Michigan Technological University

Characterization of Unpaved Road Condition Through the Use of Remote Sensing

Deliverable 6-D: Extension of GIS DSS Tools to a Nationwide Assessment Tool for Unpaved Roads

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www.mtri.org/unpaved

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Purpose of this Document

This report details an outreach and education event associated with the *Characterization of Unpaved Road Condition Through the Use of Remote Sensing* project. The event was designed to gain acceptance and increase understanding for the need and utility of the Aerial Unpaved Road Assessment (AURA) system, which was developed for this project, and its associated decision support system (DSS), the Roadsoft GIS tool. Therefore, the activities outlined in this report targeted potential users of the AURA system. This document also serves as a starting point for potential future education and advocacy efforts in this area to maintain momentum for commercialization beyond the life of the project.

Intent of the Education Outreach Effort

The original intent of Task 6-D was to provide direct support for agencies that attended field demonstrations and that were interested in working further with the AURA data and its associated DSS software. According to the original scope, this task's purpose was to *"provide support to agencies in the project's field demonstration states so that local agencies interested in data collection demonstrations with the AURA system [formerly URCAS] can understand how they can use [it] for decision support…."*

While developing the scope for this task, the project team assumed that early-adopter agencies would be interested in investigating the collection and use of unpaved road data from the system after demonstration flights. Task 6-D budgeted time for that direct agency support and outreach.

During demonstration flights, obvious enthusiasm and interest emanated from state, local, and tribal government staff who were present. However, the interest to collect further data or to use the data in conjunction with the DSS software did not materialize as well as the project team had originally hoped. Anecdotal information from interacting with agencies at field demonstration sites revealed that, while

unmanned aerial vehicle (UAV) technology was interesting and alluring to participants, many agencies were still struggling with the concept of asset management for unpaved roads. Conversations with agency staff revealed that few, if any, participating agencies have business processes set up to use condition data in their decision-making process for unpaved roads but, rather, relied on professional judgment to drive decisions. The idea of data-driven decisions appeared to be a new concept for most of the demonstration participants at our various field efforts (two in South Dakota and one in Kansas).

Participants at the Kansas and South Dakota demonstration events received surveys, which assessed their level of interest and their concerns related to the use and implementation of the AURA system. When asked about their initial impression of the AURA system, the South Dakota participants (this question was not asked in Kansas) used positive phrases like “exciting”, “useful”, “interesting”, and “impressive”. When participants from Kansas and South Dakota were asked how their agencies would use the technology if it were available, only three out of 42 participants surveyed indicated that they would use it for asset management purposes. This feedback supports the anecdotal information regarding the interest in the technology, but it also highlights a lack of a perceived need to meet asset management data requirements using the type of high-resolution, repeatable, and objective data that the AURA system was designed to create.

The project team identified a pattern of concentrated interest in the technology without an accompanying drive to develop into early adopters of the technology along with its associated data for road asset management. This pattern is similar to the reticence that developed among Michigan local agencies toward adopting handheld portable global positioning systems (GPS) in the early 2000s when GPS units were becoming financially viable and had the potential to revolutionize field data collection. The project team holds that many of the agencies participating in the demonstration flight were guided by worker experience, past practice, and professional judgment rather than data. Understandably, these agencies appeared hesitant to adopt new technologies or processes without incentives, mandated data requirements, or without evidence that the old processes are not meeting their needs.

In response to this realization, the project team developed and presented a two-hour introductory webinar on asset management concepts in light of the capabilities of the AURA system. This webinar intended to raise the awareness of the benefits for using asset management systems and the associated data gathering, helping to create demand for AURA system capabilities. The webinar would also then be available to help with outreach to any future groups interested in how road asset management and the AURA system fit together to meet their unpaved road data needs.

Webinar Learning Objectives

The project team delivered an educational webinar using the Adobe Connect web conferencing system. They selected a webinar as an appropriate format for this type of education effort by considering

the benefits and liabilities of this format. Webinars allow participants to join a learning event from the comfort of their office and interact with instructors and other participants from around the world. Webinars also yield great benefits in efficiency by allowing multiple people and instructors from different locations the ability to attend and interact in a single event without the overhead related to travel. However, the webinar format limits attendance to 2.5 to 3 hours maximum before instructors and participants fatigue and interactivity declines.

The learning objectives for the webinar were:

1) Participants will be able to outline the three phases and six steps of a general asset management process.
2) Participants will be able to relate asset management core concepts to everyday activities.
3) Participants will be able to articulate the six uses of condition data for asset management purposes.
4) Participants will be able to describe the applications of the AURA systems to their peers.
5) Participants will be able to articulate the differences between the worst-first strategies for project selection versus a mix-of-fixes asset management strategy.

The webinar consisted of 63 PowerPoint slides that were delivered over the course of two hours. In addition to the digital slides, a series of polls engaged participants and feedback quizzes helped to foster interactivity between the audience and instructors while collecting data for the project. Appendix A contains the PowerPoint slides for the webinar.

The webinar instructors were project Co-Investigator Tim Colling (Michigan Technological University's Center of Technology & Training, CTT) and project PI Colin Brooks (MTRI). The moderator was Mary Crane (CTT).

Webinar Advertisement and Marketing

The original target audiences for this training were agencies that have seen or interacted with the remote sensing for unpaved roads project (that is, the AURA system) and are interested in adopting this technology in their agency or providing it as a service to others. The intended target audience was also envisioned to be technical staff who do not yet have a full understanding of asset management concepts, and would have an understanding of the need for AURA system capabilities for unpaved road asset management after attending this webinar.

Advertising for the webinar relied on a targeted electronic mailing campaign. Participants who had provided their contact information at an AURA system field demonstration received the advertisement for the webinar via e-mail. A second mailing advertising the webinar included contacts from the Michigan Local Technical Assistance Program (LTAP) mailing list. Appendix B presents a copy of the

advertisement flyer for the webinar. A third marketing effort involved advertising the webinar in the e-mail newsletter, "Transportation Tomorrow," which is created and distributed by Valerie Lefler (a collaborator in this project) and is produced by Integrated Global Dimensions. This newsletter is distributed to over 20,000 transportation professionals worldwide.

There was no registration fee or other cost to attend the webinar. Although the webinar had no associated registration/attendance fees, agencies were required to register for the event. Registered agencies received a web conference link and telephone dial-in information to attend the webinar remotely.

Registration for the webinar was strong, with 58 individuals registered prior to the webinar. Registrants represented nine states. Only three agencies (City of Bismarck, South Dakota LTAP and North Dakota LTAP) that attended a field demonstration also had people register for the webinar. Table 1 illustrates registrants by agency type.

Table 1: Webinar Registrants by Home State

Registrant Home State	Registrants	Percent of Total
Alabama	1	2%
Arkansas	2	3%
Connecticut	1	2%
Kentucky	1	2%
Michigan	47	81%
Montana	1	2%
Nebraska	2	3%
North Dakota	2	3%
South Dakota	1	2%
Total	58	100%

We had expected more registrants from outside Michigan, but the availability of the webinar recording online should help with more potentially interest parties from other states in learning about asset management and unpaved road assessment.

Outcomes of the Webinar

A recording of the webinar, as delivered, can be found at http://mtu.adobeconnect.com/p8czppjifce/. This link will be added prominently to the www.mtri.org/unpaved project page so that anyone interested in transportation asset management can learn through this recording. The link will also be use to share webinar contents in future presentations.

Attendance for the webinar was lower than anticipated given the solid pre-registration numbers. Only 26 people attended the webinar out of the 58 that registered (45% percent of the total). This phenomenon of a high "loss rate" between registrants and attendees has been observed in other training events offered by Michigan Tech that do not require a nominal registration fee to attend. While this may seem trivial, the requirement to pay a nominal registration fee ($10, for example) for training events has been shown to increase the number of registrants who attend. Charging a registration fee creates a commitment to show up (albeit a small one) on the part of the registrant. It also removes concerns that a "free" training session has some other profit motive.

