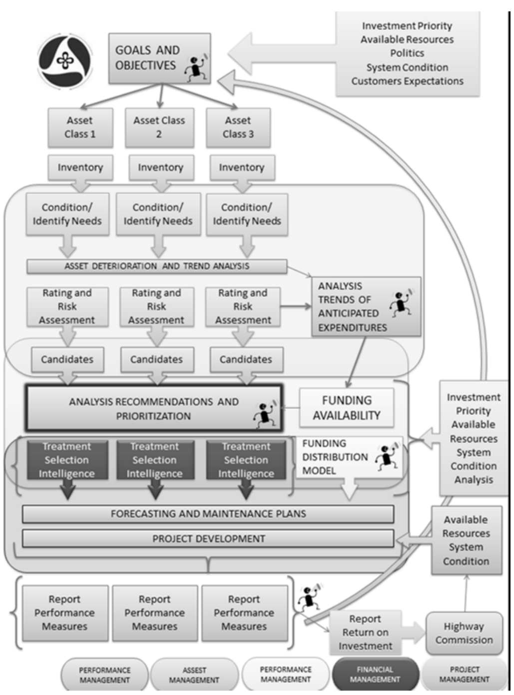
Investment Priority
Available Resources
Politics
System Condition
Customers Expectations
GOALS AND OBJECTIVES
Asset Class 1
Asset Class 2
Asset Class N
Inventory
Inventory
Inventory
Condition/ Identify Needs
Condition/ Identify Needs
Condition/ Identify Needs
ASSET DETERIORATION TREND ANALYSIS
Rating and Risk Assessment
Rating and Risk Assessment
Rating and Risk Assessment
ANTICIPATED EXPENDITURES ANALYSIS
Candidates
Candidates
Candidates
ANALYSIS RECOMMENDATIONS AND PRIORITIZATION
FUNDING AVAILABILITY
Investment Priority- Available Resources- System Condition Analysis
Treatment Selection Intelligence
Treatment Selection Intelligence
Treatment Selection Intelligence
FUNDING DISTRIBUTION MODEL
FORECASTING AND MAINTENANCE PLANS
PROJECT DEVELOPMENT
System Condition Based on Available Resources
Report Performance Measures
Report Performance Measures
Report Performance Measures
Report Return on Investment
Highway Commission
PERFORMANCE MANAGEMENT
ASSEST MANAGEMENT
FUNDING MANAGEMENT
FINANCIAL MANAGEMENT
PROJECT MANAGEMENT


GaDOT & NZTA
TAM Diagram
CUSTOMER
FINANCIAL CONDITIONS
GOALS AND OBJECTIVES
REPORTS
INSPECTIONS
INVENTORY & IDENTIFICATION OF NEEDS
FUNDING AVAILABILITY
TRENDS OF ANTICIPATED EXPANDITURES
RATING & RISK ASSESMENT
PERFORMANCE MANAGEMENT
RECOMMENDATIONS AND PRIORITIZATION
ASSEST MANAGEMENT
TREATMENT SELECTION INTELLIGENCE
FUNDING MANAGEMENT
FORECASTING AND MAINTENANCE PLANS
REPORT PERFORMANCE MEASURES
FINANCIAL MANAGEMENT
PROJECT DEVELOPMENT
FUNDING MODEL
PROJECT MANAGEMENT
PUBLIC
PERSONAL
INTERNAL
CONTRACTORS

Iowa Department of Transportation

TRANSPORTATION ASSETS MANAGEMENT
(TAM)

