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Local Pavement Management Systems

FINAL REPORT

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Submitted by

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16. Abstract This research identifies a path toward the advancement and standardization of the management of subregional (primarily county) pavement investments in New Jersey. The research is comprised of three primary elements: 1) research on the state of the practice in local pavement management (literature review), 2) direct outreach to subregional pavement managers to better understand current practices and needs, and 3) formulation of a framework for subregional pavement management in New Jersey and a corresponding pathway for implementation.		
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EXECUTIVE SUMMARY

The objective of this research is to identify a path toward the advancement and standardization of the management of local pavement investments in New Jersey. Accordingly, this research program was comprised of three primary elements: 1) research of the state of the practice in local pavement management (literature review), 2) direct outreach to subregional pavement managers to better understand current practices and needs, and 3) formulation of a framework for county level pavement management in New Jersey and a corresponding pathway for implementation. This research is consistent with NJDOT's asset management approach to investment decision-making and in line with recent national emphasis on performance management.

To support these objectives, the research team conducted the following activities:

- Reviewed best practices in local/subregional pavement management from Michigan, Wisconsin, Utah, and California and identified a set of critical pavement management elements for inclusion in a framework for NJ, with focus on data collection and rating, development and implementation of a system investment plan, and ongoing monitoring and reporting. The research team also developed estimates of the cost to collect pavement condition data on the county system and identified a core set of pavement distresses that should be addressed in a pavement management effort in order to further support formulation of the framework.

- A survey of and subsequent workshops with New Jersey subregions revealed that few county or municipal agencies are collecting data and rating the condition of their pavements, and that most agencies pursue a 'worst first' approach (wherein the worst assets are always prioritized for investment), typically treating pavements on a rolling cycle. The workshops revealed a strong interest from county and municipal engineers and planners in gaining experience with alternative treatment options (such as microsurfacing) that may allow them to more cost effectively maintain and improve the condition of their road networks.

- The research team identified suggested next steps and a potential 10-year implementation pathway to help advance the state of the practice in pavement management at the subregional level in New Jersey in the short, medium, and long terms. The elements of this pathway, which are paired with recommended activities, include: 1) capacity building at the local level, 2) ramping up data collection on pavement condition at the local level, and 3) continuing the process of designing a local/subregional pavement management framework, working with both metropolitan planning organization (MPO) and subregional partners.

INTRODUCTION

In 1989, the Federal Highway Administration (FHWA) mandated state highway agencies to implement systems to efficiently manage their pavements. The requirement was reinforced in 1991 with the authorization of the Intermodal Surface Transportation Equity Act (ISTEA). ISTEA mandated six management systems, one of which pertained to pavement systems as a condition of Federal funding at both the state and local levels. Although the National Highway System Act shortly rescinded the ISTEA mandate, a number of states and local agencies, including the New Jersey Department of Transportation (NJDOT), continued to develop and use systems to manage their pavements.

In New Jersey, although control of roadways is distributed among state, county, and local entities (in addition to special cases like the Turnpike Authority), roadway users just need the system to function safety and effectively, and are likely to have little regard for which agency is responsible for a given roadway segment. With this in mind, NJDOT Local Aid, which interfaces with county and local entities to fund roadway resurfacing and reconstruction projects, among other duties, commissioned this research to help identify a path toward the advancement and standardization of subregional pavement management in New Jersey. The long term goal is to achieve more consistency in the condition and performance of pavements across the State, and to help subregional entities stretch limited funding by promoting strategic investment decision-making for pavements and other roadway assets.

The research was comprised of the following broad work steps, which are presented in detail in the body and appendices of this report.

- **Literature review.** This step consisted of a literature review of state-sponsored local pavement management programs and tools, and a review of pavement distress measures.

- **Local pavement management practices and needs in New Jersey.** This step incorporated a survey of 18 of 21 New Jersey counties, conducted with the assistance of the applicable MPO. Subsequently, local pavement management workshops (to which every NJ county was invited) were convened in order to develop a more robust understanding of their current practices, needs, and challenges, and goals.

- **Develop recommendations for advancing local pavement management in New Jersey**. This step involved the development of several iterations of hypothetical frameworks for discussion within a Working Group, comprised of NJDOT staff and representatives from each of New Jersey's three MPOs. The framework was also used to engage county pavement management staff at the workshops. Findings from the workshops were tempered with results from all prior research activities to develop high level recommendations for the phased implementation of a local pavement management program in New Jersey over the short-, medium-, and long-terms.

LITERATURE REVIEW

This research effort is rooted in a literature review of the local/subregional pavement management programs of four state departments of transportation (DOT): California, Michigan, Utah, and Wisconsin. Information culled from these agencies supported the New Jersey research effort by providing a range of existing (already implemented) program options and opportunities for structuring local pavement programs at a state or regional level.

The selection of agencies was informed by knowledge of the national state-of-the-practice accumulated through previous research. Because California statutorily delegates local pavement management responsibility to the MPOs, in this instance the Metropolitan Transportation Commission (MTC), MPO for the nine-county San Francisco Bay Area, was reviewed.

Peer Review

Each agency's publicly available local pavement management materials were reviewed and distilled. MTC's local pavement program manager was interviewed to supplement and clarify the information collected during document review. Particular emphasis was placed on program facets that, together, succinctly convey each program's basic formulation and help facilitate useful comparisons among programs. The program facets are:

- **Participation:** Is participation in the program mandatory, incentivized (tied to funding) or voluntary? Are certain elements mandatory while others are voluntary?

- **Collection/Rating Responsibility:** Which entity is responsible for collecting and/or rating pavement information? Is this responsibility vested at the local, regional, or state levels?

- **Distress Metrics/Targets:** How is pavement distress measured? Is there a specific target or targets for pavement performance?

- **Roadway Coverage:** Which roadways are covered within the program? Is coverage determined by ownership, functional classification, etc.?

- **Frequency:** How often/at what frequency are major updates required or advised?

- **Decision Support Software:** Does the state or program administrator offer a specific decision support software tool for pavement management? Is it custom to the state or region, or widely distributed by a vendor? Is its use mandatory, incentivized, or advisory? What is the cost to users outside of the state/region, if applicable?

- **Plan Duration:** How many years in advance are local entities required or advised to plan for their pavement investments? What is the investment planning timeframe?

Table 1 summarizes these program facets for each state or region reviewed.

Table 1. Comparison of state level local pavement management programs

	MTC (California)	Michigan	Utah	Wisconsin
Participation	Mandatory	Mandatory	Advisory	Mandatory (collection only)
Collection/Rating Responsibility	MTC maintains stable of consultants for local use	Local (non state and Federal only)	Local (Optional)	Local
Distress Metrics/Targets	PCI/ PCI>75	PASER/ public consultation	Multiple/ None	PASER/ None
Roadway Coverage	All	All paved	Optional	All
Frequency	Every 2 yrs/ Every 5 yrs residential	50% of system/year	Any (not mandated)	Every 2 yrs
Decision Support Software	StreetSaver ($1,250)	RoadSoft (Free)	TAMS ($500)	None (WISLR for collection)
Plan Duration	Present + 3 years (4 yrs); 28 years for regional funding estimate	10-20 years, advisory	User preference	None

Summary descriptions of each program, as they were constituted in September, 2012, are provided below.

Metropolitan Transportation Commission (California)

Authority

Metropolitan Planning Organizations (MPOs) in California are required to certify that local jurisdictions have a pavement management system in order to receive Federal and State funding[1]. More specifically the State requires cities and counties to implement a PMS when seeking funding for projects through the State Transportation Improvement Program, the State's seven-year transportation construction and rehabilitation spending plan[2].

Pavement Management Program

The MTC, MPO for the nine-county San Francisco Bay Area, requires that each jurisdiction applying for State funds be certified as an "active pavement management system user." Certification is awarded when the adopted Pavement Management System (PMS) is capable of:

- Storing inventory data for all roads,
- Assessing pavement condition (PCI),
- Identifying all pavement sections that need rehabilitation or replacement,
- Calculating budget needs for rehabilitating or replacing deficient pavement sections.

And, the jurisdiction completes all the following:

- Every two years: Reviews and updates the inventory information for all roads;
- Every two years: Inspects pavement sections for arterial and collector routes;
- Every five years: Inspects pavement sections for residential routes;
- Calculates budget needs for rehabilitating or replacing deficient pavement sections for the current year and the next three years.

MTC documents the Bay Area's overall needs and shortfalls and uses the data to build support in the State Legislature for increased funding. MTC uses a roll up of all local data to estimate a pavement cost for the region over a 28 year period.

Software

MTC developed StreetSaver, a computer-assisted decision support system, which is specifically tailored to help cities and counties manage their roadway networks.

[1] Section 2108.1 of the Streets and Highway Code

[2] (http://www.mtc.ca.gov/services/pmp/)

Although agencies are not explicitly required to use StreetSaver, 100% of local jurisdictions currently use it.

Support and Training

MTC offers a stable of pre-qualified consultants to local jurisdictions and counties, solicited and funded through the MTC's Pavement Management Technical Assistance Program (P-TAP).

MTC provides a range of support services to address pavement management issues and questions as well as the use of StreetSaver. Their support services include: 1) periodic user meetings three times a year scheduled over a week period to provide the opportunity for users to learn about new technologies, share experiences about pavement management and other maintenance and rehabilitation issues, 2) technology seminars on topics outside the PMS software (e.g., quality control/assurance procedures), and 3) training workshops designed to address the needs of new users and to serve as a refresher training for existing users (e.g., PMS principles, budget analysis procedures, distress identification techniques).

Michigan

Authority

Michigan law requires State and local transportation agencies to use an asset management approach to managing their Federal Aid systems. The Transportation Asset Management Council (TAMC) was created by Public Act in 2002 to advise the State Transportation Commission on statewide asset management strategies and recommend procedures and analytical tools to implement such strategies on Michigan's highway system in a cost-effective, efficient manner. The Council is appointed by the Transportation Commission and reports directly to the legislature.