Webinar attendees represented four states (Michigan, Connecticut, Arkansas and Nebraska), however none of the attendees had been to a field demonstration. The total number of attendees, counted by connections, was 26. More than one person may have attended per connected site (for example, an attendee may have made the session available to multiple people sitting in a conference room while watching the webinar). Table 2 illustrates attendees by agency type.

Table 2: Webinar Attendees by Home State

Registrant Home State	Registrants	Percent of Total
Alabama	0	0%
Arkansas	1	4%
Connecticut	1	4%
Kentucky	0	0%
Michigan	22	85%
Montana	0	0%
Nebraska	2	8%
North Dakota	0	0%
South Dakota	0	0%
Total	26	100%

During the webinar, instructors asked a series of interactive poll questions designed to keep participants engaged and collect information on the audience for use by the instructors. Appendix C recounts the poll questions and responses.

The poll questions revealed that the audience who attended the webinar was not the project team's ideal target audience. While most of the attendees were technical staff, none of the attendees or their agencies were participants in any of the field demonstrations conducted for this project. Furthermore, polls indicated that the majority of attendees were already engaged in asset management activities and data collection for asset management and that the webinar material, for the most part, was not new information. However, they are now informed on the capabilities of the AURA system and how it connects to unpaved road asset management. Attendees will be sent a follow-up brochure about the AURA system.

While the webinar did not to attract the original intended audience, the participants indicated that the webinar increased their overall opinion of the importance of asset management. Figure 1 details the response to the poll question on the change in the perceived importance of asset management.

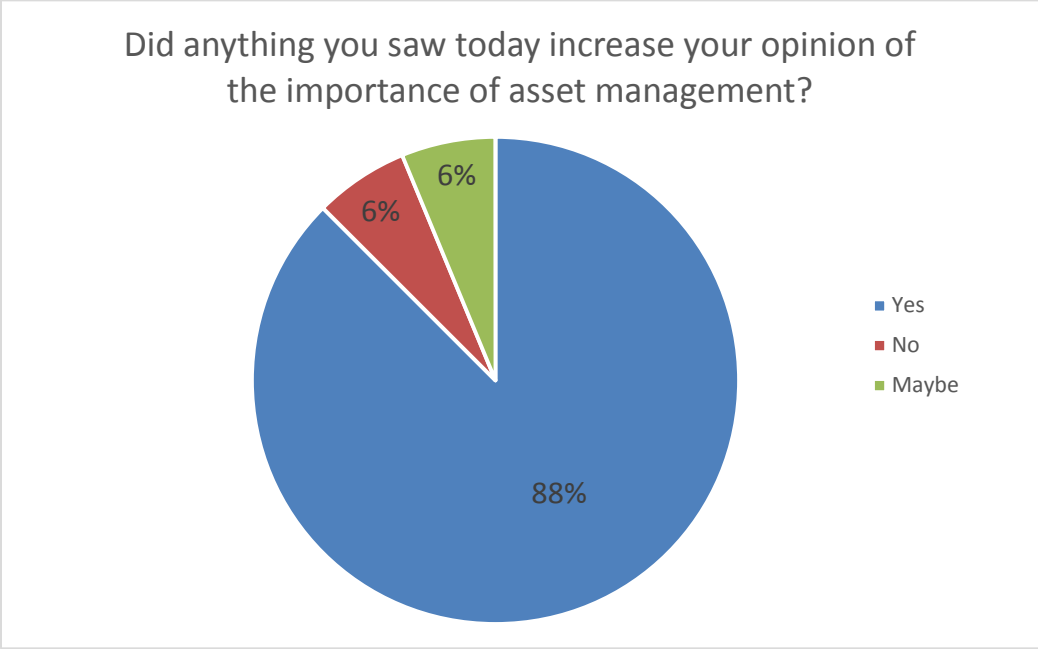
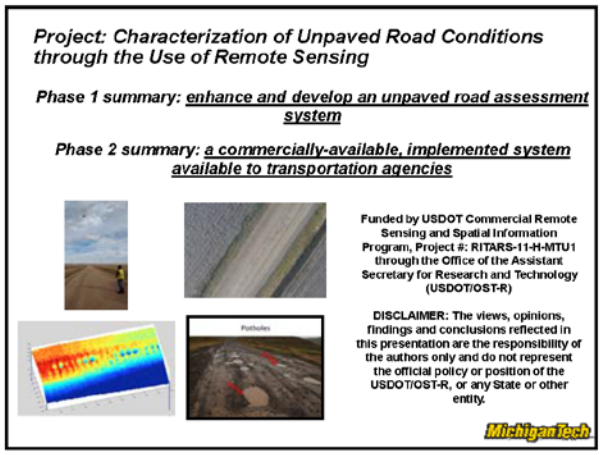


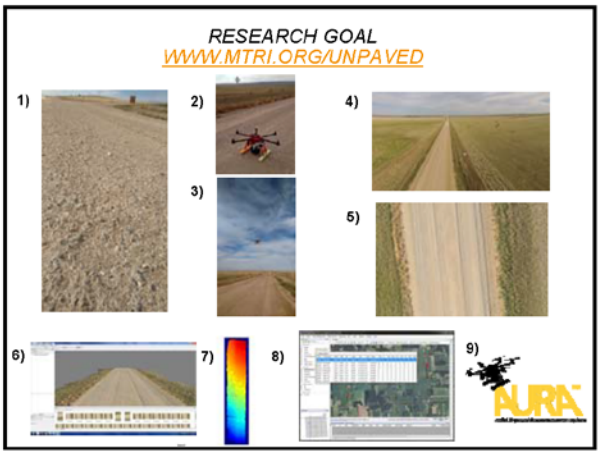
Figure 1: Response to the poll question on the change in the perceived importance of asset management.

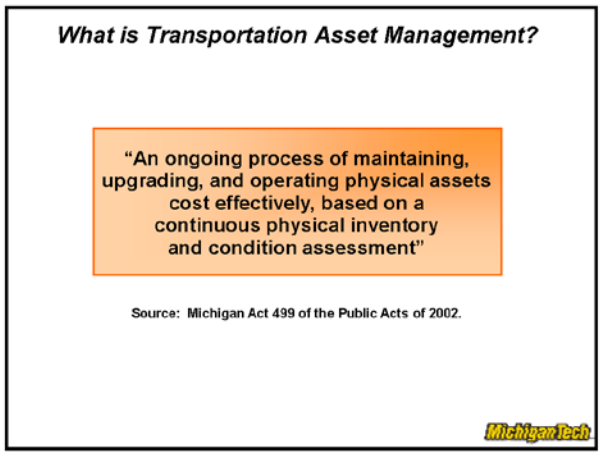
Conclusion

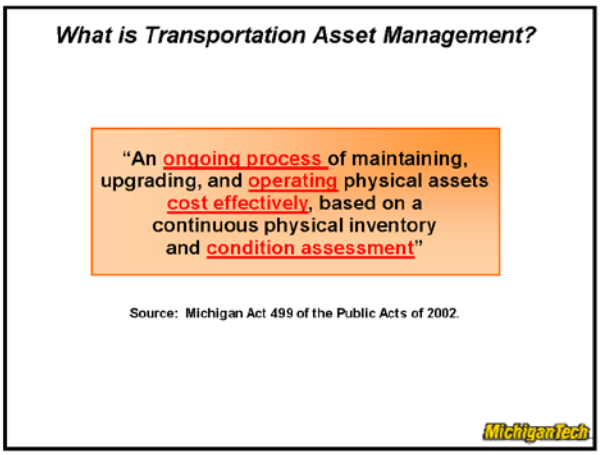
Clearly, there will always be early adopters of new technologies who will experiment with the implementation of new methods and techniques. These early adopters are critical for the advancement of new technology by blazing the trail for others to follow and by helping to refine early products and processes to meet user needs better. To move past an early adopter experimentation phase for the AURA system, the project team sees a need for an educated "second tier" of agencies that understand and acknowledge the necessity of this new technology and are ready to implement it when resources allow. The project team believes that a sustained education initiative is needed to create this second tier of agencies. This education program is necessary to introduce the concepts of asset management for unpaved roads and to bring attention to the utility of the technology behind the AURA system. With this webinar now put together and available online, the ability to reach more potential end users who would benefit from a data-driven transportation management approach will be easier.