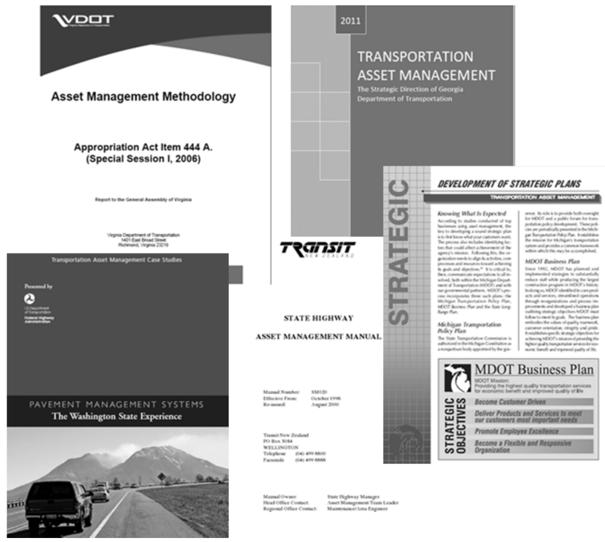
CATALINA MILLER



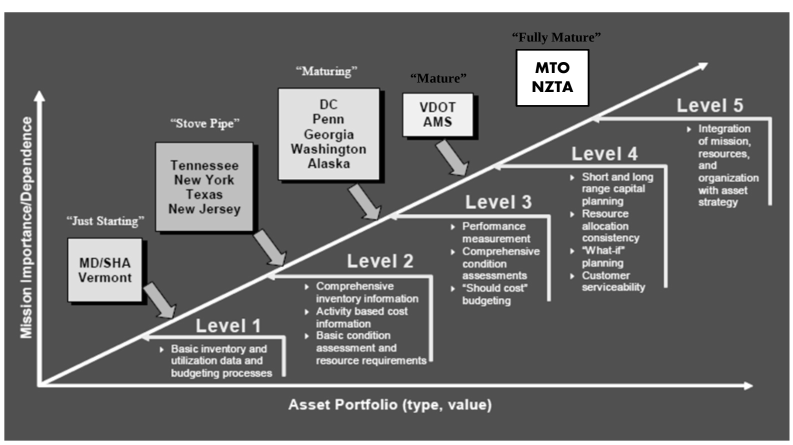
TAM PROCESS DIAGRAM

DIFFERENT EXPERIENCES

* GEORGIA
* NEW ZEALAND
* CANADA
* MICHIGAN
* VICTORIA
* WASHINGTON



STATUS OF DIFFERENT TAM BY 2006



SOCIAL DISCOUNT RATE BENEFITS

* From "worst first" to a system based on needs & risk.

↓

* If needs aren't evenly distributed, funds not be evenly distributed.
* Would this affect the rural/agricultural areas in Iowa?
* How to justify investments in infrastructure in low populated areas?

SOCIAL DISCOUNT RATE BENEFITS

Possible Models in the Literature

Impact Evaluation of Rural Road Projects

September 2008

The Social Discount Rate:

Estimates for Nine Latin American Countries

What is Missing Between Agricultural Growth and Infrastructure Development?

Cases of Coffee and Dairy in Africa

Infrastructure and Economic Development in Sub-Saharan Africa

Iowa State University

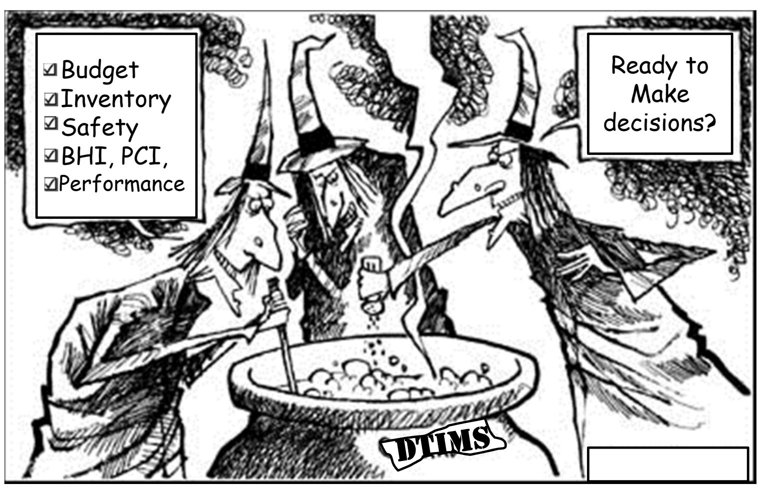
Department of Civil, Construction and Environmental Engineering