Pavement Management Program

Local road agencies must annually report the mileage and Pavement Surface Evaluation and Rating (PASER) for at least 50% of the paved roads under their jurisdiction[3] to TAMC, using a Geographic Information System (GIS) shapefile. MPOs are responsible for collection and initial quality control. TAMC is charged with compiling data from over 600 agencies and determining future distributions of ACT 51 transportation funds. TAMC establishes the standards for collecting and reporting pavement condition and provides the necessary tools and training to local transportation agencies.

[3] P.A. 499 2002, P.A. 199 2007. Michigan Department of Transportation (MDOT) is responsible for all Federal and state routes.

Software

RoadSoft pavement management software is used by over 250 local agencies in Michigan and is funded through the Michigan DOT. It is supported and distributed by Michigan Technological University's Center for Technology & Training. The software supports modules to cover non-pavement infrastructure assets and is provided free of charge to Michigan local agencies.

Support and Training

TAMC provides education and training sessions for local road agencies on asset management. The training structure consists of: 1) an introductory overview of asset management and pavement management, 2) an advanced class on pavement preservation, and 3) an advanced class on asset management. The training elements are coordinated through the Michigan LTAP, and the various metropolitan planning organizations and regional planning organizations throughout the State. LTAP also provides regular courses on the use of RoadSoft GIS.

Utah

Authority

Local/subregional pavement management is voluntary in Utah.

Pavement Management Program

The Utah Local Technical Assistance Program (LTAP) Center works with the Utah DOT to support local agencies with pavement management software and training. Utah LTAP provides and funds field data collection services for 100% of the public road network within city boundaries. The LTAP Center also provides field data collection services for assets including: pavements, signs, railroad crossings, sidewalks, and ADA ramps.

Software

Utah State University and Utah LTAP developed the GIS-based Transportation Asset Management Software (TAMS) to help local transportation agencies cost effectively preserve and improve their infrastructure assets. The software supports the integration of non-pavement asset modules and is provided at no charge to Utah local agencies.

Support and Training

Training workshops can be coordinated with the LTAP Center and out-of-state users are provided with web-based seminars.

Wisconsin

Authority

Wisconsin law[4] requires each municipality and county in the State to annually assess the physical condition of public roads under their jurisdiction and report the results to Wisconsin Department of Transportation (WisDOT). WisDOT is responsible for assessing the accuracy of information reported by municipalities and counties.

Pavement Management Program

Wisconsin's requirement covers only the collection of pavement condition data and not for the use of a pavement management system. All public roads in a local agency's network are required to be inspected, given a PASER rating, and reported to WisDOT.

Software

WisDOT, with the assistance of the University of Wisconsin Transportation Center (WI LTAP), developed a pavement management tool entitled "Wisconsin Information System for Local Roads (WISLR)." Local agencies are encouraged to submit PASER ratings directly into WISLR but are allowed to use a spreadsheet format and submit them by e-mail. Mapping and analytical tools to plan for maintenance, improvements, and perform budget analysis are also provided in WISLR. WISLR can be used to guide maintenance decisions and to meet State reporting requirements.

Support and Training

WisDOT and the Wisconsin Transportation Information Center (TIC) conduct WISLR training jointly. Over 70 trainings are held annually. Attendees are trained in how to analyze pavements, develop 5-year maintenance/improvement plans, and determine costs and consequences of different strategies.

Review of Pavement Distress Measures

In order to support the formulation of potential pavement information collection guidelines, the research team conducted a brief survey of the types of distress measures incorporated into selected pavement condition rating systems. The following entities or condition assessment protocols were considered:

- **LTPP:** *Long-Term Pavement Performance* program, Turner-Fairbank Highway Research Center, FHWA[5].
- **HPMS:** *Highway Performance Monitoring System*, FHWA[6].

[4] Statute 86.302(2)

[5] "Distress Identification Manual for the Long-Term Pavement Performance Program (4th Ed)," 2003.

[6] Highway Performance Monitoring System (HPMS) "Field Manual: Chapter 5," 2012.

- **PASER:** *Pavement Surface Evaluation and Rating* system, Transportation Information Center, University of Wisconsin-Madison[7].

- **EnterInfo:** *Enterprise Information Solutions*, based on a bid submitted to SJTPO for road asset management data collection in Salem County, NJ[8].

- **NJDOT:** *Pavement Management System*, New Jersey Department of Transportation[9].

- **Mercer:** *Transportation Asset Management Information System* (TAMIS), Mercer County, NJ[10,11].

- **MTC:** *StreetSaver*, Metropolitan Transportation Commission, CA[12].

The distress measures recommended and/or collected in each of these examples are summarized in Table 2, for asphalt or flexible pavements, and Table 3, for concrete or rigid pavements.[13] Distress measures recommended for consideration are in ***bold italics***, while distresses that may be considered for more complex management systems are listed in *italics*. Although distress terminologies are not fully standardized, leading to probable overlaps and redundancies, like distresses have been consolidated and categorized.

Note that PASER is a composite visual condition rating system, meaning that a given segment of pavement is not rated for individual distresses, but for overall condition (i.e., a segment is rated from 1-10, with 1 meaning "failed" and 10 meaning "excellent"). However, PASER raters are taught to make condition judgments by identifying common distresses and assessing their severity[14]. PASER, as a composite condition rating, may substitute or supplement either set of distresses.

Asphalt Pavements

For **asphalt** pavements, common distress measures include:[15]

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[7] "PASER Concrete Roads/Asphalt Roads Manual," Wisconsin Transportation Information Center, 2002.

[8] "FY2011 Asset Management Collection, Salem County, New Jersey," obtained from SJTPO.

[9] "New Jersey DOT Pavement Management System," Philip Bertucci, 9/24 and 9/26, 2012.

[10] Mercer has few concrete pavements and does not collect distresses on them.

[11] "Mercer County Pavement Management Program," presented by Janel A. Bisacquino and Matthew Lawson, 9/26/2012 (follow up communication, 2/12/2013).

[12] "Pavement Condition Index Distress Identification Manual," MTC, 1991.

[13] Note that there appears to be limited use of concrete pavement at the county level in New Jersey, making concrete distress identification less critical for an initial pavement program.

[14] PASER Manuals are available for free online:
- Asphalt: http://epdfiles.engr.wisc.edu/pdf_web_files/tic/manuals/Asphalt-PASER_02.pdf
- Concrete: http://epdfiles.engr.wisc.edu/pdf_web_files/tic/manuals/Concrete-PASER_02.pdf

[15] Definitions are paraphrased from the relevant PASER Manual.

- **Rutting/Depression/Settlement:** Surface deformations characterized by displacement of material, creating channels in wheel paths or depressions elsewhere on the roadway.

- **Patching/Utility Cuts/Potholes:** Asphalt patches replace defective pavements or are used to repair utility work or other excavation. Patching in poor condition is indicative of other roadway distresses.

- **Cracking:** There are multiple cracking distresses.

    - **Alligator/Fatigue/Multiple:** Alligator cracking is comprised of closely interconnected cracks. If untended, alligator cracks can deteriorate into potholes. These types of cracking may result from traffic loading (fatigue) or deficient support.

    - **Longitudinal:** Longitudinal cracks run roughly parallel to the roadway centerline, and may lead to multiple cracking, raveling, or potholes.

    - **Transverse:** Transverse cracks run roughly perpendicular to the roadway centerline, often occurring at regular intervals, sometimes extending across the entire roadway. Crack edges are vulnerable to multiple cracking and raveling (asphalt erosion).

Concrete Pavements

There were fewer points of commonality among distress measures for **concrete** pavements, part of which may be attributed to overlaps in terminology ("joint deterioration" and "joint spalling," for example). Therefore, distresses are mixed between the category of distress (such as "joints" or "cracking") and specific distress measures, such as "faulting." They are:

- **Joint Deterioration:** Concrete panels result in longitudinal joints (traveling with the centerline) and transverse joints (running at a right angle to the centerline). Joints may be subject to cracking, spalling (loss of material along the joint edges), and other types of deterioration.

- **Faulting:** Faulting describes a vertical differential, or step, between concrete slabs. As faulting grows more severe, slabs become more prone to deterioration, and ride quality suffers.

- **Patching/Utility Cuts/Potholes:** As with asphalt pavements, when defects or utility cuts are repaired with patches, the patch material may perform differently from the original pavement, potentially leading to deterioration, settlement, and/or potholes.

- **Cracking:** Concrete cracking of concern includes transverse, deterioration (or D-cracks, from poor quality aggregate), corner cracks (at the corners of slabs), and so-called "meander" cracks (which wind seemingly randomly). All of these cracks

indicate some level of slab failure, and cracks often lead to other types of deterioration (such as spalling). Map cracking, or crazing, indicated by fine, shallow, closely spaced cracking, is NOT typically a recommended distress.