Appendix A: Webinar PowerPoint Slides









House Project Selection Rational

1st Select projects that stop or reduce damage to the asset.

2nd Select projects that have the potential to save money in the future.

3rd Select projects that add functionality or value to the asset.

When presented with a choice of projects, select the one with:
a. Lowest cost per unit of improvement
b. Quickest time of payback

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Asset Management Consideration

Positive

- Efficient direction of maintenance, rehab and reconstruction activity
- Provide framework for measurement and consistency
- Provides project and network level assessment
- Communication with users

Negative

- Requires data collection
- Requires analysis time

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Asset Management Process
Components

Data Collection
1. Inventory
2. Condition Assessment (Rating)

Decision Support
3. Assess Future Conditions / Outcomes
4. Application Project Selection Policy

Execution
5. Construction
6. Reporting

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1. Inventory

You can't manage what you don't know you own

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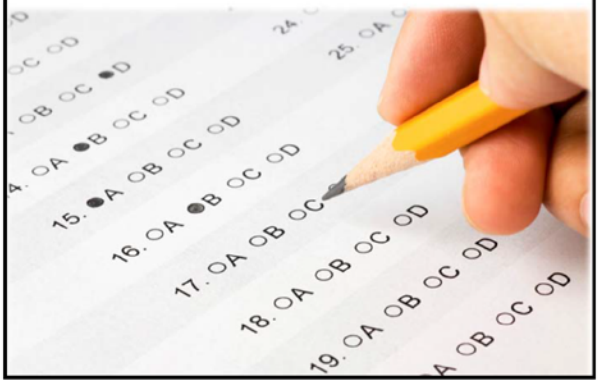
User Feedback



Inventory – Road Example

Any aspect that will impact management decisions

Collect once and update during construction

- Physical aspects (Lane width, shoulder type and width, number of lanes, pavement design, curb type etc.)
- Functional class
- Pavement type
- Year of construction
- Ownership
- Physical location (map)

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Inventory Uses

- Used as criteria for subdividing the network into like parts
- Used as criteria modify treatment options
- Used as criteria to select projects
- Used to adjust cost
- Used as factor in service life

Guiding principle: If you don't know how you are going to use it, and it can be collected later, don't collect it now.

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2. Condition Assessment (Rating)

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Why Rate Roads?

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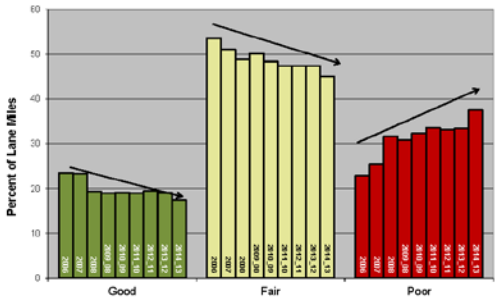
Network Level Metric



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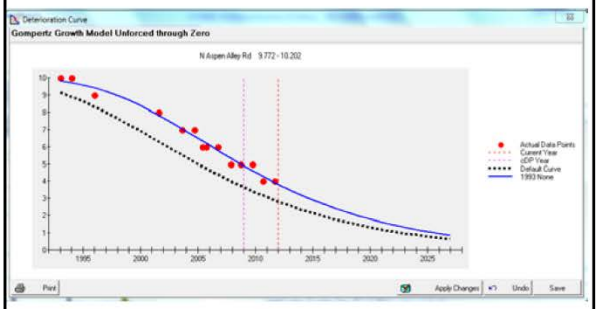
What Work To Do, When & Where?

Modeling– How will a specific road change?



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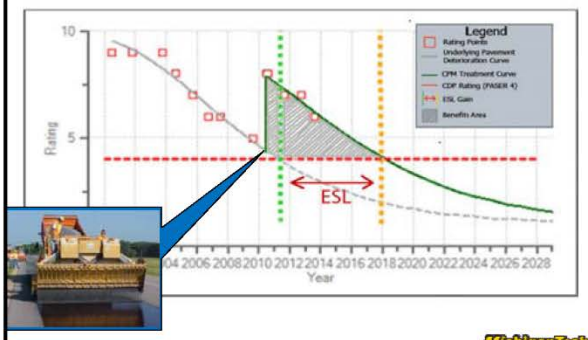
Measure Value of Fixes



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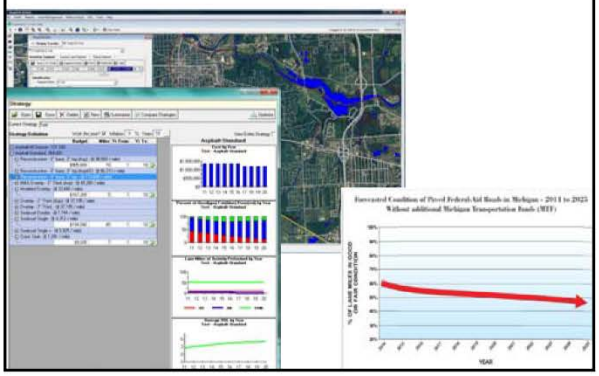
Network Level Modeling



Research

- Refine timing of fixes
- Refine materials used in pavements
- Refine construction technique
- Refine design methods
- Measure impact of treatments
- Relating distress to use

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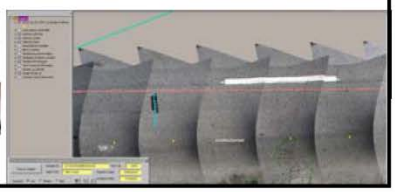
User Feedback

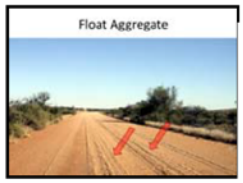
Data Collection Classification

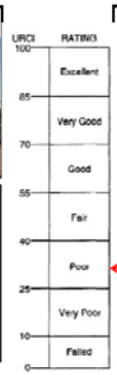
Manual

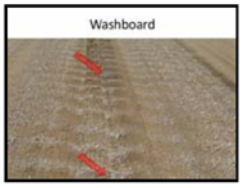
Semi-Automated



Unpaved Road Distresses







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Road Assessment Methods: Dept. Army Unsurfaced Road Condition Index (URCI)

- Representative Sample Segments
- 2 Part Rating System
  - Density
    - Percentage of the Sample Area
  - Severity
    - Low, Medium, High
- Clear Set of Measurement Requirements
- Realistic Possibility of Collecting Most of the Condition Indicator Parameters
- Potential Applicability to a Wide Variety of U.S. Unpaved Roads
- Endorsed by Technical Advisory Committee as Effective Rating System

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Equipment Platforms

- Bergen Hexacopter – our "workhorse" platform
  - Total flight time: up to 20 minutes with small payloads
  - Weight: 4kg unloaded
  - Maximum Payload: 5kg
  - $5400 as configured, made in USA (http://www.bergenrc.com/)
  - Includes autopilot system, stabilized mount that is independent of platform movement, and first person viewer system (altitude, speed, battery life, etc.)
- Nikon D800 36 mp DSLR, our main camera ($3800 with 50mm prime lense)
  - Also testing Sony α7R, same resolution/cost, ½ the weight

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Collected Imagery, 3D Reconstruction using close-range photogrammetry *(Structure from Motion)*

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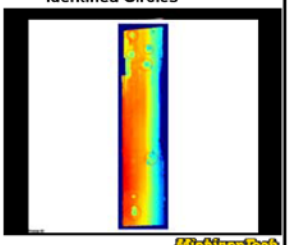
Automated Distress Detection example: Potholes (Remote Sensing Processing System)

- Canny Edge Detection Used to Locate Edges
- Hough Circle Transform is Used to Locate Potholes
- Detected 96% of potholes
- AURA RSPS also automatically analyzes:
  - Washboarding / corrugation
  - Ruts / aggregate berms
  - Crown % (sufficient crown)

Edge Detection

Identified Circles



Note: circles near edges ignored.