Transportation Asset Management and SROI Workshop

September 10th 2014

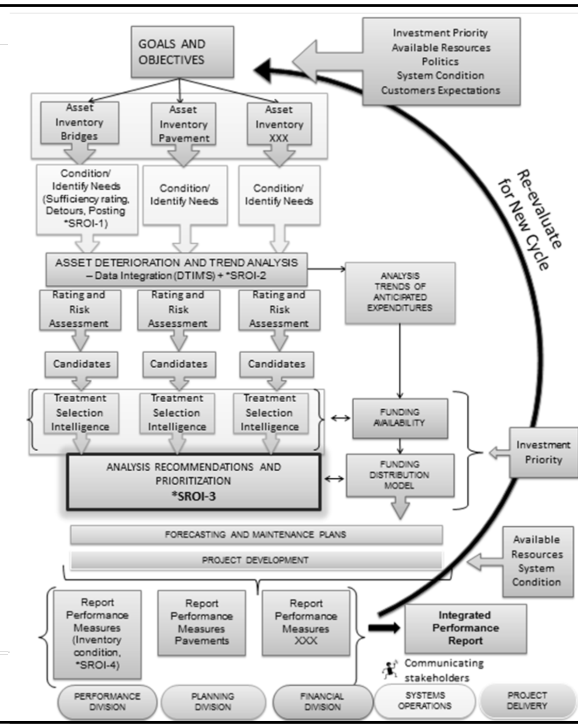
Catalina Miller Dr. Douglas Gransberg ,P.E.

Dr. Susan Tighe, PEng



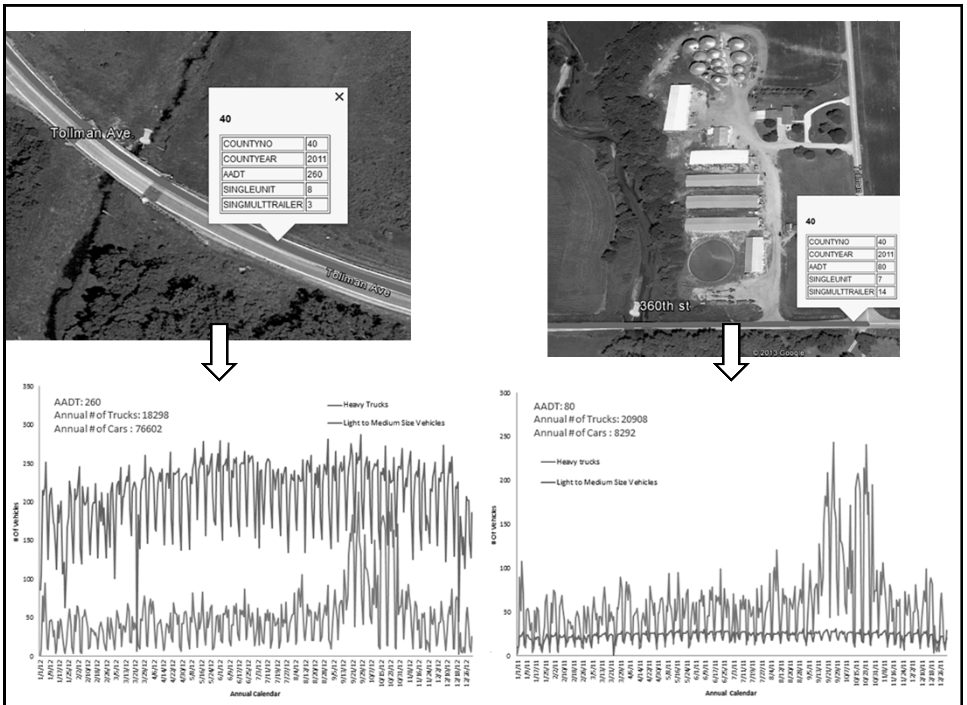
But How?

*TAM focuses on **business** and **engineering** practices for resource allocation and utilization*

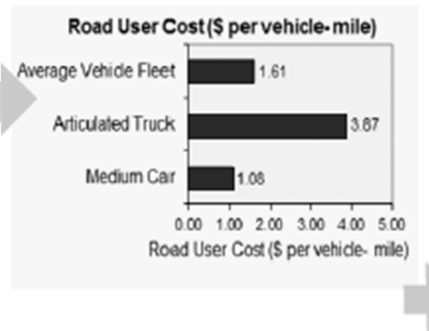


- Map21’s goal: To support regional economic growth.
- TAM’s goal: Deliver to an agency’s customers the best value…. What does add value to the users?
- IADOT’s Mission: Delivering a modern transportation system that provides pathways for the social and economic vitality of Iowa, increases safety and maximizes customers satisfaction

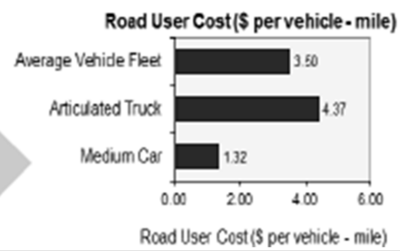
Where is the Value?