Table 2. Asphalt (flexible) pavement distress survey

Asphalt		LTPP	HPMS	PASER	EnterInfo	NJDOT	Mercer	MTC
Ride quality/roughness		n/a	IRI	n/a	No	IRI	Subjective (1-5)	n/a
Rating system		n/a	n/a	PASER	PCI	SDI	PCI	PCI
Surface Defects	*Raveling/Weathering*	X		X	X		X	X
	Polishing	X		X	X			
	Bleeding/flushing (binder)	X		X	X			
Surface Deformations	**Rutting/Depression/ Settlement**	X	X	X	X	X	X	X
	Bumps/Sag				X			
	Corrugation				X			
	Shoving/Rippling/ Distortion	X		X	X			
	Shoulder drop	X			X	X		
	Shoulder deterioration					X		
Patches and Potholes	**Patching/Utility Cuts**	X		X	X	X	X	X
	Potholes	X		X	X			
Cracking	**Alligator/Fatigue/ Multiple**	X	X	X	X	X	X	X
	Block	X		X	X		X	X
	Edge	X			X			
	Joint reflection/ reflective	X	X	X	X			
	Longitudinal	X		X	X	X	X	X
	Transverse	X	X	X	X	X	X	X
	Slippage			X	X			
	Wheel path				X	X		
Other	Drainage/Bleeding and pumping	X			X			

Table 3. Concrete (rigid) pavement distress survey

Concrete		LTPP	HPMS	PASER	EnterInfo	NJDOT	Mercer	MTC
Ride quality/roughness		n/a	IRI	n/a	No	IRI	n/a	n/a
Rating system		n/a	n/a	PASER	PCI	SDI	n/a	PCI
Surface Defects	*Polishing*	X		X	X		n/a	
	Scaling/Crazing/Map C racking	X		X	X			X
	Popouts	X		X	X			
	Punchouts	X			X			
	Shallow Reinforcing (pre-spall)			X				
	Spalling (slab, corner, non-joint)			X	X			X
Joints	*Joint Spalling*	X		X	X		n/a	X
	Long. Joint Deterioration			X		X		
	Trans. Joint Deterioration			X		X		
	Joint Seal Damage	X			X			
Surface Deformations	*Blow-ups*	X		X	X		n/a	
	Corner Breaks	X			X			X
	Divided/Shattered Slab				X			X
	Faulting	X	X	X	X	X		X
	Shoulder drop	X			X	X		
	Shoulder separation	X		X				
	Shoulder deterioration			X		X		
	Settling/heave			X				
	Manhole/Inlet cracks			X				
Patches and Potholes	**Patching/Utility Cuts/Potholes**	X		X	X	X	n/a	X

Concrete		LTPP	HPMS	PASER	EnterInfo	NJDOT	Mercer	MTC
Cracking	Alligator/Fatigue/ Multiple		X			X	n/a	
	Shrinkage				X			
	Durability (D-cracks)	X		X	X			
	Linear (Long., Trans., Diag.)	X		X	X			X
	Corner			X				
	Meander			X				
Other	Drainage/Bleeding and pumping	X			X		n/a	
	Railroad Crossing				X			

WORK PERFORMED

The objective of this research is to identify a path toward the advancement and standardization of the management of local/subregional pavement investments in New Jersey. Accordingly, the research program was comprised of three primary elements: 1) research on the state of the practice in local pavement management (literature review, presented in the previous section), 2) direct outreach to subregional pavement managers to better understand current practices and needs, and 3) formulation of a framework for county level pavement management in New Jersey and a corresponding pathway for implementation.

State of the practice in local pavement management

The research team examined a selection of existing local pavement management programs implemented at the state or regional levels across the country, including an overview of the software tools developed to support these programs. The research team also conducted a survey of pavement distress measures used or recommended by transportation agencies at all levels of government. These findings are summarized in the preceding Literature Review.

Local pavement management practices and needs in New Jersey

The research team conducted outreach designed to gain a better understanding of the current pavement (and asset) management practices of New Jersey's counties. A survey was performed to establish a baseline of understanding, and two half-day workshops were added to the work program to further engage local stakeholders and to obtain feedback on a hypothetical framework for local pavement management. The team was supported in these efforts by a Working Group including DOT staff and at least one representative from each of the New Jersey's three MPOs.

Survey

In April and May of 2012, New Jersey's three MPOs surveyed their respective jurisdictional counties, using a survey instrument developed by the research team. The goals of the survey were to determine:

- What resources counties have for managing pavements;
- How and to what degree counties collect and track pavement extent and condition;
- What systems counties currently have in place for managing pavements;
- What challenges counties face in managing pavements.

Eighteen of 21 counties responded with varying levels of information (all but Atlantic, Cumberland, and Salem). The primary respondents were Head (Chief or Director) and Assistant County Engineers, with one response each from a GIS specialist and Senior

Planner. The results reported were not independently verified and should be considered illustrative only.

Survey Questions and Responses

1. *Tell us about the county department responsible for pavement management.*
   - Responses were inconsistent, but responsibilities typically reside with the Department of Public Works, the County Engineer's Office, or the Road/Roadway Department.
   - Many counties had no dedicated, full-time pavement management staff.
2. *Tell us about the funding available for county pavement management efforts. How much do you spend annually on pavement?*
   - Of the 17 counties that reported their pavement budgets, the estimated budget per centerline mile was approximately $13,600 (estimated, when a budget range was reported, the average of the low/high figures was taken).
   - Trends were inconsistent, but a majority of respondents indicate that costs are either stable or trending up, while funding was flat or diminishing.
3. *How many miles of paved roadways is your county responsible for? What are the current condition levels of those roadways?*
   - Counties managed an average of 324 centerline miles of paved roadways, ranging from a maximum of 620 miles in Ocean County to 61 miles in Hudson County.
   - Of the 8 counties reporting tiered pavement condition, the average combined percentage of good and fair was 89%.
   - 2 counties reported pavement conditions of 100% good/fair.
   - 1 county reported its pavement condition as 60% good, but did not report other tiers.
4. *How frequently/on what schedule is pavement condition data collected? What percentage of your road network is inspected (does it differ by tier)?*
   - 4 counties collect condition data continuously or in conjunction with other activities (i.e., no formal collection schedule).
   - 4 counties collect condition data annually on 100% of their eligible roadways.
   - 2 counties collect condition data on a 10-15 year cycle.
   - 2 counties collect condition data on between 25% and 40% of their roadways annually.
   - 3 counties report collecting condition data annually, but do not provide further information.
5. *What methods are used to determine pavement condition?*
   - 56% of responding counties report using a visual pavement inspection method.
   - 28% of responding counties report using PCI and/or PCR.
   - 1 county reports using IRI currently.
6. *What attributes do you collect? Are they geocoded? What condition attributes are currently used?*

- Responses were inconsistent, but ranged from a robust list of pavement condition data and treatment information; to just pavement type, route number and milepost; to none at all.
- 22% of responding counties report geocoding their pavement data.

7. *If available, please provide an inventory table (in Microsoft Excel or Access format) with roadway condition attributes.*
   - No inventory tables were completed.
8. *Does your county currently use a pavement management system? If YES, which one and how long have you used it? If NO, why not?*
   - 22% of reporting counties use pavement management systems. 11% of counties had once used but since abandoned PMS software).
   - Of counties who did not use a PMS, most claim that time and expense are the biggest impediments to adoption.
9. *What is your asset management strategy? How well does your current pavement management system or method meet your county's objectives?*
   - 50% of responding counties reported using "Worst-First" as their sole investment strategy.
   - 61% of responding counties reported using "Worst-First" as part of their investment strategy.
   - 28% of responding counties reported incorporating the "Mix-of-Fixes" concept in their investment strategy (17% did not respond to this question).
10. *Does your system forecast the condition of your roadways based on potential treatment scenarios?*
    - 17% of responding counties reported that their systems could forecast condition.
11. *How do you pick projects? Please describe the process:*
    - 17% of responding counties reported using their PMS to pick projects.
    - 72% reported using "rules of thumb,"
    - 44% reporting using "local knowledge,"
    - 28% reported using "stakeholder involvement,"
    - 33% reported using "utility coordination," and
    - 17% reported using "lifecycle costing/benefit-cost analysis."
    - Most counties offered multiple responses.
12. *What challenges to effective pavement management has your county encountered?*
    - 56% of responding counties reported that availability of staffing resources is a challenge.
    - 28% of responding counties reported that adequate training is a challenge.
    - 44% of responding counties reported that pavement data collection costs are a challenge.
    - 6% of responding counties reported that lack of "belief in the need" for pavement management is a challenge.

Workshop Results

The key result of this research is a clear articulation of the pavement management needs and challenges prevalent among New Jersey counties, which are paired with recommendations to guide the development and implementation of a statewide, systematic approach to managing local pavements. To build on the survey and clarify the feedback that was submitted, two half-day workshops were held for county planners and engineers (one in northern NJ, to which all North Jersey Transportation Planning Authority (NJTPA) member subregions were invited, and one in southern NJ, to which all Delaware Valley Regional Planning Commission (DVRPC) and South Jersey Transportation Planning Organization (SJTPO) member subregions were invited). Although a variety of practices, experiences, and attitudes were registered in these workshops, several key themes common to all three MPO regions to varying extents emerged from these discussions and are described below. A complete description of the workshops can be found in Appendix C.

Pavement Condition Data are Needed

Among counties which participated in the workshops, few are regularly and systematically collecting data on pavement condition, a valuable clarification of the survey results. While there was not complete consensus on this point, most respondents agreed that better condition data is a necessary ingredient for developing more cost-effective treatment programs. Most counties, however, keep some record of treatments, which, with the addition of better condition data could be leveraged to determine the effectiveness of treatments.

Counties identified the major barriers to regular data collection as:

- **Scarcity of dedicated funding for collection.** Several counties expressed concern that data collection would siphon funding and staff resources from pavement treatments themselves. Some counties expressed an interest in pooled data collection (sharing resources among counties) as a potential means of lowering the incremental costs of collection.

- **Limited staff availability and capacity.** With existing staff often stretched across competing duties (including other roadway asset management and engineering tasks), some roadway engineering managers felt that data collection could not be effectively performed in-house without additional staff. Even with adequate staff availability, current county roadway staff may not have the training to reliably perform pavement ratings.

- **Lack of belief in need.** Although not a prevalent attitude, a few participants felt that their current practices (generally without a data collection component) were adequate and did not require supplementation.

Worst-First Remains Prevalent

Most participating counties currently employ a worst-first asset management strategy, targeting the most deficient or the oldest pavements for treatment. The predominant treatment, as a result, is milling and paving ("mill and fill"), which is costly and does not allow counties to make significant progress on improving the overall condition of their systems (this strategy often results in a 15+ year treatment cycle).

A few participants are currently introducing asset management principles into their treatment programs, or are interested in doing so in the future. However, overwhelmingly the participating counties did not see a strong need for, or were even resistant to, the adoption of a more strategic pavement investment approach.