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All of these together – components of the AURA system!

- Aerial Unpaved Road Assessment (AURA) system
- Creates data needed for unpaved roads asset management

AURA
Aerial Unpaved Road Assessment system

- www.mtri.org/unpaved (project details site)
- www.auramtri.com (public outreach site)

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Cost of Data Collection

- **Visual Inspection = $8 to $15 / mile**
- **Manual measurement = $30 to $100 / mile**
- **Measurement via video log / instrumented van $50 - $300 / mile**
- **UAV $1 to $20/mile (*lower cost with two 100' representative segments per mile; higher cost for measuring every part of a mile in high-resolution at ½" x,y,z*)**

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Picking a Rating System

Things to consider:

- Can you pay for collection on the network you support?
- How frequently can you afford to collect the data?
- Is there special equipment necessary? Do you own it?
- Can owner agency staff be involved in the collection or is unilaterally a contractor?
- Does the data have the correct level of detail for your uses?
  - Trigger points
  - Predictive detail
  - Unused detail
- Is the data repeatable enough for your purposes?
- Continuity, do you have control over what is collected and how?

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3. Assess Future Conditions / Outcomes

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Network Level vs. Project Level

Project: Moving pieces

Network: Winning game

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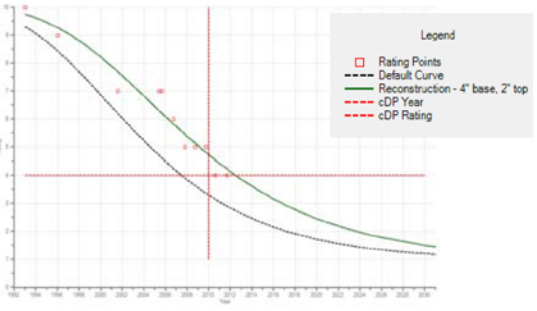
Pavement Modeling (project level)



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Observational Estimates (project level)

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Service Cycle (network)

- How big is the network?
- How much of the network do I do work on?
- How long will it take to "touch" the entire network?
- Is this longer than the expected life of my pavement?
- EXAMPLE
  - 500 lane mile road network
  - Do 10 lane miles of work each year
  - Takes 500/10 = 50 years to touch all of the network
  - Asphalt pavement only last 15 years

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Service Cycle (unpaved)

- High volume roads with "good" gravel need grading every month
- High volume roads with "poor" gravel need grading 3 times /month
- 1 grader can address 5 miles of road per day.

Question: How many graders operating would be needed to maintain this network on a monthly basis:

- 200 miles of "good" gravel
- 100 miles of "poor" gravel

200 miles X 1/month + 100 X 3/month = 500 miles grading per month

500 miles/ month / (5 miles/day X 20 work days/month) = 5 graders

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NCPP Network Condition Health
MI Example — 625 Lane Mile Network

Programmed Activity	Fix Cost per Lane Mile	ESL Years	# of Lane Miles of Fix	Lane Mile Years	Total Cost
Crack Seal	$4,800	1	6	6	$28,800
Non Struc Ovl	$32,000	2	7	14	$224,000
Mill & Overlay	$68,000	8	5	40	$340,000
Rehabilitation	$170,000	14	6	84	$1,020,000
Reconstruction	$530,000	15	4	60	$2,120,000
				204	$3,732,800

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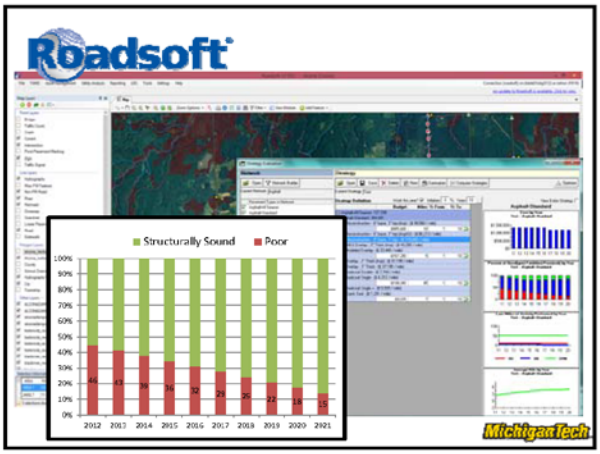

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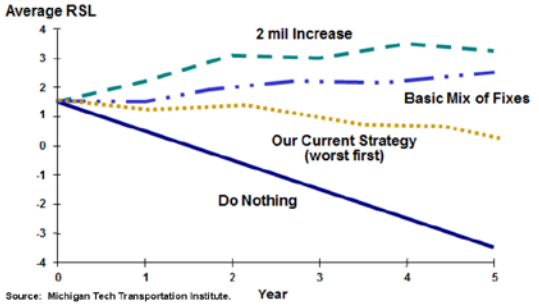
Future Condition –
Critical to telling your story



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4. Application Project Selection Policy

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Key Pavement Management Definitions

- CDP - Critical Distress Point
  - The CDP is the point where the pavement distress changes from needing preventive maintenance to needing structural improvement.
- RSL - Remaining Service Life
  - RSL is the time in years from the present where the pavement reaches the point where distresses are structural in nature (CDP) and preventive maintenance treatments are no longer beneficial.
- ESL – Extended Service Life
  - ESL is the time in years added to the current RSL based on the type of fix used. It does not represent the longevity of the treatment

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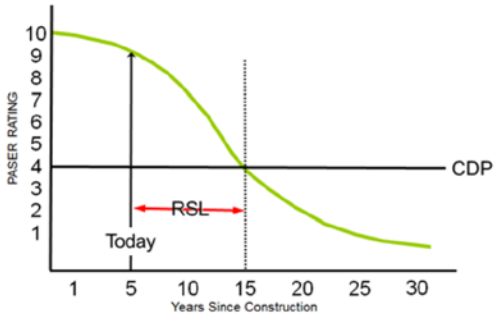
Pavement Terms: RSL & CDP



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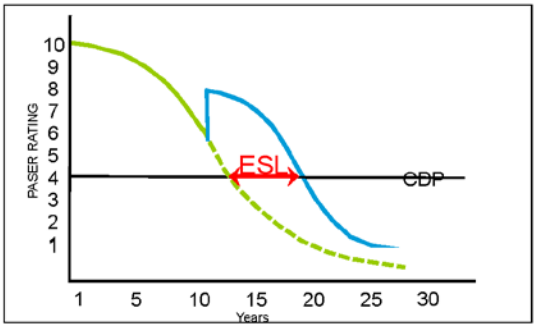
Extended Service Life



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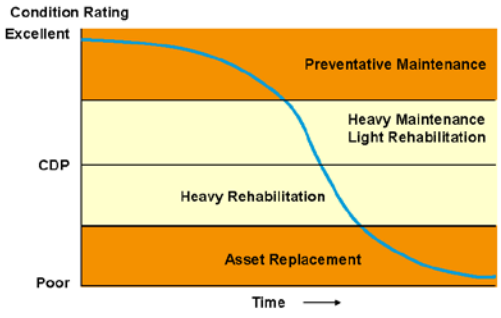
Window of Opportunity



