ASSET MANAGEMENT DOCUMENTATION
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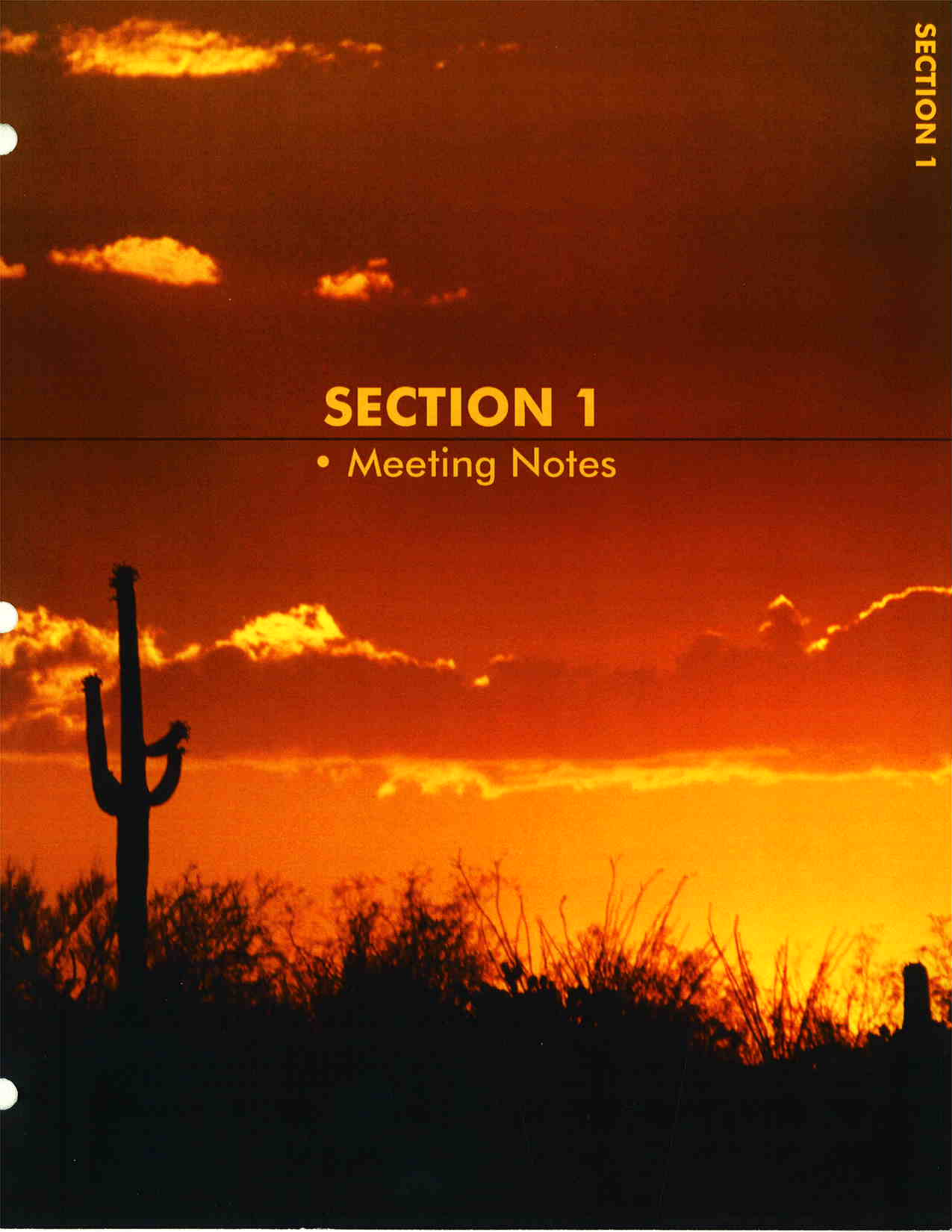

SECTION 1

- Meeting Notes

April 8, 2005

Jerry Fay

Meetings with Mike Sabatini, Assistant County Engineer Planning and Kent Hamm, Assistant County Engineer Program Management, Maricopa County Department of Transportation

On the morning of April 14, 2005 I met with Mike to discuss the entire MCDOT organization regarding our contract to update their Transportation System Plan and Needs Assessment and in the afternoon, Steve Rhoten and I met with Kent to discuss the county's new project management system.

During my meeting with Mike, he provided me with an entire set of detailed organization charts for MCDOT and went over each chart in detail. For purposes of this report, I will only discuss the revisions to their project delivery system. As Kent Hamm's discussion was identical to Mikes the following is a summary of both meetings.

The reason for the change in the project delivery process and the creation of the Project Management and Construction Division is the problem that the county has had in delivering their capital program. They have consistently missed bid dates and sometimes by as much as a year. Under Mike Ellegood's leadership and direction, Kent Hamm will be in charge of the new division as Director. The Planning, Operations and Engineering Divisions will remain in tact with little change. However, the Engineering Division will be primarily responsible for smaller in-house projects and all of the major projects will be overseen by the new PM&C Division.

Their new process will work as follows: When a project leaves the Planning Division and moves to the PM&C Division it will be assigned to a project manager. The project manager will be responsible for environmental, R/W, design and construction activities. All design efforts will include maintenance considerations. The project manager will select and manage the consultants for the various stages of the project. The current organization calls for a Senior Project Manager, Bob Erdman, and four project managers, Ray Smith, Tom Larson, Sami Ayoub and Nariman Zadeh. Chuck Williams will be the Program Manager. Construction Administration is under H. Miller and Bill Hahn will not be a project manager at this time due to immigration and citizenship issue.