Interest in Alternative Treatments is Substantial

The participating engineers displayed significant interest in learning about alternative treatments, such as microsurfacing and sealing, which could offer more cost-effective options than what the counties typically use, which is a standard mill and fill treatment. However, alternative treatments are likely to be regarded with caution until further research and/or field testing establishes their viability and proper use in this region.

Due to the limited availability of contractors and smaller purchasing power at the county level, some counties were interested in the possibility of accessing microsurfacing contractors through a cooperative purchasing agreement with NJDOT.

Counties Seek Opportunities for Information Sharing

County engineers sought guidance on or displayed curiosity about a wide range of issues related to the management of pavements, including triggers for ADA compliance, the use of capital vs. maintenance funds, and utility coordination, for example. Ongoing coordination and communication among New Jersey's counties as well as with NJDOT and the MPOs on this topic will be important to further advancing the efficient management of pavements on county roads in New Jersey.

Framework and Preliminary Implementation Pathway

A framework for local pavement management program development was formulated based on examples from the national literature review and enriched with NJDOT standards. The framework evolved through several iterations with the Working Group, and was employed to help structure discussion at the county workshops. Because one of the key findings of this research is that significant additional capacity building is needed, the framework presented necessarily remains in an incomplete state, with key questions noted. Finalizing and implementing this framework will require making several significant decisions on responsibilities for data collection, reporting, and other activities that depend on national and New Jersey specific policy initiatives.

The framework includes four primarily elements, detailed below:

Condition Data and Rating

Any strategic management approach requires a basic level of data and information to support decision-making.

Data collection and rating

The regular collection and assessment of pavement condition information is the foundation of the local pavement management framework. Data on pavement condition must be collected consistently in order to ensure that PMS programs are calibrated to actual conditions over time. At the local level, it is recommended that pavement condition collection include other assets such as guiderail and signs. The key questions that must be addressed in this area include:

- What roadway systems should be included? The initial discussion of this framework focused on arterials in the 500 Series of roads, though there was general recognition that this framework would likely be expanded over time to include additional roadway types.

- How frequently should condition data be collected? Typical timeframes for data collection range from annual to three or four years. Actual collection intervals will likely depend on the roads evaluated, with data collected more frequently on arterials and higher volume roads and less frequently on lower functional classifications or lower volume roads. Collection cycles may be coordinated with NJDOT pavement data collection.

- What agency or mechanism should be used to collect data? The working group and county workshop participants were interested in exploring efficiencies in data collection through joint contracts, use of creative funding mechanisms (for example, the Southern Jersey Transportation Planning Organization has used State Planning and Research (SPR), funds to support data collection and system development activities for several counties and municipalities in Southern Jersey). Both statewide data collection and pooled resources for data collection were discussed as options to consider.

- Which distress measures should be collected? This is a critical question and was raised as a significant concern at the workshops. While distress collection can be complicated, distress collection mechanisms can be simplified and made more cost-effective based on user needs (see Mercer County's TAMIS, for example).

Activities were conducted under this research effort to estimate the cost of typical pavement data collection efforts and to identify likely distresses for collection. Three sources of collection and rating costs were used to establish the range of potential cost estimates: NJDOT's estimated in-house "testing mile" costs, EnterInfo's image capture and rating costs (conducted on behalf of SJTPO for City of Vineland), and high and low vendor bids for collection and rating on the NJDOT system (cited by NJDOT). Table 4 presents high and low cost per mile for collecting condition data from each source. Table 5 summarizes the total expected data collection and rating costs for 500 and 600

series roads, as well as the entire county and municipal network and solely for principal arterials. Additional detail on quantifying the range of potential costs involved in expanding pavement condition collection and rating to the State's county-owned roadways is provided in Appendix A.

Table 4. Estimated testing mile costs

Source	Year	$/Testing Mile (rounded)	
		Low	High
NJDOT	2012	$44	$58
EnterInfo	2010	$208	
NJDOT bidder	2008	$67	$82

Table 5. Estimated pavement data collection and rating costs for county roads

County Series	Total Extent (Route Miles)	Low Cost	High Cost	Principal Arterials (Route Miles)	Low Cost	High Cost
500	4295.50	$164,433	$777,317	839.32	$32,124	$151,858
600	5641.44	$215,954	$1,020,875	384.83	$14,691	$69,447
500 & 600	8,645.16	$380,387	$1,798,192	1,063.97	$46,815	$221,305
TOTAL	13,300 (*est.*)	$585,200	$2,766,400	1167.10	$51,352	$242,757

Note: System extent is given in directional route miles, the metric NJDOT uses to capture pavement data.

To support efficient collection of distresses, the following recommendations were developed based on a review of existing data collection practices:

- Create condition equivalencies across rating systems: Several rating systems are currently in use. Some, like PCI (EnterInfo, Mercer, and MTC) and SDI (NJDOT) rely on an assessment of specific distresses, while others, such as PASER (Wisconsin DOT, Michigan DOT) consider the overall condition of a segment, without an explicit ranking and weighting of distresses. Rather than selecting a specific rating system it may be valuable to translate ratings (e.g., PCI, SDI, PASER) into "Good/Fair/Poor" equivalencies to permit flexibility in approach but promote standardization of results. An example equivalency table is provided below (Table 6). These equivalencies should reflect the type of treatments required (e.g.,

maintenance, resurfacing, reconstruction), rather than simply represent a composite level of pavement distress.

Table 6. Example condition equivalencies

Rating System	Condition Equivalency Examples		
	Good	Fair	Poor/Deficient
PASER	10-8	7-5	4-1
PCI[16]	100-70	69-50	49-0
SDI	3-5	<3-2	<2
IRI	0-94	95-169	170+
PSR	5-4	3-2	1-0

- Promote visual inspection: Although some distress types can be collected with highly sensitive instrumentation, the severity of distress can also be gauged visually without the same resource requirements (often on a "high, medium, low" scale).

- Collect based on decision-making needs: Any baseline standard of distresses recommended for collection must strike a balance between enabling robust decision-making and ensuring flexibility in the choice of pavement management software. Based on the review of NJDOT's distress metrics and other programs, potential distress measures were suggested (see Tables 2 and 3 in the Literature Review).

Data storage

Data should be comparable and compatible from subregion to subregion and should facilitate analysis by NJDOT and/or the MPOs. County and municipal governments, MPOs, and NJDOT each may have distinct purposes for the pavement data and ratings, ranging from basic reporting, project prioritization, and investment planning. Options for data storage include centralized and localized options, or a hybrid of localized storage with key items provided to one or more central repositories (i.e., NJDOT or one in each MPO), that allow for consistent review of the data and support for longer term investment planning.

Track treatments

Over time, a record of treatments helps establish the effectiveness of investment programs. Currently, most county agencies are tracking the treatments made on the pavements in their jurisdictions. Combining these data with condition data can be useful for understanding the consequences of past decisions, helping to ensure that future decisions consider the most economically efficient option. Key questions in this area include:

[16] These equivalencies are consolidated from MTC's 2011 "Pothole Report," which references the PCI condition tiers as: Very Good = 80-89; Good = 70-79; Fair = 60-69; At-Risk = 50-59; Poor = 25-49.

- What types of treatments should be recorded? Major pavement reconstruction and resurfacing activities should clearly be tracked. Tracking ongoing maintenance activities (e.g., pothole filling) may be a lower priority in the short term. Major treatments should be geocoded. For pavement segments of lower functional classifications (Local Access, for example), it may be sufficient to record the year of last treatment and/or average spending per year.

Develop a system investment plan

Investment planning involves linking condition data and performance measures to decision-making. It is a means to answer critical questions like: "How much should we be investing in pavement maintenance, resurfacing, and reconstruction to meet our performance goals efficiently?" The key steps of investment planning are described here.

Estimate unit costs

Formulation of a feasible pavement investment program is enabled by relatively accurate cost information for common categories of pavement maintenance, resurfacing, and reconstruction activities. As part of this research effort, typical treatment costs data were reviewed from the NJDOT SAGE grant management system. Data from 93 pavement treatment projects were reviewed for the years 2009-2011. Table 7 summarizes the average costs by type of project (resurfacing, reconstruction, and other). Additional detail on this review can be found in Appendix B.

A large majority of the 93 records sampled were classified as "Resurfacing" projects. Due to small samples and widely varying project scopes, "Reconstruction" and "Other" project costs and lane-mile average costs are not considering instructive for future costing. Although resurfacing projects also vary significantly in scope, the larger sample size and smaller range of costs may be more useful for lane-mile costing. Excluding counties with very small sample mileages (less than 15 miles), average lane-mile costs range from $197,417 (Essex) to $386,815 (Union).

Table 7. Summary results by record type

	Resurface	Reconstruct	Other	TOTAL
Records	74	12	7	93
Total Cost	$ 159,817,417	$ 78,028,195	$ 14,248,022	$ 252,093,634
Total Miles	495.02	30.10	3.31	528.43
Weighted Avg. Lane-Mile Cost	$ 322,854	$ 2,592,299	$ 4,304,538	$ 477,066

To support investment planning, additional work may be required to develop reasonable, locally specific average costs for major treatments. These cost items may then help inform an investment plan and provide inputs for potential analysis tools.

Develop Funding Scenarios

Investment planning typically considers the implications of varying investment in a given program area. The New Jersey Capital Investment Strategies (CIS) process considers various funding scenarios to help determine where additional investment is needed. These scenarios are typically formulated as a percentage increase or decrease from current funding or relative to system needs (e.g., eliminate a backlog of needs).

In the short term, it may not be necessary to consider varying funding, but instead focus on the strategies that may help county and municipal agencies in New Jersey get the most out of a fixed amount of funding.