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Approaches To Managing Assets

Worst First

- Select worst roads
- Little or no preventive maintenance
- Reconstruct
- Rehabilitation

Mix of Fixes

- Select roads in good shape for PM projects
- Many miles of Low cost treatments
- Reconstruction if money permits

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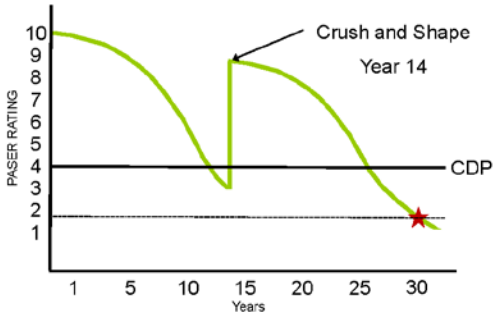
Rehabilitation at 14 Years
Cost $150,000



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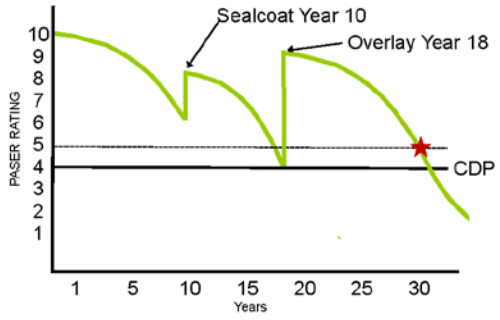
Sealcoat at 10, Overlay at 18
Cost $120,000



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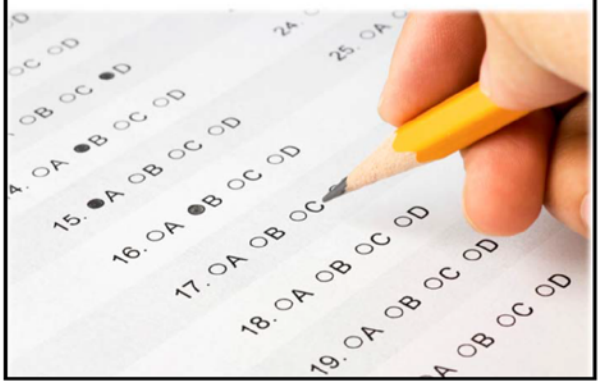
User Feedback



Differential Maintenance Assessment

Outline benefits of treatment vs no treatment:

- Grading vs. stabilization?
- Grading vs. adding new gravel?
- Grading vs. paving or BST?

Maintenance of Paved & Unpaved Roads in Alachua County

Surface Treatment Life-Cycle Cost Analysis

Surface Treatment	Vehicular Capacity (ADT)	Life Expectancy	Initial Construction Cost (per mile)	Routine Maintenance Cost (per mile)	Routine Maintenance Frequency	Life-Cycle Annual Cost (per mile)
Limerock Only	500	N/A	N/A	$75	2-4 weeks	$1,950
Dust Control	750	2 months	N/A	$5000	2 months	$30,000
Sand Seal	1000	5 to 10 years	$20,010	$300	2 years	$2,806
Chip Seal	2500	10 to 15 years	$53,140	$300	1 years	$4,256
Open-graded Cold Pave	3000	20 years	$92,390	$300	10 years	$6,201
Hot mix Asphalt	10000	20 years	$81,990	$300	10 years	$4,886

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Determining Gravel Strategy

Table 4-1. Maintenance alternatives

Distress	*Severity code*	*cost code*	*Description*
01-Improper cross section	L	B	Grade only.
	M	B/C	Grade only/grade and add material (water or aggregate or both), and compact. Bank curve. Adjust transitions.
	H	C	Cut to base, add aggregate, shape, water, and compact.
02-Improper roadside drainage	L	B	Clear ditches every 1-5 years.
	M	A	Clean out culverts.
		B	Reshape, construct, compact or flare out ditch.
	H	C	Install underdrain, larger culvert, ditch clean, rip rap, or geotextiles.
03-Corrugations	L	B	Grade only.
	M	B/C	Grade only/grade and add material (water or aggregate or both), and compact.
	H	C	Cut to base, add aggregate, shape, water, and compact.
04-Dust stabilization	L	C	Add water.
	M	C	Add stabilizer.
	H	C	Increase stabilizer use. Cut to base, add stabilizer, water, and compact. Cut to base, add aggregate and stabilizer, shape, water, add compact.
05-Potholes	L	B	Grade only.
	M	B/C	Grade only/grade and add material (water, aggregate, or 30/50 mix of calcium chloride and crushed gravel), and compact.
	H	C	Cut to base, add aggregate, shape, water, and compact.
06-Ruts	L	B	Grade only.
	M	B/C	Grade only/grade, add material, and compact.
	H	C	Cut to base, add aggregate, shape, water, and compact.

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5. Construction

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Construction Data

- Who, what, when, where, how?
- Useful in analyzing network strategy
- Needed for determining cost effectiveness of treatments
- Don't need all info in a management system
- Can be used along with condition data to guide project selection

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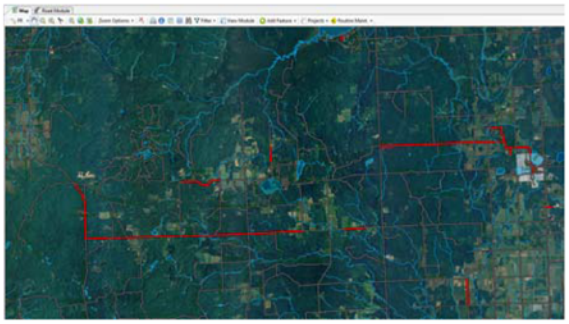
Applying Network Strategy to Guide Project Selection



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6. Reporting Results

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Why Report?

- Engages stakeholders and decision makers by providing actionable data.
- Show transparency and provide accountability.
- Show progress toward goals or policies
- Some reporting is required by State / Federal agencies

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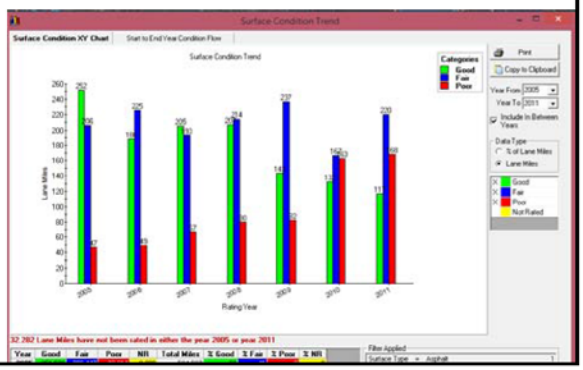
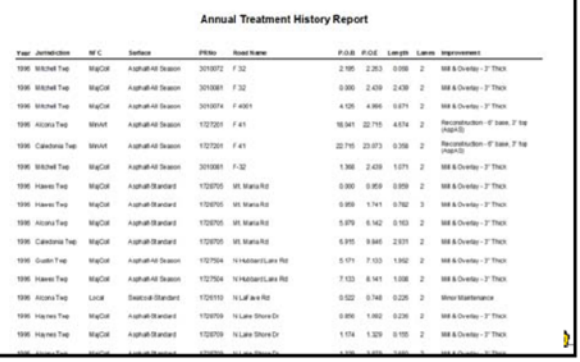
Reporting Local Trends