Other miscellaneous items of interest discussed included possibility of county bonding to accelerate "Yes on 400" projects, Mike Ellegood wants to get more small local firms involved and they are considering hiring a consultant to manage a portion of their program, similar to ADOT's process. Projects being considered for acceleration are Williams-Gateway, SR 303, Grand Avenue and the ADOT I-10 Reliever.

Copies of the organization charts will be distributed at our next strategy meeting.

April 20, 2005

Jerry Fay

Meetings with Chris Plumb, Manager Transportation Programming and Systems Analysis, Maricopa County Department of Transportation

I had an excellent meeting with Chris and he was very helpful and informative and offered further meetings if I have additional questions. I was specifically interested in how they use their management systems to select projects and program projects and how they use the HERS Model in that process. I was also interested in his thoughts regarding the maintenance and any information he had on how maintenance programs their funds. The following is a summary of the information provide by Chris, which was in a somewhat unstructured format.

They have a Transportation Management System that includes four subsystems that they use to program projects. The systems are Congestion Management, Safety Management, Roadway Management and Bridge Management.

Under congestion management they keep current counts that are consistent with the MAG Model and are integrated in to their GIS. They look at the known capacity and utilize V/C to determine what roads need to be improved. They have a Roadway Design Manual that has LOS data. They look at the absolute capacity using the MAG Model.

For bridges they have PONTIS, but do not use it. They rely on the annual bridge sufficiency ratings for selecting bridge projects.

They use ADOT accident data for safety analysis which looks at accident rate and severity. ADOT assigns a dollar value to the accidents. Accident rate and dollar value are used in the evaluation to select projects.

Their Pavement Management System is part of the Roadway System and they are developing their own system, software. They have all the data they need, but as yet they have not been successful in finishing the development of the program. They currently only program maintenance for one year and predictive model is being developed to enable longer term programming of maintenance funding needs. They currently know the average pavement condition for all functional classifications.

The HERS Model looks at system condition and performance and is supposed to enable decisions to be made regarding maintenance and capital expenditures. There is a large number of variables that need to incorporated in to the modeling, such as; roadway condition information, geometrics and accidents. You can set the pavement level and look at benefit form various cost levels. This is measured by the International Roughness Index (IRL). HERS looks at the surface improvements needed and selects roads for maintenance. They have a pavement service ability index that provides and overall view of the pavements. This information is contained in the Maintenance Manual. They currently do not have a policy that establishes their overall pavement condition rating. They do know that over the past several years that the overall rating has been going up because of additional funds being transferred from the capital program. The question becomes what is our system condition over the next twenty years if we continue at the current funding levels and what happens if we vary the funding. Only collectors and arterials are rated and not local streets. This causes a major problem when areas like Sun City, which was built forty years ago needs major rehabilitation and restoration. In the case of Sun City they are considering it to be a capital project because of the cost. Their maintenance cycle used to be six to seven years, but now is in the twelve to fifteen year range.

Regarding the relationship of the planning group to the new program management group, planning takes a project through the Candidate Assessment Report (CAR) and program management begin with the Design Concept Report (DCR).

There are major concerns regarding the YES on 400 projects and how they are programmed and funded. MCDOT has developed an Arterial Life Cycle Program (ALCP) for all of the projects. Chris believes it is not acceptable to do accelerated projects with out considering inflation. He thinks they should just readjust the schedule in to five year increments and move forward. He believes MAG is not capable of administering the YES on 400 arterial projects and that the phasing and inflation process will be a nightmare.

The County Supervisors are looking at bonding to accelerate freeway projects. However, Chris feels that once they look at the amount of money they can raise from bonding versus the impacts on there HURF funding over time, they will decide to not do it. The financial arm of the county is currently doing the analysis.

Regarding some final thoughts, the HERS Model has all the data in the system and could have the ability to be utilized effectively for programming capital and maintenance in the future.

May 2, 2005

Jerry Fay

Meeting with Gary Lashman, Operations Division Manager, Maricopa County Department of Transportation

Gary is responsible for roadway maintenance and traffic operations. One of his main responsibilities is management of the Roadway Management System (RMS). The following are my notes from my meeting with Gary:

The first area of discussion was the RMS. The RMS uses the following information for the Roadway Inventory Data:

Roadway name and cross road reference
Segment length
Functional Classification of the roadway
Number of lanes
Width of lanes
Surface type
Shoulder width and type
Maintenance history
Traffic volumes
Right-of-way width

Noise is also becoming an issue. They now do some milling and then overlay with rubberized asphalt instead of chip sealing.

They utilize the HERS model, however it only works on the main roads. Cost is an issue in trying to make valid comparisons. Roadway maintenance is $8,000 to $9,000 per mile yearly.

The RMS provides a lot of data on individual roadway segments, by evaluating cracking, rutting, raveling, etc. The International Roughness Index (IRI) is also determined using profiling and measuring devices. The majority of discussion can be found in the Divison Procedures for the RMS.

Based on our discussions there appear to be two areas that can provide the comparative data necessary to determine the impact of various expenditures. The two measures are overall system performance, the Pavement Serviceability Index (PSI) and the International Roughness Index. The impacts of various expenditure levels over time base on establishing an acceptable standard of performance can provide the data necessary to support budget decisions.