Develop a system investment plan

Critical to developing a robust system investment plan is sufficient consideration of the strategies that can help an agency meet its goals. Building on the information identified in the recent Federal transportation authorization – Moving Ahead for Progress in the 21st Century (MAP-21) – the key elements for an investment plan may include:

- Inventory and condition of the asset (i.e., current conditions);
- Asset management objectives and measures (i.e., what the agency hopes to achieve, potentially in the form of a target);
- Performance gap identification (i.e., how close the agency is to the target);
- Lifecycle cost and risk management analysis (i.e., the expected cost to maintain the asset in its current condition and the risks that may prevent an agency from achieving objectives);
- A financial plan (i.e., how the investments will be paid for); and
- Investment strategies (i.e., the specific mix of fixes that will help an agency achieve its goals).

Each of the local pavement management efforts identified in the literature review provides a customized analysis tool (also called a Pavement Management System or PMS) to help guide decision making. Common elements of these tools include:

- Condition ratings for each pavement segment, as well as essential attributes (such as volumes);
- The ability to select from a general list of treatments for each segment;
- Unit costs for each general treatment, with the ability to assign estimated costs for treatments selected for each segment;
- Rules of thumb (adapted over time based on agency-specific observations) that identify the expected future segment conditions based on selected treatments;

- The ability to calculate the collective impact of the program of treatments on condition targets and determine total program costs;

- The ability to develop work plans using decision-trees; and

- The ability to predict pavement condition by roadway type/category.

There are also key questions pertaining to the roll out and use of pavement management tools at the subregional level, including:

- Should there be a mandate to use a specific tool or a tool that meets a set of minimum standards?

- Should NJDOT invest in development of such a tool, potentially minimizing the cost to individual agencies by providing a standardized solution?

Establish decision-making targets

Part of the process of developing an investment plan is the creation of performance targets for decision-making, which indicate the types of expected or desired outcomes. A robust framework will establish an iterative relationship between target setting and investment planning. Targets are set to help guide investments, but funding constraints necessarily limit the targets that can be achieved and constrain the strategies available for implementation.

Initially, it may be appropriate to set targets as the outcome of the investment planning process, indicating what an agency believes it may be able to achieve given available resources. Over time, and as an agency reviews targets for other programs, other target setting options should be considered. Potential options for consideration include:

- Minimizing threats to safety and/or mobility;

- Maintaining the percentage of pavement already in acceptable condition (e.g., overall percentage of pavements in fair or better condition);

- Increasing the percentage of pavement already in acceptable condition over time to meet a system performance goal (e.g., 80% or more of lane miles shall be in good or fair condition); and

- Varying decision-making targets by roadway type (e.g., functional classification or roadway series) to prioritize investments.

System investment plan implementation

An investment plan should provide guidance on the specific mix of investment types to be made on the system over a fixed timeframe, typically 5 to 10 years. The plan may also consider multiple scenarios that address changes to funding or risk factors that may impact the achievement of plan goals and targets. Implementation of the

investment plan refers to the ongoing process of executing prescribed activities and tracking performance in relation to the expectations established in the plan, and making adjustments accordingly.

Reporting

Reporting is one of the foundational components of this framework. Reporting on pavement performance over time can help to ensure that investments have been consistent with program goals and reflective of best practices in pavement management. MAP-21 will begin requiring regular reporting by state DOTs and MPOs on a variety of performance measures, including infrastructure condition (pavements and bridges).

At the local/subregional level, establishing a pavement performance reporting program will enhance understanding of how the system is performing over time. A simple initial pavement conditions reporting program can be expanded over time to track treatments, expenditures, and the effectiveness of the investment program. Reporting activities should be correlated with the data collection, decision-making, and implementation activities described in the other components of this framework.

CONCLUSIONS AND RECOMMENDATIONS

The research team suggests pursuing a three pronged approach, combining the short and intermediate term actions of 1) building capacity and communication and 2) implementing a collection and rating program for a portion of county roadways with the longer term goal of 3) active, policy driven, county level pavement management.

Now and Ongoing: Training and Capacity Building

The workshops identified the need for training and capacity building activities and venues for communication among county engineers and between counties and NJDOT. Suggested program elements include:

- **Asset management training:** This element could include ongoing outreach and training on the principles and practices of asset management ("Why Asset Management"). Without this capacity building, many counties will not fully grasp the need for a more active, consistent pavement management program in the long term. The university community is a potential partner in this endeavor, and broadly available asset management training materials, such as those issued by the National Highway Institute, could be leveraged. (See Appendix D for selected resources).

- **Research and knowledge exchange:** The other critical element in capacity building is the generation and dissemination of pavement treatment information, customized to the NJ context. This could involve a program of context-appropriate materials research (not physical research, necessarily) and a complementary engineering working group, and local/county engineers to facilitate knowledge transfer (both ways).[17]

Early and Intermediate: Program Implementation

The Group should work together to identify low hanging fruit that show promise for short term implementation. Suggested program elements include:

- **Reporting:** At the very least, the counties can provide/update information on their current activities (some of which they already document for SAGE, but for which there is no unified format or even required elements).

- **Collection and tracking:** A collection, rating, and project tracking program could help overcome a major barrier to broader program implementation, and eventually form the foundation of an active pavement management program. Based on the collection/rating cost research (Appendix A), a variety of collection methods

[17] The Rutgers Center for Advanced Infrastructure and Transportation (CAIT) is engaged in a complementary projected titled "Appropriate Implementation of Pavement Preservation Treatments." This project has researched relevant pavement treatments for local agencies and has been supporting demonstration projects and other efforts to build capacity around these projects (Source: Dr. Nicholas Vitillo, CAIT).

(NJDOT, contract, cooperative, or singly) could be discussed with the Working Group, along with the intent of the program (advisory, mandatory, or phased). Selected areas (Mercer County, SJTPO) have developed workable data collection protocols that can be considered as useful examples.

- **Tool/System Approach:** Although the specific features and functionality of a pavement management tool (or broader system) will emerge as the overall program matures, it is import to continue engaging stakeholders, including NJDOT, the MPOs, and the counties, to begin developing and sketching in the outlines of a standardized/systematized approach. The fundamental concepts at play in the development of an approach include:
    - Flexibility vs. consistency;
    - Expectations vs. funding;
    - Funding allocations ;
    - Consistency of application;
    - Scope of application; and
    - Program participation:
        - Advisory (local entities are advised, but not required, to use local PMS methods and resources);
        - Mandatory, Procedural (local entities are required to follow a pavement management procedure, but are ultimately unconstrained in their decision-making);
        - Mandatory, Performance-based (local entities are required to utilize a pavement management system and to demonstrate that decision-making is based on the results);
        - Transitional (this model would move from Advisory, to Mandatory-Procedural, and finally to Mandatory-Performance-based at set intervals).

Medium and Long Term: Building toward a Full Lifecycle Approach

Table 8, on the following page, presents a potential implementation pathway, which builds toward full program deployment through a decade-long, time-stepped sequence of implementation concepts. Although the specific parameters of these actions are left for later determination, the hypothetical framework produced in preparation for the workshops provides detail for many of these actions, and characterizes the types of choices required at each stage of pavement management system development, including data, tools, reporting, and investment strategy. Training, education, and other capacity building programs and activities should be developed in collaboration with NJDOT Pavement Management, the MPOs, and the university community.

Table 8. Conceptual county pavement management implementation pathway

Area	1. Current Practice	2. Establish Program	3. Build toward Implementation	4. Implement Decision Support System(s)	5. Achieve Full Lifecycle Approach
Timing	To date	Immediate – Early 0-12 months	Early – Intermediate 12 months-3 years	Medium 2-5 years	Long 5-10 years
Training, education, & capacity building	• Outreach through county workshops (begun)	• Establish research and knowledge sharing forum • Training: Asset management principles & alt. treatments	• Continue research and knowledge sharing forum • Training: Pavement data collection and rating (if applicable)	• Continue research and knowledge sharing forum • Training: Management systems	• Continue research and knowledge sharing forum • Training: Strategic investment planning for pavement/assets
Data	• Limited condition data, adequate data on treatments • Identified typical costs of treatments (SAGE) • Established estimated range of collection costs	• Continue tracking treatment locations and costs • Sharing of peer data collection practices (e.g., Mercer County) • Determine minimum set of pavement distresses	• Establish minimum data collection and rating standards and frequency by road type	• Begin regular data collection activities	• Continue regular data collection activities

Area	1. Current Practice	2. Establish Program	3. Build toward Implementation	4. Implement Decision Support System(s)	5. Achieve Full Lifecycle Approach
Management systems and tools	• Limited use of management system tools	• Determine system and tool approach • Identify pilot counties, if applicable	• Determine specifications for tool • Begin tool development or procurement, if applicable	• Provide tool(s) to support investment decisions	• Integrate tool outputs for statewide investment planning
Reporting	• None from subregions to State of NJ	• Establish reporting approach • Begin basic reporting	• Begin summary reporting of system condition	• Report treatments and treatment frequency by location	• Regular reporting of system condition and investment strategy
Investment Strategy (typical)	• Worst-first (some exceptions)	• Worst-first (some exceptions)	• Begin investigating new/alternative treatment types and maintenance techniques	• Ongoing testing, beginning adoption of alternatives into treatment toolbox	• Strategic mix of treatments to achieve performance targets

APPENDIX A – County Pavement Management Program Cost Estimate

At the request of NJDOT Local Aid, Cambridge Systematics (CS) calculated a range of potential program costs for collecting and rating pavements under the jurisdiction of New Jersey's 21 counties. The methodology employed requires data on the extent of all county roadways statewide, which are then segmented by series type and/or functional classification to support partial system estimates. Extents are then multiplied by the observed range of collection and rating unit costs (sourced from SJTPO and NJDOT). Where units of extent and units of costs are different (e.g., lane miles vs. directional miles), an adjustment factor is applied in order to align the units.