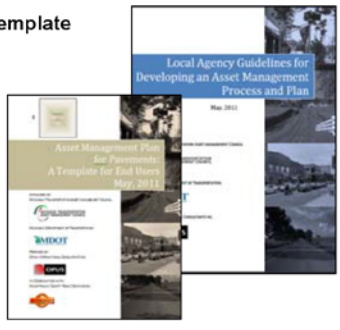


Reporting Work History



Asset Management Plan

Asset Management Template



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Points to Walk Away With

- Asset management is for all types of agencies
- Asset management = Accountability – both ways
- The process promotes Transparency in decision making
- Provides documentation to justify budget increase proposals or confirm level of service
- Performance Management is coming whether you are ready or not!
- Asset management can & should be part of unpaved roads management strategies, in addition to paved roads

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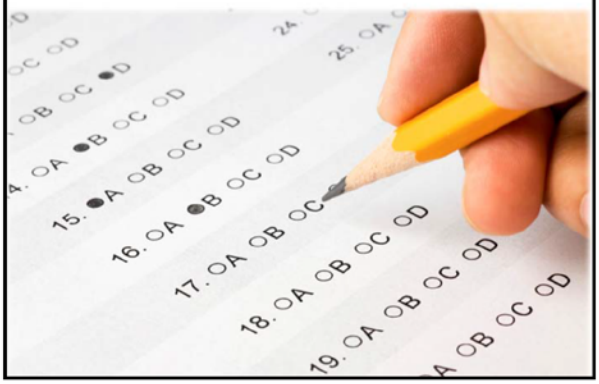
User Feedback



Questions?

Tim Colling – tkcollin@mtu.edu
Colin Brooks – cnbrooks@mtu.edu

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Appendix B: Marketing Flyer

Figure B-1: Flyer advertising the Introduction to Transportation Asset Management webinar.

Appendix C: Webinar Poll Questions and Results

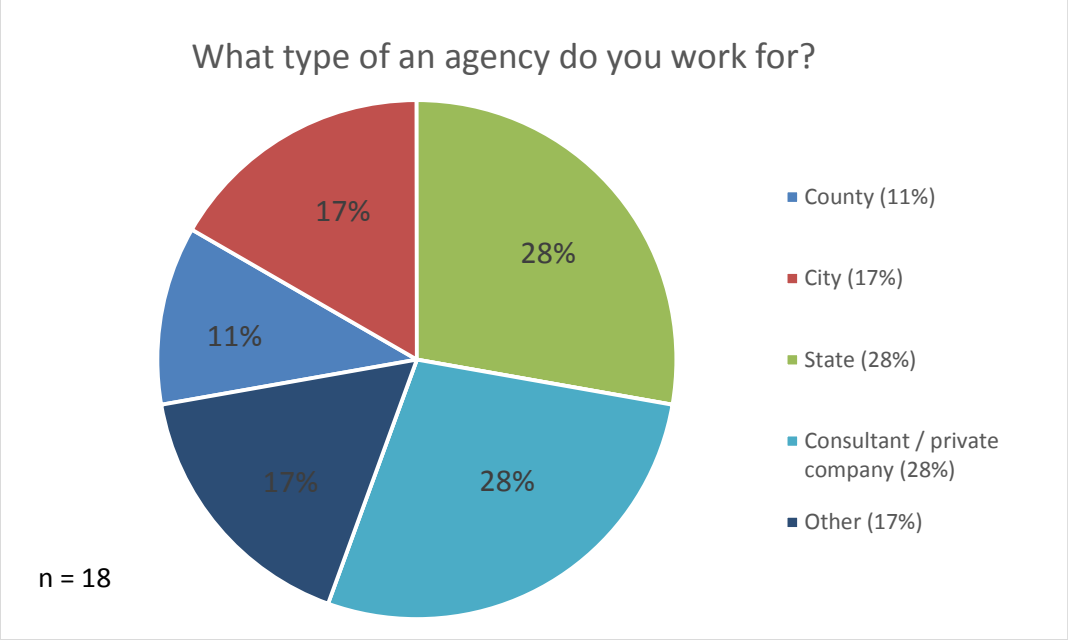

Figure C-1: Results of webinar poll question regarding agency type.

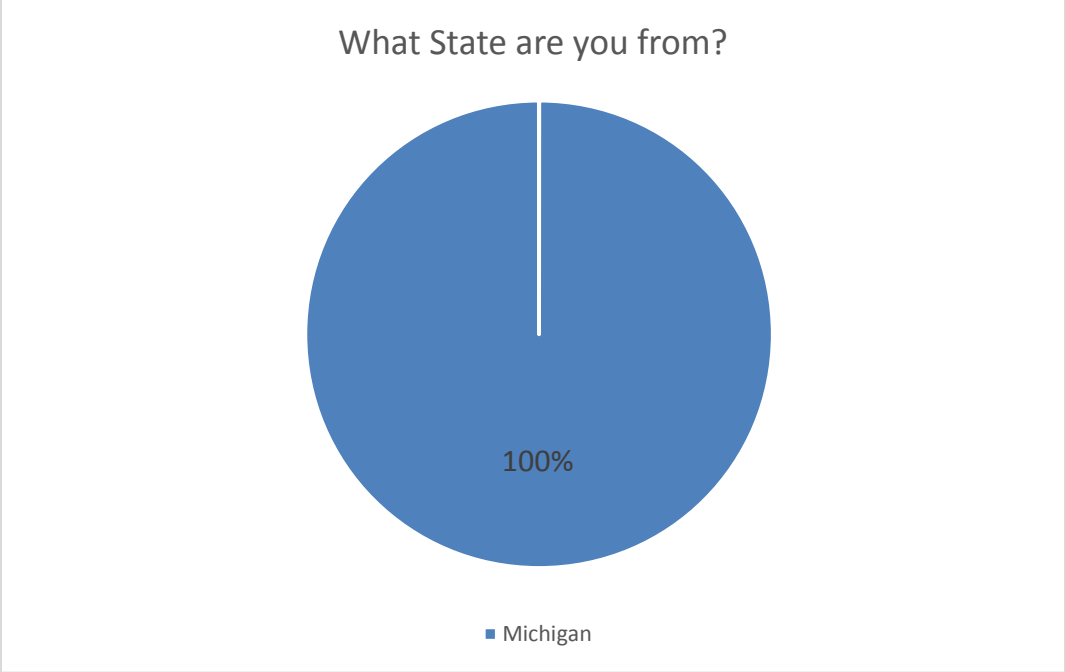

Figure C-2: Results of webinar poll question regarding state of origin.

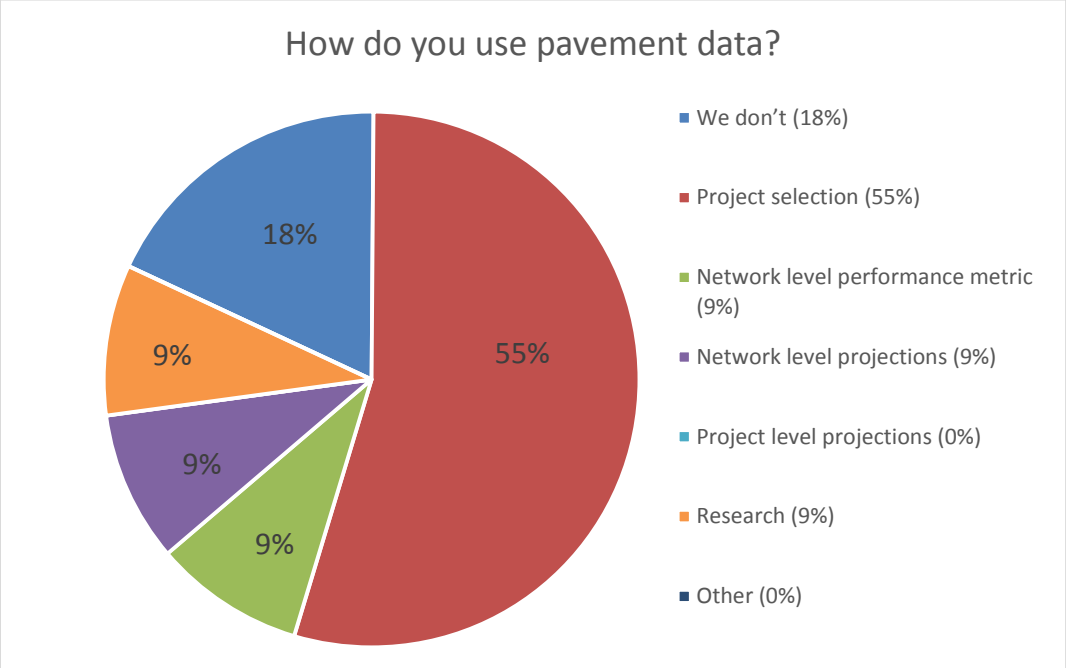

Figure C-3: Results of webinar poll question regarding use of pavement data.