In Paved Road



Where is the Value?



In Gravel Road

VOC

IMPACT = Outcome – Deadweight – Drop Off

$$\textbf{SROI} = \frac{\text{Total Present Value of the Impact}}{\text{Present value of the Project}}$$

SROI

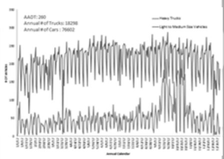
Estimated LCCA of a Similar Bridge with CIP Deck

ITEM	COST
Initial Costs	$375,642
Annual Maintenance	$250 / Year
Inspections (Required Every Two Years)	$200 / Occurance
Five Year Increment Scheduled Maintenance	$1,000 / Occurance
25 Year Scheduled Maintenance	$25,000
50 Year Scheduled Maintenance	$45,000
75 Year Scheduled Maintenance	$25,000
100 Year CIP Design Life Reached	$375,642
120 Year Residual Value of CIP Bridge	$297,313
User Costs Associated with Construction and Maintenance	$233,842

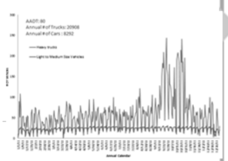
TOTAL LIFE CYCLE COST $**662,756**

(FHWA. (2013). Publication NO. FHWA-HIF-13-031. May 2013)

AADT: 260
Annual # of Trucks: 18298
Annual # of Cars : 76602



AADT: 80
Annual # of Trucks: 20908
Annual # of Cars : 8292



SROI

Detour Distance = 3.75 miles
# of Heavy trucks & users cost = 18,298 @ $3.87 per mile

TOTAL ANNUAL USERS COST due to Detour = $265,550

TOTAL IMPACT (PV)

$$\sum_{t=0}^{(life\ span-1)}\left(\frac{Impact\ at\ end\ of\ year\ 1(1-deterioration\ rate)^t}{(1+r)^{t+1}}\right)$$

Present value $=\sum_{t=0}^{119}\left(\frac{(265{,}550\,(1-0)^t}{(1+0.04)^{t+1}}\right) = \$6{,}578{,}759$

$$SROI = \frac{\text{Total Present value of benefits}}{\text{Value of investments}}$$

$$SROI = \frac{6{,}578{,}759}{662{,}756} = 9.93$$

Detour Distance = 5.5 miles
# of Heavy trucks & users cost = 20,908 @ $4.37 per mile

TOTAL ANNUAL USERS COST due to Detour = $502,524

TOTAL IMPACT (PV)

$$\sum_{t=0}^{(life\ span-1)}\left(\frac{Impact\ at\ end\ of\ year\ 1(1-deterioration\ rate)^t}{(1+r)^{t+1}}\right)$$

Present value $=\sum_{t=0}^{119}\left(\frac{(502{,}524(1-0)^t}{(1+0.04)^{t+1}}\right) = \$12{,}449{,}573$

$$SROI = \frac{\text{Total Present value of benefits}}{\text{Value of investments}}$$