Fay, Jerry

From: Spargo, Benjamin
Sent: Wednesday, August 17, 2005 7:49 AM
To: Fay, Jerry
Subject: MCDOT TSP Meeting 8/10/05

Jerry-

Here are some notes that I took from the Asset Management meeting last week. Those attending were Ed Fritz, who runs the HERS model for MCDOT, Rick, who runs the pavement/roadway management services, and Alex, who does software development. I'll use the Meeting Agenda to help organize the general discussion.

- MCDOT's RMS development:

  RMS Phase 1 - Capture the data. Gather the existing information available from Rick's group including IRI, PCR, etc. Close to complete.

  RMS Phase 2 - Future strategies. The goal of RMS is to be able to create funding scenarios in order to keep the network at a chosen performance level. Where HERS is good for the capital program, the RMS is designed to provide a similar evaluation method for the maintenance program. Currently under development.

  HERS Model weakness - only able to use 1 maintenance strategy. Currently MCDOT institutes numerous types of maintenance procedures to repair and maintain pavement performance. Mainly outputs benefit/cost (b/c) ratios

  HERS Model pavement curve - the HERS Technical Report (Dec. 2000, FHWA) provides the background information for all of the curves, models and equations that are used within the model. MCDOT has adjusted many of the default curves to better reflect the climate and conditions of the environment in Arizona.

- HDR's asset management findings to date:

  Research peer jurisdictions to develop a rationale for the background models in the RMS.

  RMS - project's data needs:

  Develop performance standards (justification for the levels requires research of peer jurisdictions)
  Decide whether software should analyze the "bang for the buck" or the "buck for a certain performance measure"
  Pavement degradation curves (historical data, peer jurisdictions with similar climates, etc.)
  Further b/c analysis

- HDR's remaining asset management tasks:

  Support the development of MCDOT's RMS as needed
  Coordinate HERS training session with Ed to better understand the input and output data.

- Also:

  Continue making better decisions with maintenance funding. Not necessarily improve the worst roads first.
  Continue looking for better products and more efficient ways to deliver the improvements.
  Work to change the culture of the budgeting department to meet the needs of the maintenance program and then fund the capital program with remaining funds.

Ben

Ben Spargo, EIT

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MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION

DIVISION PROCEDURE

PPG NO: 94-3 Effective Date: March 5, 1997	Revised Date: November 5, 2002	DIVISION: Construction & Operations
SUBJECT: Road Management System	Authorized Signature:	
Owner/Contact: Rick Boeger – 602-506-4509	M. Kent Hamm, P.E. Assistant County Engineer Operations	

PROGRAM OVERVIEW AND BACKGROUND

The Road Management System (RMS) is a tool used to analyze the physical attributes of roadways as well as the current condition of roadway pavement and ride quality. The information derived from the RMS is used to make recommendations to decision makers concerning how to best maintain and preserve county roads. The primary goal of the RMS is to ensure acceptable ride quality and safety for the traveling public in a cost efficient manner in accordance with the specifications of the MCDOT Roadway Design Manual.

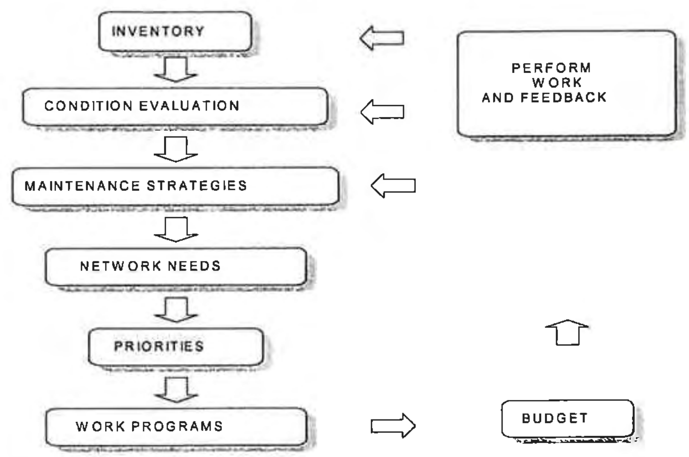
Purpose of the RMS

All road surfaces deteriorate over time due to traffic and environmental conditions. MCDOT's analysis has shown that it costs the traveling public less to have good roads than bad roads but only if the roads are kept at a reasonable level of serviceability. Therefore, the County has set up a program to continuously monitor roadway conditions, report the roadway conditions to the decision makers through the RMS, and attempt to maintain all of its roadways at an acceptable level. Preventive maintenance is the soundest way to reduce pavement failure.

Preventive maintenance is the treatment applied to prevent or reduce the rate of deterioration on roads and the expenditures for pavement work. Preventive maintenance is limited to such activities as surface seals and thin overlays that do little to change the structural capacity of the pavement but do add years of life to the road surface. The old colloquial saying of "pay me now, or pay me later" truly applies to pavement maintenance.

The County's general framework for roadway management activities is shown in Figure 1. The first feature is an inventory of the pavements in the network; Second, a systematic procedure is used to evaluate the condition of these pavements and; Third, the RMS defines maintenance and rehabilitation strategies. Finally, based on the pavement condition, the RMS identifies the network maintenance and rehabilitation needs, selecting the most appropriate strategy for each pavement section. The RMS program repeats the analysis for a five-year period and projects the Pavement Condition Ratings (PCR) over time so that long-term work plans and budgets can be prepared.

Figure 1: Roadway Management Process



LAWS AND POLICIES AFFECTING THE RMS

The Maricopa County Transportation System Plan and Comprehensive Plan outlines four management systems to help plan and program future roadway improvement projects. These management systems include Roadway, Safety, Congestion and Bridge. All were patterned after those described and required in the Federal Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991.