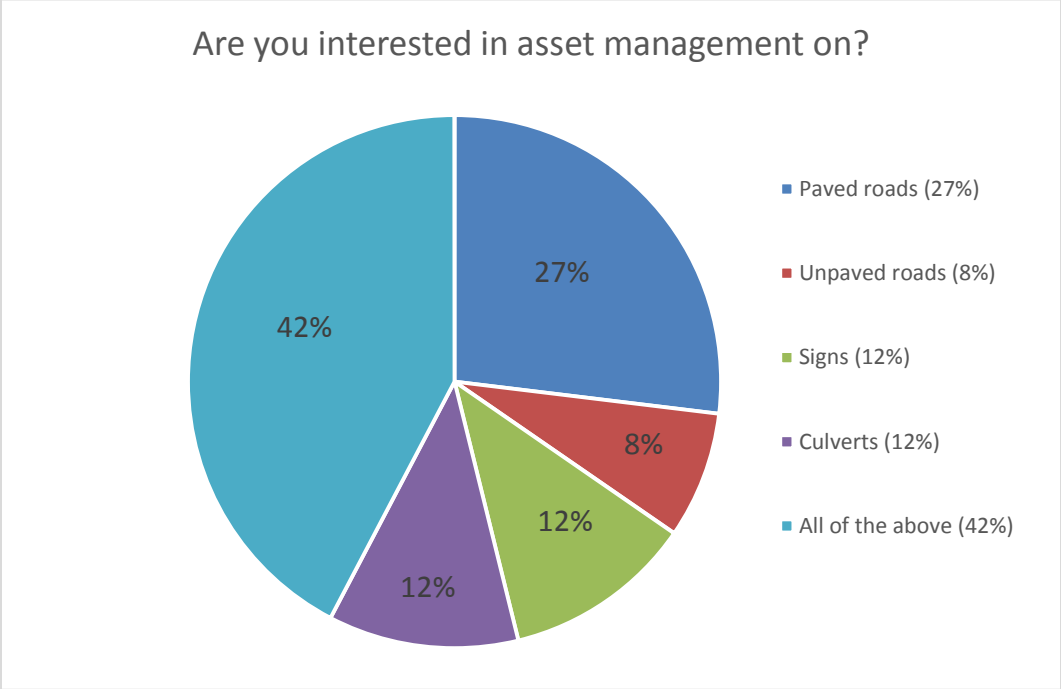

Figure C-4: Results of webinar poll question regarding type of interest in asset management.

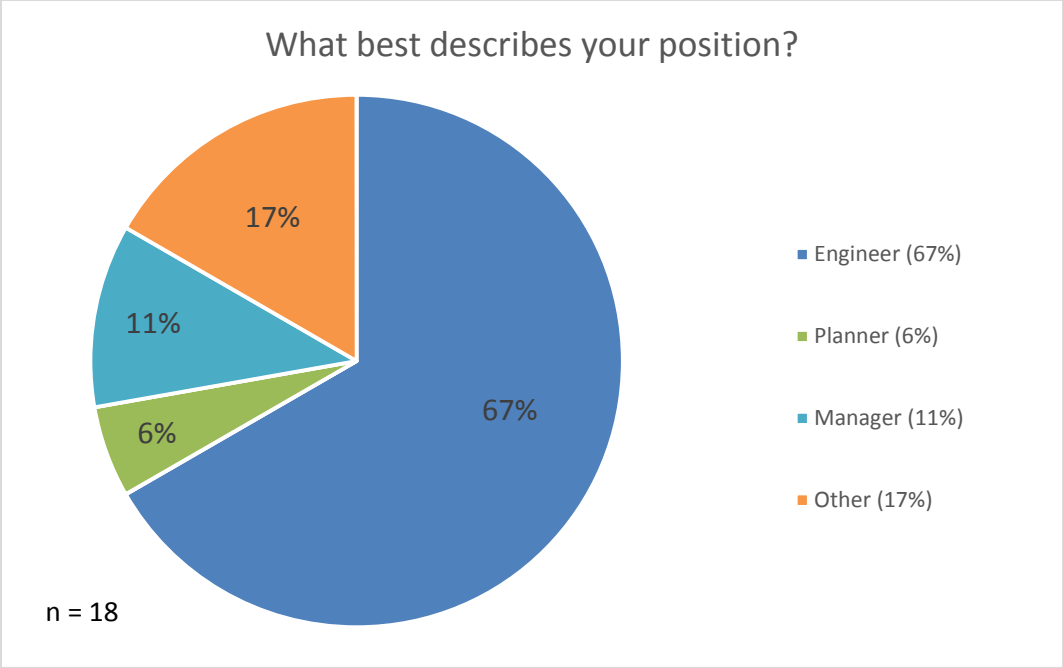

Figure C-5: Results of webinar poll question regarding participants' job type.

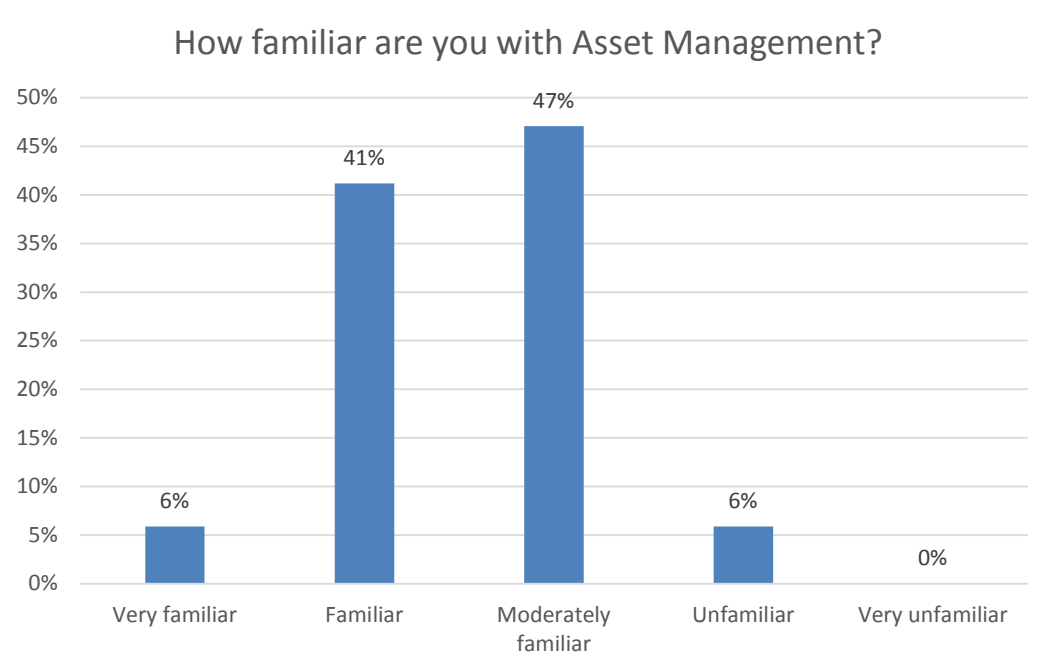

Figure C-6: Results of webinar poll question regarding familiarity with asset management.