$$SROI = \frac{12{,}449{,}573}{662.756} = 18.8$$

City Bridge Candidate List 2014

Accept/ Decline	County #	FHWA Structure #	City	City Street	Feature Crossed	Sufficiency Rating	ADT	Detour Length	Posting Tons	Relationship of Operational Rating to Maximum Legal Load (SI&A Item 70)	Structure Open, Posted, or Closed to Traffic (OPCL)	Sufficiency Rating Score	ADT Score	Detour Length Score	Relationship of Operational Rating to Maximum Legal Load Score (SI&A Item 70)	Replacement Score	Type of Funding
A	3	361690	LANSING	SOUTH ROAD	CLEAR CREEK	20	113	2	5	0	P	8	1	6	10	25	Federal
D	67	501110	WHITING	WEST ST	McCandless Cleghorn Ditch	34	60	2	15	0	P	7	1	6	10	24	–
A	78	504045	COUNCIL BLUFFS	10TH STREET	INDIAN CREEK	32	990	1	15	0	P	7	3	4	10	24	Federal
D	78	504040	COUNCIL BLUFFS	9TH STREET	INDIAN CREEK	38	1103	1	15	0	P	6	4	4	10	24	–
D	78	2700	COUNCIL BLUFFS	BENTON ST	INDIAN CREEK	32	853	1	15	0	P	7	3	4	10	24	–
A	23	123490	WELTON	180TH ST	SILVER CREEK(WEST)	33	60	6	15	2	P	7	1	10	6	24	Federal
D	56	8370	MONTROSE	X-28 & MIDDLE R	MISSISSIPPI SLOUGH	23	990	1	10	1	P	8	3	4	8	23	–
D	97	10760	SIOUX CITY	MAIN ST	PERRY CREEK	37	833	1	10	0	K	6	3	4	10	23	–
D	97	10770	SIOUX CITY	MARKET ST	PERRY CREEK	35	700	1	5	2	K	6	3	4	10	23	–
A	67	37220	WHITING	K-45	CLEGHORN DITCH	16	1090	19	0	5	A	9	4	10	0	23	Federal
A	91	335250	DES MOINES	CLOVER HILL DRI	MID SOUTH CREEK	39	150	99	5	2	P	6	1	10	6	23	Federal
D	57	220880	BERTRAM	BIG CREEK RD.	BIG CREEK	20	140	4	15	3	P	8	1	10	4	23	–
D	97	502190	SIOUX CITY	EXT MILITARY RD	BIG SIOUX RIVER	58	9200	8	0	5	A	4	9	10	0	23	–
A	82	503700	DAVENPORT	KIMBERLY RD	DUCK CREEK	65	13500	4	0	5	A	3	10	10	0	23	Federal
A	88	2720	CRESTON	ADAMS ST	MCKINLEY LAKE	22	2320	2	0	3	P	8	5	6	4	23	Federal
A	6	14550	KEYSTONE	5TH AVE S	PRAIRIE CREEK	31	1300	16	5	4	P	7	4	10	2	23	Federal
A	99	4360	EAGLE GROVE	9TH ST SOUTH	DRAINAGE DITCH #15	20	321	1	5	1	P	8	2	4	8	22	Federal
A	81	300120	LAKE VIEW	QUINCY AVE	INDIAN CREEK	43	70	3	10	1	P	5	1	8	8	22	Federal
A	94	343190	FORT DODGE	160TH ST	SOLDIER CREEK	50	45	2	10	0	P	5	1	6	10	22	Federal
A	86	5555	GLADBROOK	GRAND ST	DRAINAGE	34	60	1	15	0	P	7	1	4	10	22	Federal
	97	10570	SIOUX CITY	18TH ST	FLOYD RIVER	26	2960	3	0	5	A	8	5	8	0	21	
	23	2240	CLINTON	W DEER CK RD	DRAINAGE	25	80	2	5	2	P	8	1	6	6	21	
	79	820	BROOKLYN	ORCHARD ST	LITTLE BEAR CREEK	44	470	1	10	0	P	5	2	4	10	21	
	85	180	AMES	6TH ST	SQUAW CREEK	42	4160	3	0	5	A	6	7	8	0	21	
	82	3130	DAVENPORT	E 53RD ST	GOOSE CREEK	75	22200	4	0	5	A	1	10	10	0	21	
	43	178621	WOODBINE	BUS BROWN DR	DRAINAGE	25	940	0	0	0	P	8	3	0	10	21	
	3	503880	WATERVILLE	LOCAL	PAINT CREEK	18	152	0	15	0	P	9	1	0	10	20	
	57	640	BERTRAM	ELY ST	BIG CREEK	34	130	4	15	4	P	7	1	10	2	20	

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Total Funds:$87,758,303
Total SROI index for 2014: 24