System Extent

Roadway extents can be measured in centerline miles (the length regardless of the number of lanes), lane miles (the total length of all lanes, or centerline miles * number of lanes), or directional miles (the distance of the roadway in both directions regardless of the number of lanes, or, with a few exceptions, centerline miles * 2). NJDOT collects pavement data on the rightmost lane in each direction (directional miles), but, in acknowledgment that multiple collection approaches could be valid, quotes its costs in units of "testing miles." Similarly, SJTPO's contractor, EnterInfo, quotes its collection estimates in "miles driven."

According to a query of the Straight Line Diagrams performed by the NJDOT Pavement Management group, there are approximately 6,650 centerline miles of county roadways in the State of New Jersey. Of these, about 584 miles are Principal Arterials and require full extent testing by HPMS[18]. A cross-check using HPMS data indicates that New Jersey has 1,345 lane miles managed by the counties that qualify as Principal Arterials (primarily functional classification 14, almost all of which are 500 or 600 series roadways). Dividing lane miles by centerline miles yields an average of 2.3 lane miles per centerline mile. Assuming 2 directional miles per centerline mile, a lane mile equates to about 0.87 directional miles (2/2.3 =.8696), on average. HPMS data indicates that there are 4295.5 lane miles (3,737 directional miles) of 500 Series roadways and 5,641.4 lane miles (4,908.0 directional miles) of 600 Series roadways in New Jersey.

[18] HPMS mandates that NJDOT collect International Roughness Index (IRI) data for these routes.

Table 1. County principal arterials in NJ (Comparison of Sources and Units)

County Series	Total Extent	Principal Arterials	Units	Source
500	4295.5	839.32	LM	HPMS
600	5641.44	384.83	LM	HPMS
TOTAL	15,295*	1344.77	LM	HPMS
TOTAL	6,650	583.55	CLM	SLD
500 & 600	8,645.16	1,063.97	DRM	HPMS
TOTAL	13,300*	1167.10	DRM	NJDOT

* estimated

Collection/Rating Costs

Three sources of collection and rating costs are used to establish the range of potential cost estimates:

- NJDOT's estimated in-house "testing mile" costs, including salaries, benefits, indirect costs, and equipment costs (use of the high speed profiler). Two unit costs are provided for NJDOT. The first, provided by NJDOT, adjusts the estimated annual cost of the profiler by the proportion of the year during which it is used (22 weeks of 52 = 43.3% of total annual costs). The second, by CS, includes the profiler's entire annual cost ($112,500) with the reasoning that, whether it is in active use or not, the van costs the same to NJDOT[19]. This estimate also includes the costs of gasoline associated with collection, plus a 20% premium for non-collection mileage, totaling $1,600[20]. No maintenance costs are added. This estimate does not include any post processing.

- EnterInfo's image capture and rating costs (not including travel and lodging or other assets such as signs, guide rail, etc.) for Salem County, as derived from a bid document (2010 dollars). Two-way non-divided roads were to be driven in one direction, and non-divided roads of 4 lanes or more and all divided roads were to be driven in both directions.

- High and low vendor bids for collection and rating on the NJDOT system (cited by NJDOT).

[19] Perhaps, if the profiler were lent for county level collection its utilization rate would rise without additional capital costs, but this speculation is uncertain, given that the vehicle's life may be limited by mileage rather than time, and that the collection season is limited.

[20] Ford E-350, EPA rated at 13 miles/gallon combined. 4,665 testing miles * 1.2 = 5,598/13 = 431 gallons of gas @ $3.75/gallon.

Table 2. Estimated testing mile costs

Source	Year	$/Testing Mile (rounded)	
		Low	High
NJDOT	2012	$44	$58
EnterInfo	2010	$208[21] ($158.21 + $50)	
NJDOT bidder	2008	$67	$82

Although not factored into the testing mile cost range represented above, Mercer County collects six pavement distress metrics on its 178 mile system by deploying six teams of trained road crew supervisors (approximately 72 labor hours annually). This model (leveraging existing staff and equipment to collect a limited set of essential distress metrics) might be workable for other counties with limited pavement management resources as well.

Results

Using the testing mile cost data recorded in Table 2, estimates of total collection and rating costs are provided in Table 3, below. These estimates assume the directional miles method of testing employed by NJDOT (rightmost lane in both directions).

Table 3. Estimated pavement data collection and rating costs for county roads

County Series	Total Extent (Route Miles)	Low Cost	High Cost	Principal Arterials (Route Miles)	Low Cost	High Cost
500	4295.50	$164,433	$777,317	839.32	$32,124	$151,858
600	5641.44	$215,954	$1,020,875	384.83	$14,691	$69,447
500 & 600	8,645.16	$380,387	$1,798,192	1,063.97	$46,815	$221,305
TOTAL	13,300*	$585,200	$2,766,400	1167.10	$51,352	$242,757

* estimated

[21] $56,481 for image capture and image QA/QC ($158/testing mile) + $17,850 for "windshield" pavement rating services ($74,331 total)/357 miles = ~$208/testing mile. It should be noted that other types of asset data were collected for the County (signs, sign post, and guardrail), but based on the bid structure there is no indication that the up front costs would be reduced if these services were omitted. The relatively low testing mile cost registered for NJDOT may reflect the benefits of economies of scale.

Table 4, below, indicates estimated collection and rating costs for all county Principal Arterials for all cost data sources.

Table 4. Estimated collection and rating costs for county principal arterials

Source	Year	$/Testing Mile (Year of Estimate) Low	High
NJDOT	2012	$51,352	$67,692
EnterInfo (*one estimate only*)	2010	$242,757	$242,757
NJDOT bidder	2008	$78,196	$95,702

Figures quoted cover one collection/rating iteration. If collection/rating is performed every two years, estimated annual costs would be 50% of the quoted figure. For collection every fourth year, estimated annual costs would be 25%, etc.

With incremental collection and a limited number of distress metrics collected (an approach adopted by Mercer County, which collects 6 metrics), costs might be lower. Further inquiries with Mercer County may be warranted to establish potential costs for this approach.

APPENDIX B - County Pavement Management SAGE Record Transcription[22]

[22] An Excel spreadsheet titled NJDOT SAGE pavement (2009-2011).xlsx was delivered on CD.

At the request of NJDOT Local Aid, CS transcribed 93 pavement resurfacing and reconstruction records from the New Jersey System for Administering Grants Electronically (SAGE) into an Excel spreadsheet. The purpose of this exercise was to consolidate cost information into a single easily accessible location (the spreadsheet), and to develop a range of lane-mile and unit costs for pavement treatments.

Transcription Protocol

CS attempted to obtain a minimum of three pavement project records from each of New Jersey's 21 counties, with the objective of transcribing up to 100 individual records. CS had access to records from each county for the years 2009-2011.

Data Transcribed

Using this protocol, 93 records were entered. Table 1 depicts the distribution of records across counties and years. Sixty-six records were from 2011, 19 from 2010, and 8 from 2009.

Table 1. Distribution of Records

	TOTAL	2011	2010	2009	CONS	DETAIL
Atlantic	10	10	0	0	N	Y
Bergen	4	2	1	1	Y	Y
Burlington	3	1	1	1	Y	Y
Camden	10	10	0	0	N	Y
Cape May	11	11	0	0	N	Y
Cumberland	5	5	0	0	N	N
Essex	3	1	1	1	Y	Y
Gloucester	4	3	1	0	N	Y
Hudson	8	3	3	2	N	Y
Hunterdon	4	2	1	1	N	Y
Mercer	0	0	0	0	N/A	N/A
Middlesex	4	1	3	0	N	Y*
Monmouth	1	1	0	0	N	Y*
Morris	3	1	1	1	Y	Y
Ocean	3	3	0	0	Y	N**
Passaic	3	3	0	0	Y	N**
Salem	5	5	0	0	N	Y
Somerset	1	1	0	0	Y	N
Sussex	6	1	5	0	Y	N***
Union	3	1	1	1	Y	Y
Warren	2	1	1	0	Y	N
TOTALS	**93**	**66**	**19**	**8**	**-**	**-**

No roadway preservation or other applicable projects were logged in SAGE for Mercer County. For Monmouth County, a single mobility oriented project which contained pavement unit cost data was transcribed, but no pavement preservation projects were logged. Somerset County provides a highly consolidated estimate for all projects, which does not contain sufficiently granular cost information. A single instance (2011) is transcribed for reference. Costs are not adjusted to a baseline year (they are recorded in project year dollars).

Half of the 20 counties for which a record was transcribed included a consolidated estimate, meaning that a roll-up of all projects for a given year was provided, but no individual project estimates were included (these counties are indicated in the "CONS" column of Table 1). Twelve of 20 counties provided unit costs at some level, whereas the remainder included lane-mile costs or lump sum costs only. Seven counties provided project level estimates with unit cost details.

Results and Key Metrics

A large majority of the 93 records sampled were classified as "Resurfacing" projects, with 74 entries, as opposed to 12 for "Reconstruction" and 7 for other project types (see Table 2). Due to small samples and widely varying project scopes, "Reconstruction" and "Other" project costs and lane-mile average costs are not considering instructive for future costing, except at a unit level, unless the detailed estimates in SAGE are considered directly.

Table 2. Summary Results by Record Type

	Resurface	Reconstruct	Other	TOTAL
Records	74	12	7	93
Total Cost	$ 159,817,417	$ 78,028,195	$ 14,248,022	$ 252,093,634
Total Miles	495.02	30.10	3.31	528.43
Weighted Avg. Lane-Mile Cost	$ 322,854	$ 2,592,299	$ 4,304,538	$ 477,066

Although resurfacing projects also vary significantly in scope, the larger sample size (both in terms of records and total mileage) and smaller range of costs may be more useful for lane-mile costing. The weighted average lane-mile cost for resurfacing projects was $322,854. Excluding counties with very small sample mileages (less than 15 miles), average lane-mile costs (include all materials, labor, and support services but not contingencies) range from $197,417 (Essex) to $386,815 (Union). Figures for counties with less project mileage (greater than 1 but less than 15) tended to read as outliers, with lane-mile costs ranging up to $1,280,232.