The 1998 implementation of the TEA 21, the Transportation Equity Act for the 21st Century, created changes to all of the Management Systems. While these reports are no longer required, Maricopa County has made a commitment to continue to collect data and carry out all management system reports for roadways under the County's Jurisdiction.

ROLES OF THE RMS IN CAPITAL IMPROVEMENTS PROGRAMMING

The RMS determines preventive maintenance, rehabilitation, and reconstruction needs over a five-year span. It also recommends strategies that maintain the overall network at a condition required by the MCDOT Roadway Design Manual and expected by the traveling public. These determinations are presented each November to the MCDOT Construction & Operations Division and Planning Division for consideration in the Transportation Improvement Program (TIP) or the Construction & Operations Maintenance Program.

RMS reports generated for use by MCDOT include:

- Transportation Improvement Projects (TIP) recommending road widening.
- Recommending reconstructing various two-lane roads to improve sufficiency rating.
- Recommending roadways to receive structural overlays.
- Recommending roadways to receive thin (maintenance) overlays.
- Recommending roadways to receive surface treatments (i.e., chip seal, slurry seal, crack seal, fog seal, routine maintenance.)

ROADWAY EVALUATION PARAMETERS

The RMS uses six different categories of information to determine which roadways in the network require attention. These categories are both independently analyzed and mathematically combined to offer a snapshot for the decision makers to annually monitor roadway conditions.
Data included in the RMS are the road inventory, the pavement conditions rating, the international roughness index, the sufficiency rating, the work history data, and the traffic volumes data. All play important roles in determining: What work needs to be done annually.

Roadway Inventory Data

Roadway Inventory information comes from the Road Information System (RIS) Platform Conversion Application (RPCA) to the RMS databases. The following types of information are available in the databases for roadways owned by the County:

- Road name, and cross road references
- Segment length
- Functional classification of the roadway
- Number of lanes
- Width of lanes
- Surface type
- Shoulder width and type
- Maintenance history
- Traffic volumes
- Right-of-way width

Pavement Condition Rating (PCR)

The MCDOT Road Management Section evaluates pavement conditions by inspecting all segments of paved roads in the County. The result allows for a quantifying of the overall pavement condition in the road network. Pavement conditions are updated annually on most section line roads (Arterials) and every other year on local roads. Measuring surface distress types determines the Pavement Condition Ratings (PCR) (see Table 1) such as:

- Transverse cracking
- Longitudinal cracking
- Fatigue cracking
- Block cracking
- Rutting
- Raveling
- Shoving / Pushing / Corrugations
- Excess asphalt Patching

The above information is then combined so that each road is scored on a scale from 1 to 100 with 100 representing an excellent roadway surface.

The Maricopa County Department of Transportation relies on the PCR for looking into potential preventive maintenance strategies and long range planning. Pavement preventive maintenance treatments need to be performed before the pavement conditions get to the point of rehabilitation or reconstruction. Timely treatment strategies prove to be the most cost effective.

Figure 2 shows the effectiveness of the Maricopa County Department of Transportation's preventive maintenance strategy.

Figure 2: Pavement Maintenance Strategies

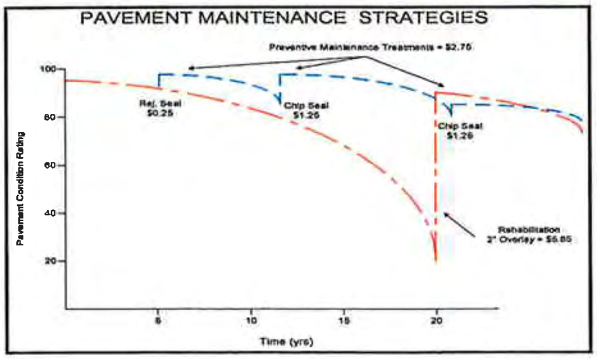


Table 1: Asphalt Pavement Surface Distress Evaluation

ASPHALT PAVEMENT SURFACE EVALUATION
100 Point System

TRANSVERSE CRACKS

EXTENT SPACING	SEVERITY WIDTH <3/8"	SEVERITY WIDTH >3/8"
>50 ft.	1	4
12 ft. to 50 ft.	2	5
<12 ft.	3	6

LONGITUDINAL CRACKS

EXTENT	SEVERITY WIDTH <3/8"	SEVERITY WIDTH >3/8"
Centerline Single	1	4
Wheel Path Single	2	5
Multiples	3	6

FATIGUE CRACKING

EXTENT	SEVERITY WIDTH <1/8'	SEVERITY WIDTH >1/8"	Blocks
One or two < 50 sf	1	5	9
Three or more < 50 sf	2	6	10
One or two > 50 sf	3	7	11
Three or more > 50 sf	4	8	12

BLOCK CRACKS

EXTENT BLOCK SIZE	SEVERITY WIDTH <3/8"	SEVERITY WIDTH >3/8"
>50 ft.	1	4
12 ft. to 50 ft.	2	5
<12 ft.	3	6

RUTTING

EXTENT	SEVERITY DEPTH >1/2"
Localized or only partial length	1
Entire length of section	2

RAVELING

EXTENT	SEVERITY PITTING Minor	SEVERITY PITTING Major
Wheel Paths < 50% length	1	5
Wheel Paths > 50% length	2	6
Entire Width < 50% length	3	7
Entire Width > 50% length	4	8

SHOVING/PUSING/CORRUGATIONS

EXTENT	SEVERITY RIDE DISCOMFORT Mild	SEVERITY RIDE DISCOMFORT Harsh
At intersections only	1	4
Between intersections only	2	5
Present in entire section	3	6

PATCHING

EXTENT NUMBER	SEVERITY QUALITY OF REPAIR Good	Fair	Poor
< 5 Repairs	1	4	7
5 to 15 Repairs	2	5	8
>15 Repairs	3	6	9

EXCESS ASPHALT

EXTENT	SEVERITY FILM Thin	SEVERITY FILM Thick
Wheel Paths < 50% length	1	5
Wheel Paths > 50% length	2	6
Entire Width < 50% length	3	7
Entire Width > 50% length	4	8

Standard evaluation section should be minimum 10% of road termini length i.e.; 1 mile = 500' rating section and be subjectively selected to represent the general road way condition.