BRIDGE ID	Sufficiency Ra		SROI		Bridge Posting		TOTAL
	Ratin	iority Poi	Rating	iority Poi	Ratin	iority Points	
10060	2	10	190.29	10	0	10	10
9980	14	9	82.37	9	0	10	9
4360	20	8	133.77	10	1	8	9
4845	24	8	75.58	8	0	10	9
152160	25	8	149.94	10	2	6	9
254330	17	9	40.71	7	0	10	8
60	2	10	66.30	8	2	6	8
178621	25	8	50.12	7	0	10	8
220880	20	8	134.72	10	3	4	8
335250	39	6	180.61	10	2	6	8
503910	24	8	40.71	7	0	10	8
7410	17	9	22.53	6	0	10	8
2720	22	8	97.09	9	3	4	8
11525	4	10	15.34	5	0	10	8
6170	17	9	11.76	5	0	10	7
14550	31	7	134.72	10	4	2	7
37220	16	9	299.76	10	5	0	7
503880	18	9	0.00	5	0	10	7
8370	23	8	31.99	6	1	8	7
8800	24	8	21.70	6	1	8	7
10590	22	8	0.00	5	0	10	7
12250	23	8	18.65	5	0	10	7
171400	36	6	21.04	6	0	10	7
6140	34	7	15.64	5	0	10	7
354290	29	7	37.86	6	1	8	7
6160	20	8	9.46	4	0	10	7
10760	37	6	0.00	5	0	10	7
10770	35	6	0.00	5	0	10	7
361690	20	8	6.16	4	0	10	7
820	44	5	13.78	5	0	10	6
692	22	8	9.45	4	1	8	6
6030	2	10	38.76	6	4	2	6
51870	55	4	189.08	10	5	0	6
312930	4	10	27.72	6	4	2	6
2700	32	7	4.05	3	0	10	6
5020	15	9	2.38	2	0	10	6
5615	18	9	3.03	2	0	10	6
123490	33	7	11.03	5	2	6	6
501110	34	7	5.07	3	0	10	6
420	32	7	3.29	2	0	10	5
1970	48	5	79.63	8	5	0	5
3130	75	1	230.31	10	5	0	5
5555	34	7	3.70	2	0	10	5
8230	31	7	3.43	2	0	10	5
11830	34	7	6.22	4	2	6	5
300120	43	5	6.65	4	1	8	5
504045	32	7	3.99	2	0	10	5
1630	22	8	3.72	2	1	8	5
3530	21	8	39.77	6	5	0	5
7610	41	6	9.78	4	2	6	5
52770	56	4	73.48	8	5	0	5
504040	38	6	3.75	2	0	10	5
11831	14	9	2.27	2	2	6	5
343190	50	5	3.91	2	0	10	5
110	36	6	24.43	6	5	0	5
2240	25	8	3.05	2	2	6	5
5530	87	0	91.11	9	5	0	5
9820	21	8	1.78	1	1	8	5
40770	37	6	7.82	4	3	4	5
6540	30	7	1.42	1	1	8	4
209070	23	8	8.08	4	5	0	4
503755	22	8	6.87	4	5	0	4
7530	40	6	2.53	2	3	4	4
5730	47	5	39.77	6	5	0	4
180	42	6	10.79	5	5	0	4
500140	66	3	40.71	7	5	0	4
502190	58	4	45.76	7	5	0	5
503700	65	3	48.20	7	5	0	4

Proposed City Bridge List

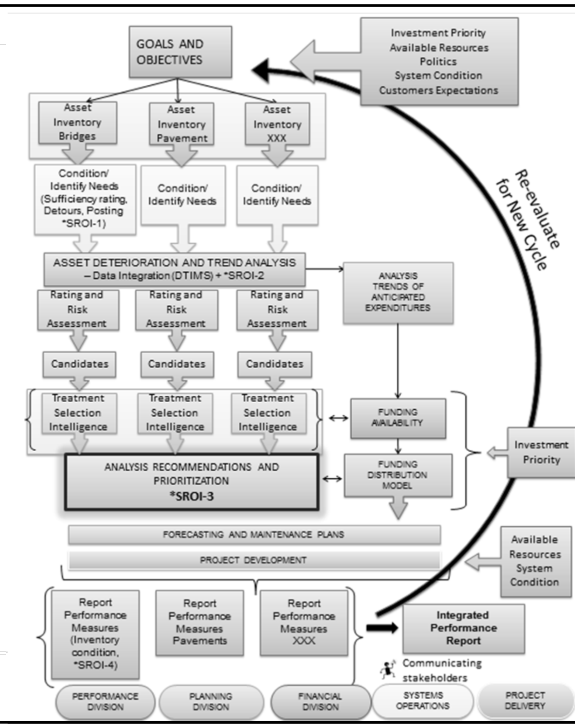
Current		Proposed	
25%	Sufficient Rating	Sufficient Rating	25%
25%	Estimated AADT	SROI	50%
25%	By Pass, Detour		
25%	Bridge Posting	Bridge Posting	25%
100%	**Rating Score**	**Rating Score**	**100%**

66 of 97. 22 New bridges were added

Total SROI index: 28 vs 24 of actual method

	Investment	Impact	Life Cycle	SROI
New Bridges Added	$13,670,523	$1,032,800,880	$13,422,713	77
Bridges Left out	$13,556,872	$629,544,568	$13,565,948	46