Cost per lane-mile did not correlate strongly with material costs. For example, among the 11 counties with greater than 1 mile of resurfacing and that reported surface course

asphalt units in tons, all used between 1,923 and 3,343 tons per lane-mile (a difference often related to the thickness of the surface course and the width of paving, although neither measure was consistently reported). With HMA surface course costs ranging from $56.67 to $96.88 per ton (average, $72.18), surface course asphalt lane-mile costs fell across a broad spectrum, from $115,361 to $288,533; this variance does not explain the much wider range of total lane-mile costs. For instance, although surface course costs per lane-mile in Atlantic County ($145,404) were 26% greater than those for the lowest cost county (Essex, $115,361), Atlantic County's total average lane-mile costs were 294% greater. Atlantic County's total lane-mile costs were 5.4 times its surface course lane-mile costs, whereas the figure for Essex is only 1.73. For all four counties with total average lane-mile costs greater than $500,000, this ratio ranges from 3.1 to 5.6, whereas the ratio for all other counties (when it could be calculated) fell between 1.68 and 2.25 (excluding Cumberland, with an unrealistically low 1.04 ratio). A review of projects in these higher cost, higher ratio counties suggests that factors like the amount of driveways, sidewalks, curbs, and landscaping, coupled with factors like traffic control expenses, may drive these differences.

Because costs are clearly more closely related to differences in project scope, rather than varying material costs, it is recommended that counties consider the data transcribed into the accompanying spreadsheet in correspondence with project specific details (or even project specific estimates), whenever possible. The unit costs transcribed, which include elements common to most paving projects, should prove useful for building project estimates, although the lump sum adjustments for asphalt and fuel complicate the simple multiplication of units by unit costs. Unit costs may also support a constructive price comparison among counties. Differences in pavement makeup alone should not result in such a broad range of asphalt costs as that observed ($56.67-$96.88/ton for surface course, $55.00-91.25 for base course).

APPENDIX C – County Pavement Management Workshop Summaries

North Region Snapshot Summary (September 24, 2012)

Subregional Attendees

Name (in order of sign in)	Subregion
Jeffery Reeves	Jersey City
Joseph Glembocki	Hudson
Joe Femia	Bergen
Sue Dziamara	Hunterdon
Juan Feijoo	City of Newark
Zafar Alvi	City of Newark
Rob Mulloy	Ocean
Frank Scarantino	Ocean
Lisa Betz	Union
Steve Edmond	Passaic
Tim Mettlen	Passaic
Barth Johnson	Warren
Raymond Bragg	Monmouth
Chris Vitz	Morris
Debra Dellagiacoma	Morris
Gary Cortelyou	Somerset
Chris Gluch	Somerset
John Lang (unclear)	Hudson

Presenters

- **Zenobia Fields of NJTPA** presented on the goals and objectives of the forthcoming regional asset management system. NJTPA envisions this as a web-based, GIS enabled integrated database of sign, bridge, pavement, rail, and other transportation assets.
- **Paul Leso of Union County** presented on the County's pavement data collection efforts. The County hired a firm to collect IRI on its roadways and also compiled data on roadways that were resurfaced within the past 15 years, which were made into GIS layers.
- **Juan Feijoo of the City of Newark** presented on its ICON asset management system. ICON allows the City to generate reports, budgets, and maps to support decision-making for resurfacing projects. This system was purchased around

2007/2008 for approximately $180,000. To date, the City has not incorporated inspection data into the system due to time constraints.

- **Philip Bertucci of NJDOT** presented on the Department's Pavement Management System, describing the process of collection and rating, and its contribution to strategic decision-making. He spoke about the value of employing an asset management approach in order to cost-effectively manage the State's pavements.

Pavement Management Practices

Note: not all subregions were present, and not all present subregions engaged in discussion on each of the points covered below. The recorded results, therefore, are not representative.

Data Collection

Where they are now (current practices):

- **Data collection:** Most subregions collect condition data (visual distress) every few years (a quick poll revealed the range to be 1-5 years, while a few never collect condition data on their entire system). Collection is most often accomplished via windshield surveys, which are typically performed by road inspectors or engineering supervisors. Some subregions have road crews report observe distress on a rolling basis.
    - One county collects condition data annually, tracks in a GIS.
    - Newark collects data on all roadways annually.
    - Union County collected IRI on its roadways with consultant support.
    - Several counties noted that they had consistency issues between pavement raters.
- **Differentiation by roadway type:** Most subregions report that they have a reasonable understanding of which segments are likely to require work based on their usage. Several mentioned that some low usage roadways had gone 30 years without treatment and had no significant condition issues. Subregions generally saw no point in collecting condition data on these types of roadways.
- **Tracking of treatments:** Almost all subregions have a record of the roadway segments that have been resurfaced, some of which stretch back over 30 years.
    - A few counties keep a GIS record of treatments.

Where they would like to be (potential future practices)

- **Data collection:** Subregions were generally hesitant to specify an ideal collection cycle, even for higher volume roadways.
    - Passaic suggested that collecting 20-25% of the system annually would be useful (i.e., a 4-5 year collection cycle).
    - It was suggested that training might be needed for raters, to better ensure consistency.

    - Subregions did not seem enthusiastic about a potential pool of trained consultant raters, expressing concern that county pavement raters would no longer be necessary.
- **Differentiation by roadway type:** Most subregions agreed in concept that it made sense to have better data on roadways of higher importance (500 Series, for example), but were not able to specify an ideal collection cycle.
- **Tracking of treatments:** Subregions felt that they are currently doing a good job tracking their treatments, and needed no specific improvements.

System Investment Planning and Implementation

Where they are at (current practices):

- **Pavement management/project selection:** Many subregions rank their roadways and choose projects to treat the sections in worst condition (worst-first). Others select projects based on an annual resurfacing schedule (a specified number of miles or dollar value of milling and filling), often picking projects based on time since last resurfacing (i.e., cycling through their inventory of roads in sequence).
    - Although all subregions employ elements of pavement management, only Newark uses a purpose-built pavement/asset management system.
    - With the possible exception of Newark, no subregion present claimed to be choosing projects/treatments based on asset management principles.
- **Unit costs and funding:** Funding is stable or trending downward across the board; all could use more funding. Cost estimates ranged from $100,000 $400,000 per lane mile, with costs in the lower range for more rural areas and in the higher range for urbanized areas.
- **Types of treatments:** A majority of current treatments are standard resurfacing (e.g., 2" fill).
    - One county mentioned that it made limited use of crack sealing and microsurfacing.

Where they would like to be (potential future practices)

- **Pavement management/project selection:** Some subregions expressed tepid interest in pavement management software, although there was skepticism from counties which were concerned about costs (thus reducing the resurfacing budget) and from counties which had formerly used, but since abandoned, pavement management systems. Although many subregions admitted that they were falling further behind each year, most attributed this to a tightening of funding, not the prevalent worst-first method of project selection.
- **Unit costs and funding:** Subregions seemed to recognize that pavement competes against a host of other funding priorities. Nobody felt that additional funding was realistic, even if the case could be better articulated through enhanced data. A more common hope was that pavement funding would hold steady, as would costs. Subregions were concerned that the scope of paving

projects would continue to increase (past examples include ADA retrofitting), which would lead to greater unit costs.

- **Types of treatments:** Most subregions were interested in learning more about alternative treatments, such as microsurfacing, which may hold promise for increasing pavement longevity at a fraction of the costs of resurfacing.

Challenges, Opportunities, and Interests

- **Utilities:** Several subregions expressed frustration with the level of coordination by utilities, which sometimes results in tearing up newly paved roadways.
- **ADA:** Subregions say that the cost of paving projects have increased by 30% due to ADA retrofitting requirements, meaning fewer projects could be undertaken in any given year. Subregions are looking for effective ways of managing these costs while fulfilling the mandate.
- **Training/capacity building:** Counties were generally interested in learning more about alternative treatments. Counties that noted perceived inconsistencies in the assessments of roadway inspectors felt that better training could help address this issue.
- **Resources/funding:** Subregions were adamant that they could not afford to take on additional pavement management requirements themselves. Even with more money, several counties mentioned that they either did not have adequate staff availability or staff capacity. Part of the doubt expressed by subregions about the value of pavement management systems was related to the lack of time and staff to run the program.

South Region Snapshot Summary (September 26, 2012)

Subregional Attendees

Name (in order of sign in)	Subregion
Gary Worek	Burlington
Rajesh Desai	Burlington
Ashvin Patel	Burlington
Theresa Ziegler	Gloucester
Edward Rose	Gloucester
Douglas Whitaker	Cumberland
Chris Markley	Mercer
Matthew Lawson	Mercer
Janel Bisacquino	Mercer
Robert Brewer	Cumberland
John Feairheller	Atlantic City

Presenters

- **Bill Schiavi of SJTPO** presented on the progress of regional pavement/asset management efforts. Pavement condition data, including 22 different distress metrics, have been collected for all four counties and Vineland under a contract with EnterInfo. The collection also included data on signs and guiderail. The contract also provides for asset management software, which incorporates GIS, deterioration curves, and decision trees to support project selection.
- **John Coscia, Jr. of DVRPC** spoke about the region's strides toward implementing guide rail and sign management systems, using the SRI and mile markers that NJDOT utilizes. DVRPC wants to continue to work with the counties and have them drive the process of developing a more robust pavement management system.
- **Matthew Lawson and Janel Bisacquino from Mercer County** described their pavement management system, which was developed in-house, entitled Transportation Asset Management Information System (TAMIS). Mercer inventoried all paper maintenance records back to 1977, dividing their roadway system into 312 segments. Road crew supervisors were used to perform windshield surveys, focusing on 6 distress metrics: block cracking, depression, fatigue "alligator" cracking, linear cracking, patching, and raveling and weathering. The collection/rating effort requires approximately 72 hours of staff time annually (performed by road crew supervisors). All results are entered into a GIS database. The County is interested in learning more about national best practices, especially regarding climatically appropriate treatments.