Sufficiency Rating

The geometric information for each section of the road is maintained and used in this rating. The MCDOT Road Management Section collects sufficiency data for each arterial road. The rating identifies how each roadway segment compares to the MCDOT Roadway Design Manual (RDM) standards for each road segment's functional classification. The following information is maintained in the RMS for each road segment:

- Lane width
- Shoulder width
- Bottleneck features
- Drainage features
- Vertical sight distance
- Horizontal sight distance

The above information is then combined so that each road is scored on a scale from 1 to 100 with 100 representing a road in complete compliance with the RDM standards.

International Roughness Index (IRI)

International Roughness Index (IRI) is determined by a CLASS II direct profile measuring devise as classified in the Highway Performance Monitoring System (HPMS) Field Manual published by the Federal Highway Administration. IRI rating (inches per mile) is achieved by dividing the total roughness count by the distance measured and reported as a whole number.

MCDOT uses Laser Road Profiler (LRP) and a Distance Measuring Instrument (DMI) mounted in a two wheel drive vehicle. The LPR measures the vertical displacement (upwards and downwards) that the vehicle would experience traveling at the posted speed limit. This is accomplished by measuring with the laser the distance between the road surface and the laser pick up every three inches (seven and half centimeters). The road roughness is measured in tenths of an inch (two and half millimeters) increment and converted through the IRI software. The DMI accumulates and records the total distance traveled. To ensure accuracy, all equipment is periodically calibrated on MCDOT or ADOT test sections with established profiles.

This information is then combined so that each roads is scored on a sliding scale from 1 to 500 scale with 500 representing an extremely rough section of a road.

Work History Data

The work history on each roadway is kept in the surface treatment RCPA database maintained by the Road Inventory Section. Records of major construction and maintenance activities performed on pavements are maintained by MCDOT and contain the following types of information:

- Type of work
- Material used, types, and thickness
- Completion date

Traffic Volume Information

The MCDOT Traffic Engineering Section conducts all traffic counts for MCDOT. Raw traffic count information is converted to Average Daily Traffic (ADT) volumes on all roadways within the network. The County conducts annual traffic counts on a major portion of roads classified as either collectors or arterials. Local roads are counted as needed. This data is used to determine preservation strategies and traffic congestion levels throughout the County.

Preservation Strategies and Maintenance

The Preservation Strategy Table 1 (next page) confirms that providing timely preventive maintenance curtails roadway failure and reconstruction. While the total mileage in the system has decreased, the percentage of preventive or low maintenance strategies has remained stable. As the matrices in the following table shows a roadway's roughness and pavement conditions are the determinants as to what preservation strategy is necessary. Additionally, if a road is deemed insufficient (a rating below 40) then reconstruction is recommended.

Recommended Roadway Widening

The RMS not only uses traffic volumes to recommend improvement strategies but also widening suggestions. Each roadways number of lanes and accompanying average daily traffic (ADT) affect possible expansion. Roads that have two or less lanes and currently experience more than 5,000 ADT are recommended for study. Additionally, roads that are projected to have more than 7,000 ADT (2 lane) and 15,500 ADT (4 lane) within six years are also recommended. Future ADT counts are estimated by using current data compounded annually 3.5%. Table 2 shows an example of the reported generated by the RMS section for the TIP Review Committee, with the 47.51 miles of County roadways recommended for widening.

Table 1: PCR vs. IRI Preservation Strategy Matrix

Maricopa County Department of Transportation
Operations Division
Roadway Management System

PCR vs. IRI Preservation Strategy Matrix
ASPHALT CONCRETE PAVEMENTS

		IRI		
		<=95	<=170	>170
PCR	>=70	PM	PM	TO
	>=40	ST	ST	SO
	<40	TO	SO	RE

PCR vs. IRI Preservation Strategy Matrix
PENETRATION AND CHIP PAVEMENTS

		IRI		
		<=125	<=220	>220
PCR	>=70	PM	PM	TO
	>=40	ST	ST	SO
	<40	SO	SO	RE

PM = Preventive Maintenance	(Crack Seal and/or Fog Seal)
ST = Surface Treatment	(High Volume or Low Volume Chip Seal or Slurry)
TO = Thin Overlay	(<= 2" Asphalt Rubber Overlay)
SO = Structural Overlay	(>= 2" Asphalt Rubber Overlay)
RE = Reconstruct .	(Replace Pavement Structure)

All chip seals and overlays are repaired (patched) and crack sealed prior to resurfacing.
A "Sufficiency Rating" below 40 indicates a road section of poor design and will generate a recommendation to "Reconstruct"

Traffic volume also influence the recommended strategy, if projected ADT > 7,000 and the road section is two lanes then a "Reconstruct 2 to 4 lanes" strategy is generated.

PROJECTED (6) YEAR ADT = 3.50% Compounded Annually (22.8% / 6 years)
Section Line Collectors and higher.