2 out of the 46 are out

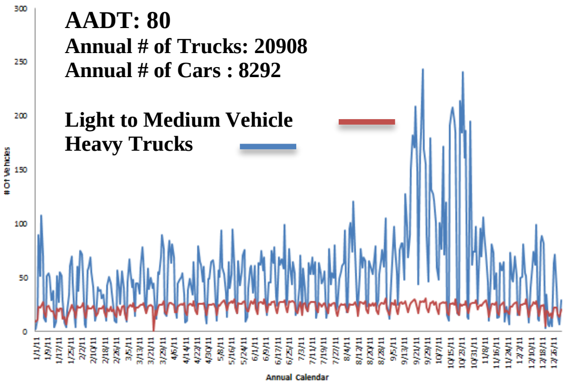


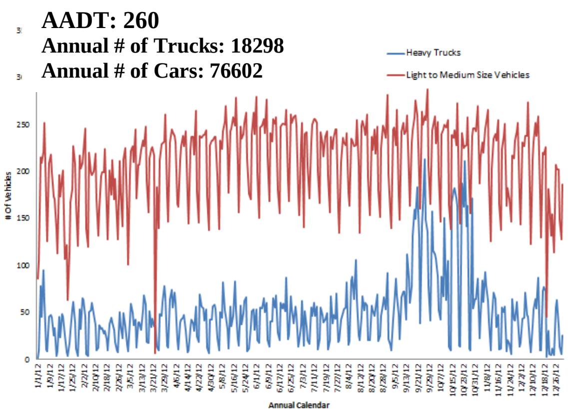
- Its is important to start from the goals and strategic plans the agency has set.
- The state must work as a team including the local agencies and integrating and sharing the knowledge with the counties about TAM.
- This includes unifying the processes and data gathering.
- Build valuable data for future life cycle analyzes, it is indeed necessary to create a system that allows the maintenance department to keep track of the tasks and costs delivered to each structure.

Lessons Learned and Recommendations

Impact

Total AADT ≠ More Impact





VOC?

The Vehicle Operation Cost of a Semi on gravel roads is about 4 times more than a small vehicle on paved roads!!!

Catalina Miller

Phone: 407.276.7311
E-mail address
mmiller1@iastate.edu

SMARTER | SIMPLER | CUSTOMER DRIVEN

Iowa State University
Department of Civil, Construction and Environmental Engineering

IADOT Transportation Asset Management (TAM)

It is a team effort

Measuring and Valuing Social and Economic Impact

*TAM focuses on **business** and **engineering** practices for resource allocation and utilization*

What is TAM?

"TAM is a strategic plan that helps the DOT's to focus on the business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."(ASSHTO, 2012)

TAM's GOALS:

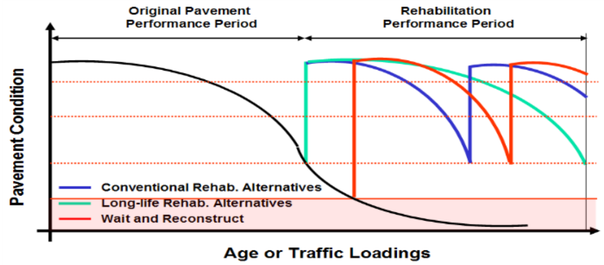
Build, preserve and operate facilities more cost-effectively with improved asset performance.

Deliver to an agency's customers the best value for the public tax dollar spent.

Enhance the credibility and accountability of the transportation agency to its governing executive and legislative bodies.

Worse First ≠ More Impact

LIFE-CYCLE COST ANALYSIS PROCEDURES MANUAL



Treatments:

What kind of treatment is most cost-efficient?

When should they be applied to extend life cycle?

What resources are available?

What resources will be available for sustainability?

How are users been impacted?

What about adjacent assets?

Key:

To know the inventory and its condition

Where is the Value?

Map21's goal: To support regional economic growth.

TAM's goal: Deliver to an agency's customers the best value.... What does add value to the users?

IADOT's Mission: Delivering a modern transportation system that provides pathways for the social and economic vitality of Iowa, increases safety and maximizes customers satisfaction

Social Return on Investment (SROI)

IMPACT = Outcome – Deadweight – Drop Off

SROI = $\frac{\text{Total Present Value of the Impact}}{\text{Present value of the Project}}$