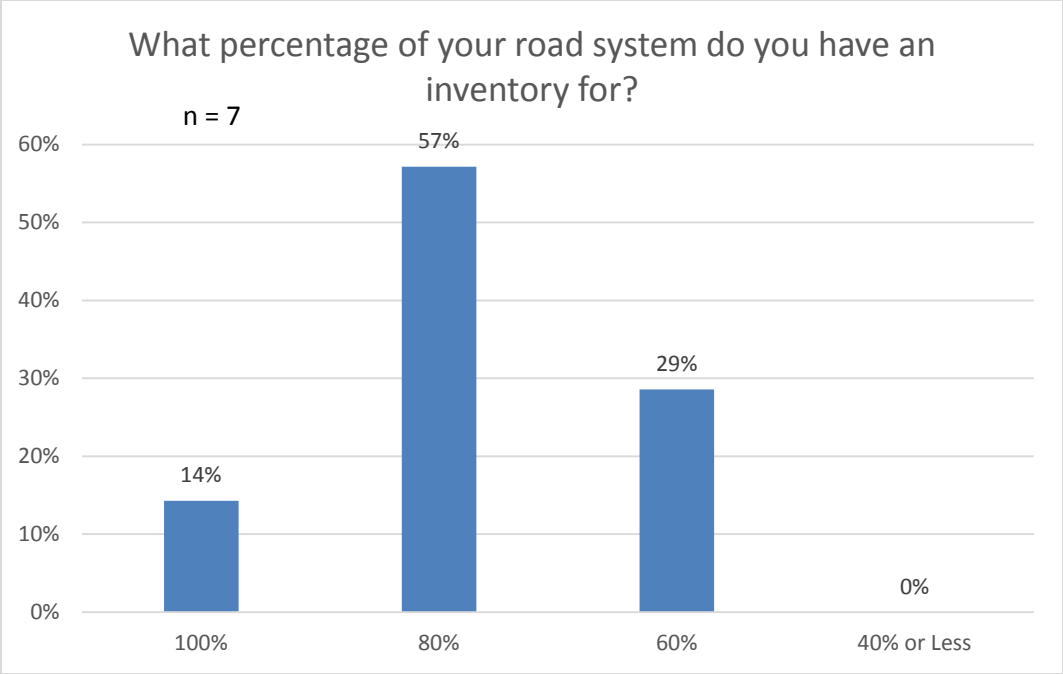

Figure C-7: Results of webinar poll question regarding percentage of inventoried road system for participants' agencies.

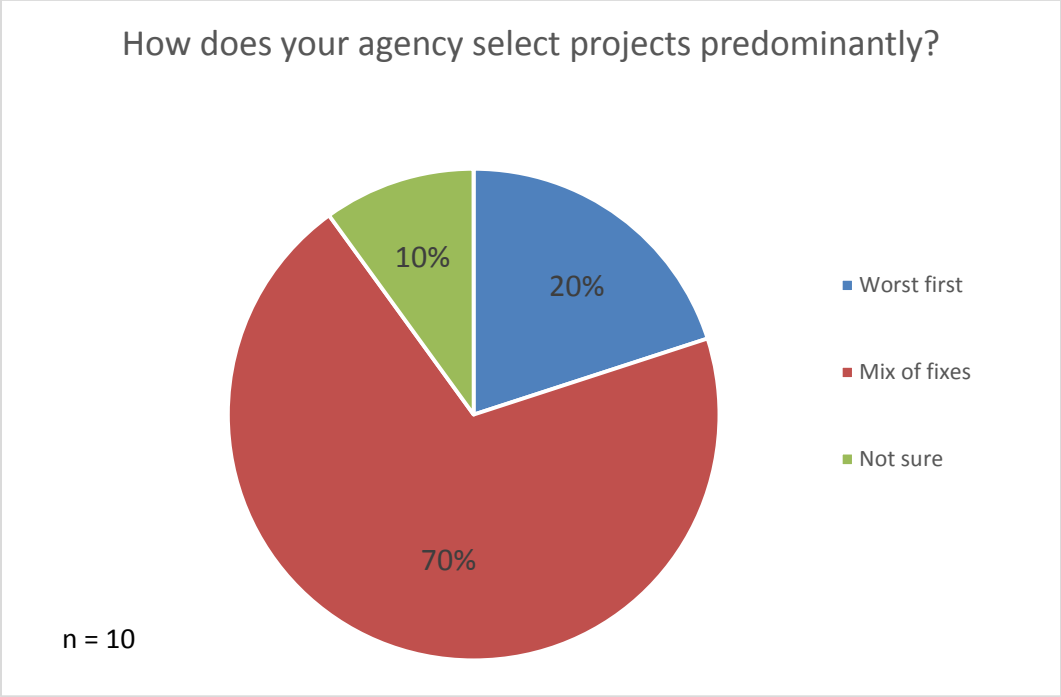

Figure C-8: Results of webinar poll question regarding method of selection for maintenance/rehabilitation projects.

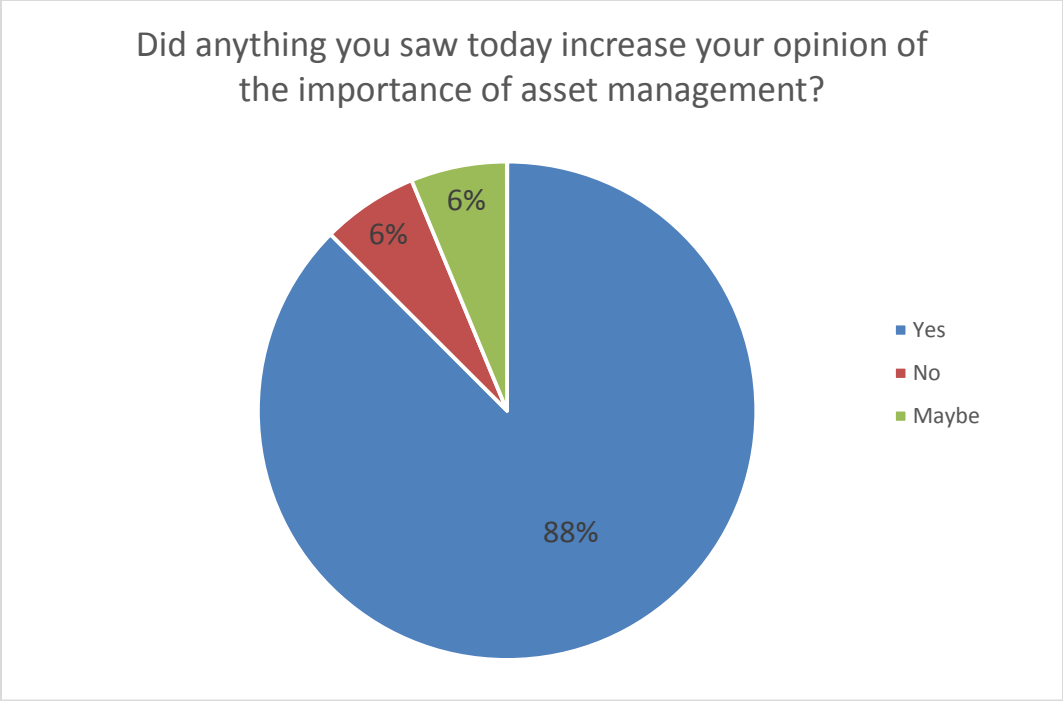

Figure C-9: Results of webinar poll question regarding participants' change in perception regarding asset management.