	1995 ADT	2001 ADT
Source : Cathy Arthur, MAGTPO 5/22/95	5500	7000

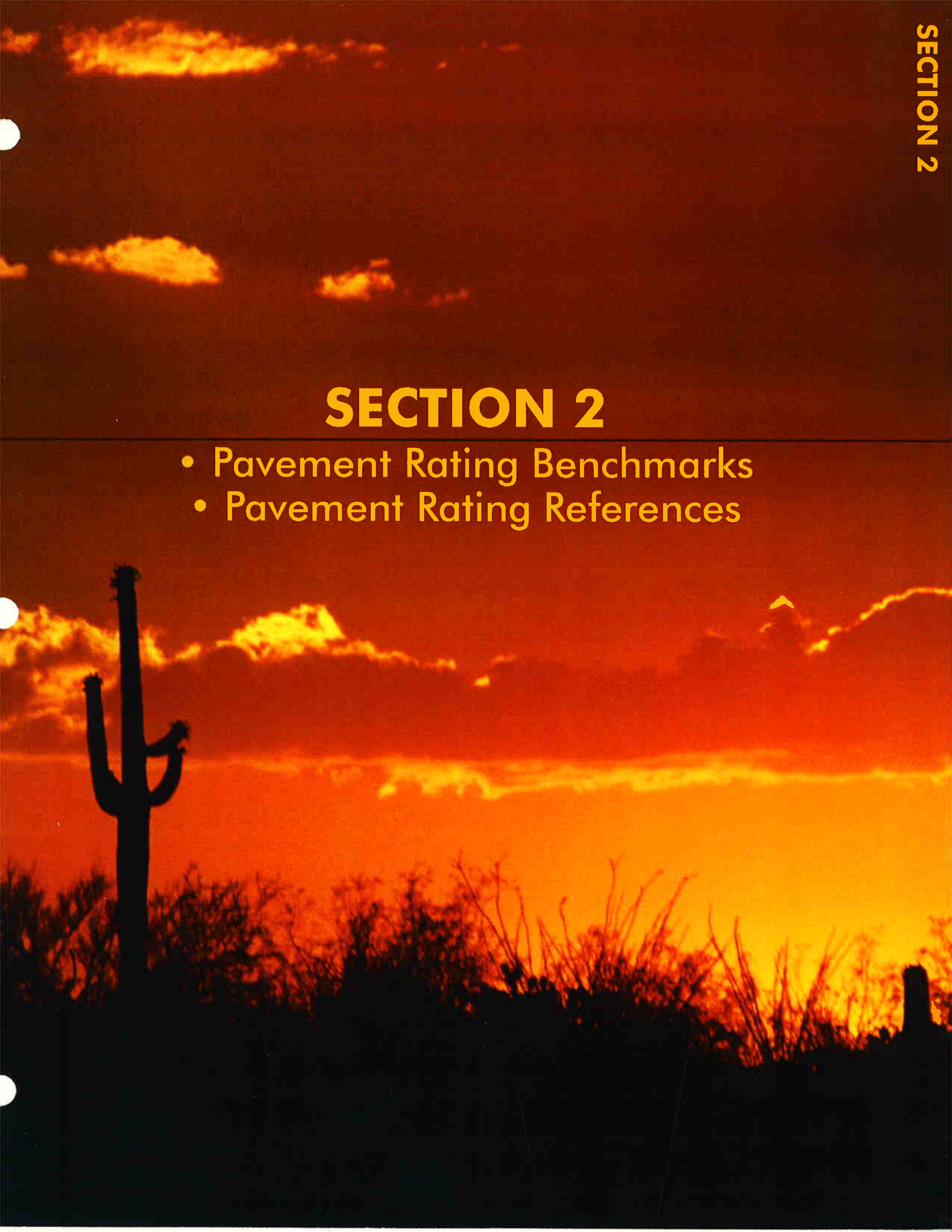
Mathematical models are used to generate recommended strategies, priority values and estimated cost for each road section for each of the next five fiscal years.

Road	From	To	Total Miles	ADT	Current Lanes	Future ADT
35th Ave	Baseline Rd	Southern Ave	1.00	5724	2	7029.07
56th St	I 10 Fwy	Gila River Indian Reservation	0.30	10879	2	13359.41
67th Ave	Pinnacle Peak Rd	Happy Valley Rd	1.00	7686	2	9438.41
83rd Ave	Peoria City Limits	Pinnacle Peak Rd	0.93	8740	2	10732.72
91st Ave	Camelback Rd	Northern Ave	3.00	19810	2	24326.68
99th Ave	Glendale City Limits	Loop 101	0.10	40038	2	49166.66
Alma School Rd	Mc Kellips Rd	Mcdowell Rd	0.68	6658	2	8176.02
Camelback Rd	El Mirage Rd	115th Ave	1.00	5937	2	7290.64
Carefree Hwy	7th Ave	52nd St	6.50	18514	2	22735.00
Cave Creek Rd	Phoenix City Limits	Cave Creek City Limits	0.90	16719	2	20530.93
Del Webb Blvd	Bell Rd	107th Ave	0.27	18651	2	22903.43
Ellsworth Rd	Empire Blvd	Germann Rd	5.00	6640	2	8153.00
Hayden Rd	Henshaw Rd	Mc Kellips Rd	1.00	24651	2	30271.43
Maricopa Rd	Queen Creek T. I.	I 10 Fwy	2.08	13656	2	16769.57
Mc Dowell Rd	Alma School Rd	Arizona Ave	0.77	13536	2	16622.21
Mc Kellips Rd	Mesa City Limits	Crismon Rd	0.51	5513	2	6769.96
Meridian Rd	Broadway Rd	Apache Tr	0.50	8477	2	10409.76
Northern Ave	115th Ave	Loop 101	2.12	9335	2	11463.38
Olive Ave	Reems Rd	Dysart Rd	3.00	6309	2	7747.00
Olive Ave	El Mirage City Limits	99th Ave	3.01	15204	2	18670.50
Peoria Ave	111th Ave	Peoria City Limits	2.00	9923	2	12185.00
Recker Rd	University Dr	Adobe Rd	0.50	10613	2	13032.76
Riggs Rd	I 10 Fwy	Price Rd	1.57	12355	2	15171.94
Rittenhouse Rd	Williams Field Rd	Recker Rd	0.95	6216	2	7633.25
Rittenhouse Rd	Power Rd	Ellsworth Rd	3.71	9235	2	11340.58
Southern Ave	35th Ave	27th Ave	1.00	5886	2	7228.01
Thunderbird Blvd	98th Ave	Peoria City Limits	0.49	20844	2	25596.43
Union Hills Dr	107th Ave	99th Ave	0.62	12177	2	14953.36
University Dr	Ellsworth Rd	Meridian Rd	3.00	18633	2	22881.32