- **Phil Bertucci of NJDOT** presented on the Department's Pavement Management System, describing the process of collection and rating, and its contribution to strategic decision-making. He spoke about the value of employing an asset management approach in order to cost-effectively manage the State's pavements.

Pavement Management Practices

Note: not all subregions were present, and not all present subregions engaged in discussion on each of the points covered below. The recorded results, therefore, are not representative.

Data Collection

Where they are now (current practices):

- **Data collection:** Of the subregions present, only Mercer County regularly collects condition data (performed on an annual basis). Other counties noted that Mercer has a smaller roadway system to manage (178 miles).
- **Differentiation by roadway type:** Subregions present generally had either a smaller system (Mercer County) or a preponderance of one roadway type (Gloucester and Cumberland County Routes are predominantly rural).
    - Burlington County places additional emphasis on monitoring higher volume roadways
    - Atlantic City knows where its chronically problematic roads are (which it says seem to carry a disproportionate amount of volume).
- **Tracking of treatments:** Mercer County tracks treatments, unknown if others do as well.

Where they would like to be (potential future practices)

- **Data collection:** Subregions were in general agreement that it would be useful to have updated condition data on a regular basis.
    - Burlington mentioned 2-4 years as a reasonable collection cycle.
    - Gloucester specified 3-5 years as its preferred collection cycle.
    - Mercer collects condition data every year.
- **Differentiation by roadway type:** Subregions were in basic consensus that having better data on higher volume roadways was a good use of resources.
- **Tracking of treatments:** No discussion.

System Investment Planning and Implementation

Where they are at (current practices):

- **Pavement management/project selection:** Currently, Burlington, Cumberland, and Gloucester all have the chief engineer or engineering staff make project selections. Burlington paves an average of 25 miles annually, which makes for a 10-15 year paving cycle. Cumberland paves 27 miles annually. These subregions generally employ a worst-first approach to project selection.

    - Mercer County uses an in-house, GIS enabled pavement management system to help choose projects based on asset management principles.
- **Unit costs and funding:** Mercer noted that it paid $2.25 per square foot (just for paving). Burlington County knew its costs as well, but that value was not recorded. All subregions noted that it was important to distinguish between maintenance (for which funding is generally restricted) and capital improvements.
- **Types of treatments:** Currently, the dominant treatment is resurfacing – milling and filling.
    - No microsurfacing was reported.
    - Very few maintenance (non capital) treatments were reported.

Where they would like to be (potential future practices)

- **Pavement management/project selection:** Subregions expressed interest in tools that would help demonstrate the value of alternative treatments and treatment cycles.
    - Mercer County will continue to develop and refine its PMS.
- **Unit costs and funding:** With funding flat or declining, subregions were interested in exploring treatments that could cost effectively extend the life of pavements. There was also interest in accessing funding currently dedicated to capital improvements for activities more oriented toward preservation.
    - Counties may be interested in accessing microsurfacing contractors through a cooperative purchasing agreement with NJDOT.
- **Types of treatments:** All subregions expressed interest in learning more about alternative treatments, such as microsurfacing.
    - Mercer County called for more research on the performance of alternative treatments in similar climates.

Challenges, Opportunities, and Interests

- **Utilities:** Subregions encounter challenges with pavement performance related to the work performed by utility companies.
    - Mercer County has passed an ordinance requiring utility companies that make longitudinal cuts to mill and fill.
    - Atlantic City (much like the more urbanized areas in northern New Jersey), has trouble with the effects of resurfacing on aging subterranean infrastructure. They have banned the use of vibratory rollers.
- **ADA:** Subregions expressed concern that ADA requirements reduce their ability to keep up with pavement performance needs.
- **Training/capacity building:** All subregions could use more information, and perhaps trainings, on the subject of alternative pavement treatments.
    - Cumberland County noted that it is under staffed and could do more with greater staff resources.
- **Resources/funding:** With the exception of Mercer, which is already collecting condition data and administering a PMS, subregions were cautious about the fiscal and staffing resources burdens that would come with a collection program (which they seemed to see value in, however).

APPENDIX D - Pavement Management Programs: Resources

State Level Local Pavement Management Programs: Selected Resources

Metropolitan Transportation Commission (California)

- Metropolitan Transportation Commission, Pavement Management Program website
    - http://www.mtcpms.org/

Michigan

- RoadSoft-GIS software
    - http://www.roadsoft.org/
- 2011 TAMC PASER Training Manual
    - http://www.michiganltap.org/workshop/materials/2011PASER/2011%20TAMC%20PASER%20Training%20Manual.pdf
- Transportation Asset Management Council
    - http://tamc.mcgi.state.mi.us/mitrp/Council/Default_Council.aspx

Utah

- Utah LTAP Center
    - http://utahltap.org/
- Utah LTAP software center
    - http://www.utahltap.org/htm/software/tams

Wisconsin

- Wisconsin Transportation Information Center
    - http://tic.engr.wisc.edu/index.lasso
- Wisconsin Department of Transportation, programs for local governments
    - http://www.dot.wisconsin.gov/localgov/wislr/

Federal Highway Administration: Selected NHI Courses

FHWA Office of Asset Management provides leadership in pavement management by disseminating best practices and technical expertise to transportation agencies. The Office, in partnership with AASHTO and other FHWA offices, assists agencies by developing and promoting systematic approaches to the management of pavement assets.

FHWA provides non-regulatory guidance; training and technical assistance that range from courses introducing asset management to sessions specifically focused on pavement management systems. Through the National Highway Institute (NHI), the following courses are available:

- **Transportation Asset Management –** One day course that covers the principles, techniques, benefits, and steps to implement asset management (*NHI-131106)*
- **Pavement Management Systems: Characteristics of an effective program.** One day course targeted to transportation professionals from NJDOT and local agencies responsible for managing, maintaining, and prioritizing pavement projects for programming purposes. The course introduces the basic components of an effective pavement management program. It is designed to help improve the effectiveness of an existing pavement management program and provide opportunities for participants to identify strategies that will help enhance their existing capabilities. (*NHI-131116)*
- **Pavement Preservation: Design and Construction of Quality Preventive Maintenance Treatments.** Series of courses designed for construction foremen, agency construction inspectors, and recommended for asset management team members. The courses cover all the categories of preventive maintenance treatments in widespread use today, focusing on the best practices for designing and constructing those treatments. (*NHI-131103)*
- **Pavement Preservation: Optimal Timing of Pavement Preservation Treatments.** The three-hour online course helps upper and mid-level highway agency professionals to determine the optimal time to apply a preservation treatment. Topics range from treatment timing and selection, collecting treatment performance relationship data, and key cost and benefit considerations. (*NHI-131114)*
- **Pavement Preservation: Selection and Timing of Preventive Maintenance Treatments.** Two-day course to improve the skills of those involved in implementing pavement preservation programs. This includes improving the selection of pavement preventive maintenance projects and the selection of preventive maintenance treatments. The target audience for this course is mid- or upper-level highway agency professionals responsible for pavement preservation/maintenance and management. For local agencies, this group might include Public Works Directors or Chief Engineers/engineers of cities, towns, counties, and metropolitan planning organizations (MPOs). (*NHI-131115)*

Key Transportation Asset Management Publications

- AASHTO, Transportation Asset Management Guide: Volume 1, Washington, D.C. (2002)
- AASHTO, Transportation Asset Management Guide: Volume 2 – A focus on Implementation, Washington, D.C. (2011)
- Cambridge Systematics, Inc., Asset Management Guide for Local Agencies in Michigan, Michigan Transportation Asset Management Council (2006)
- D.G. Peshkin, T.E. Hoerner, and K.A. Zimmerman, NCHRP Report 523: Optimal Timing of Pavement Preventive Maintenance Treatment Applications, Transportation Research Board (2004)
- University of Wisconsin – Madison**,** Asphalt-PASER Manual, Pavement Surface Evaluation and Rating, Transportation Information Center (2002) http://epdfiles.engr.wisc.edu/pdf_web_files/tic/manuals/Asphalt-PASER_02.pdf
- Rohan Perera, A.S. Pulipaka, and S.D. Kohn, Pavement Management Catalog, Federal Highway Administration (2008) http://pavementmanagement.org/other_references/Pavement_Management_Catalog_2008.pdf
- Cambridge Systematics, Inc., PB Consult, Inc., and Texas Transportation Institute, NCHRP Report 551: Performance Measures and Targets for Transportation Asset Management, Transportation Research Board (2006)
- Cambridge Systematics, Inc., PB Consult, Inc., and System Metrics Group, NCHRP Report 545: Analytical Tools for Asset Management, Transportation Research Board (2005)
- G.W. Flintsch and J.W. Bryant, Asset Management Data Collection for Supporting Decision Processes, Federal Highway Administration (2009) http://www.fhwa.dot.gov/asset/dataintegration/if08018/assetmgmt_web.pdf

Glossary of Terms

CAIT

Center for Advanced Infrastructure and Transportation at Rutgers University.

IRI

International Roughness Index, a statistic used to estimate the amount of roughness in a measured longitudinal profile.

PASER

Pavement Surface Evaluation and Rating System. PASER is a system for visually rating the surface condition of a pavement from a scale of 1 to 10, with 1 being a pavement in a failed condition and 10 being a pavement in excellent condition.

PCI/PCR

Pavement Condition Index/Pavement Condition Rating. PCI/PCR rates the condition of the surface of a road network on a scale from 0 (worst) to 100 (best). PCI measures the type, extent, and severity of pavement surface distresses as well as the smoothness and ride comfort of the road.

PSR

Present Serviceability Rating. PSR is a subjective rating system based on passenger interpretations of ride quality, as rated on a scale of 0-5, with five being very good, and 0 being very poor (or essentially impassable).

SDI

Surface Distress Index measures the severity of surface distresses such as cracking, patching, shoulder condition, shoulder drop, faulting and joints, rated on a scale of 0-5 (5 being without distress).