Total Miles **47.51**

SECTION 2

- Pavement Rating Benchmarks
- Pavement Rating References



Metropolitan Transportation Commission

Street Talk

Volume 15 Number 2 | Current Issues in Pavement Maintenance and Management | July 2002

A Snapshot of the Region's Pavement Condition

by Theresa Romell

The pavement management staff at MTC has put together a summary of current pavement conditions as a precursor to the comprehensive "state of streets and roads" report MTC issues annually for the Bay Area. The findings show that, while 59 percent of Bay Area roads are in "Good" or better condition, 16 percent of the Bay Area's local streets and roads fall into the "Fair" category, and are in need of immediate repair. Sixteen percent are in the "Poor" or "Very poor" category, meaning that they require resurfacing or reconstruction and are very difficult to drive on.

Inside:

- *Improving Pavement Projections page 2*
- *MTC Selects Projects for P-TAP Round 4 page 3*
- *What Is FDR? page 3*
- *Upcoming Events page 4*
- *Software News and Information page 4*

The information for the MTC summary comes from databases received from jurisdictions using MTC's pavement management software, primarily through the Pavement Management Technical Assistance Program.

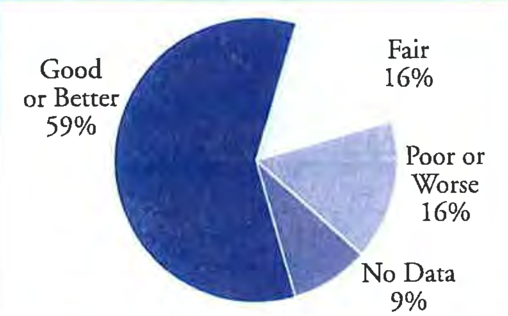
The unit of measure used to rate the condition of pavements is the pavement condition index (PCI), which rates pavements on a score of 0 to 100. A higher value of PCI indicates a better pavement condition.

Excellent: PCI 90–100 Pavements are most likely newly constructed or resurfaced and have few or no distresses.

Very good: PCI 75–89 Pavements require mostly preventative maintenance and have only low levels of distress such as minor cracks or surface flaking.

Good: PCI 60–74 Pavements exhibit some low-severity distresses but still have satisfactory ride quality. Pavements at the low end of the "Good" range have significant levels of distress and may require a combination of rehabilitation and preventative maintenance to keep them from deteriorating rapidly.

Pavement Condition of Local Roadways



Fair: PCI 45–59 Pavements are deteriorated and require immediate attention, including rehabilitative work; ride quality is significantly inferior to the better pavement categories above.

Poor: PCI 25–44 Pavements have extensive amounts of major distresses and require rehabilitation or reconstruction. Pavements in this condition significantly affect the speed and flow of traffic.

Very poor: PCI 0–24 Pavements need reconstruction and are difficult to drive on.

continued on page 2

Bay Area Local Streets and Roads Mileage/Condition

Condition	Excellent	Very Good	Good	Fair	Poor	Very Poor	No Data	Totals	Avg. PCI
Miles	2,648	5,626	2,945	3,000	1,591	1,533	1,660	19,003	66
Percent	14%	30%	15%	16%	8%	8%	9%	100%	

Join Us for Our User Week Awards Luncheon

July 22
12 noon
MTC Auditorium

RSVP 510.817.3201

Improving Projections for Pavement Needs and Shortfalls

by Theresa Romell

As an advocate for local streets and roads in the Bay Area, MTC is seeking to put together new projections that will illustrate as precisely as possible the region's pavement needs, revenues and shortfalls through the year 2007.

Our goal is to greatly increase the accuracy of our projections so that they can be used as a reliable tool by jurisdictions seeking funding for local streets and roads. We think this can be achieved in three ways. Two of these require your help and cooperation:

1) The more databases we include the better. We now have 102 jurisdictions actively utilizing MTC's pavement management software, as opposed to only 39 active users in 1998. This means that we have more experience and information to draw on to make our projections.

2) Verifying the information we already have about pavement conditions and revenues will help ensure that we are relying on the latest and best numbers available. MTC will begin contacting jurisdictions later this summer to launch this phase of the work.

The third element in improving projections is to limit our projections to a shorter time frame, covering a 5-year period as opposed to the 25 years we have used in the past. By reducing the length of time covered, we increase the confidence that our numbers are statistically valid.

Accurate projections benefit cities and counties that are trying to make the case for funding streets and roads in an era when public service budgets are shrinking and competition for local, state and federal transportation funds is growing. Improved streets and roads projections will serve as ammunition in the battle for a fair share of public moneys.

As many of you know, MTC has published projections on several occasions in the past. Most recently, MTC's pavement management staff produced 25-year projections for the Bay Area *2001 Regional Transportation Plan*. While these projections were done with a great deal of care, we hope that, with your help, the pavement management annual report that we expect to complete by the end of the year will be the most accurate and useful that we have done to date.

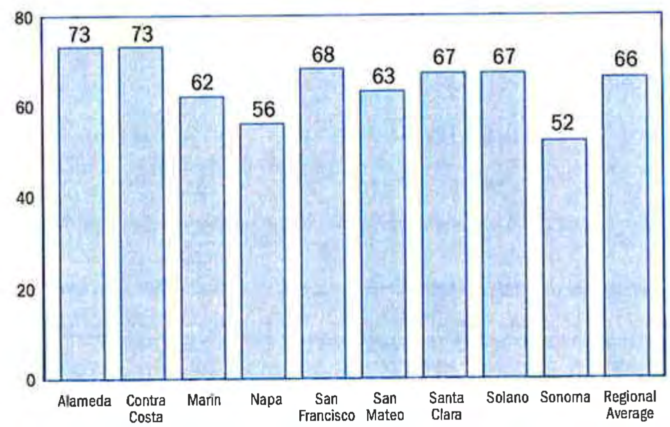
A Snapshot of the Region's Pavement Condition

continued from page 1

Based on the available data, the Bay Area averaged a regionwide PCI of 66, placing the general condition of the region's pavements in the "Good" category. Although this seems like a positive rating, it is only a few points higher than the threshold at which a significant amount of maintenance and rehabilitation will be required: Rapid deterioration of pavements typically occurs after roadways drop to a PCI score of 60 or lower.

MTC's summary shows that, while no Bay Area jurisdiction's pavements have yet reached the top rating of "Excellent," some are getting close. The cities of Belvedere and Los Altos have achieved the upper stratum of the "Very good" category, with a PCI of 86, and Brentwood and Oakley are not far behind, with a PCI of 85 and 84 respectively. Rounding out the top six are Contra Costa County and the city of Santa Clara, each with a PCI of 80.

Average Pavement Condition Index by County
(includes counties and cities)



In compiling the data for its summary of Bay Area pavement conditions, MTC did not use information about jurisdictions that do not use MTC's pavement management software or those that did not provide updated pavement condition information.

The exceptions to this are the jurisdictions of Larkspur, San Rafael and San Francisco. While the former two do not use MTC's software and San Francisco is too new an MTC PMS user to have converted its data from its old system, the pavement condition data of all three were correlated to MTC's PCI scale in order to be able to include their information in this summary.

For a full description of the method used to determine pavement conditions, contact Theresa Romell at 510.817.3243 or tromell@mtc.ca.gov. The method used also will be described in detail in MTC's pavement management annual report, due out at the end of 2002.

BAY AREA

Bay Area Jurisdictions Falling Behind in Roadway Repairs; Some Bright Spots

- Typical pavement conditions on the Bay Area's roughly 19,000 miles of local streets and roads continued their slow but steady deterioration in 2003, with the average pavement condition index (PCI) score dropping to 63 (out of a possible 100) from 65 in 2002 and 66 in 2001.

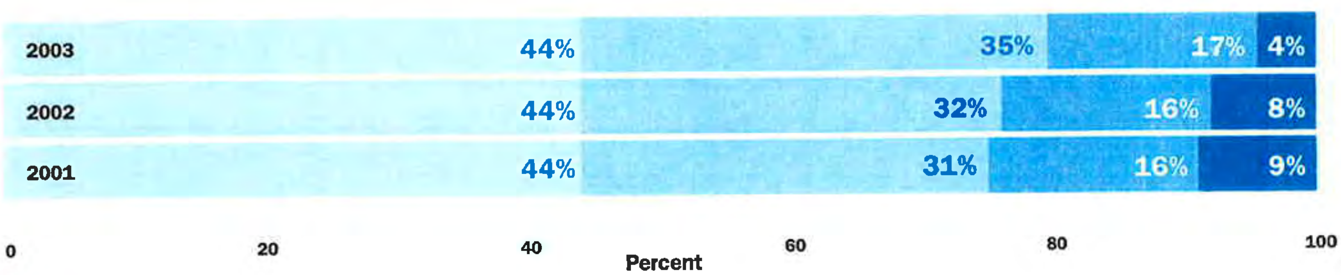
- The share of pavements rated "excellent" or "very good" remained steady at 44 percent of Bay Area roads in 2003. These roads require preventive maintenance only. Pavements in "good" or "fair" condition – which require some rehabilitation but are still drivable – increased to 35 percent from 32 percent a year earlier. Pavement in "poor" or "very poor" condition, which needs extensive rehabilitation, increased from 16 percent to 17 percent.

- The increases in pavement rated less than very good are small, but they are significant enough to tip the regional average downward. And while the average falls into the "good" category, it is sliding toward the lower end of this range.

- At present, the Bay Area is not spending the money needed to maintain the condition of its pavement over time. Tight city budgets – and the failure of the state to pass along road maintenance funds authorized by the voters in 2002 – have forced many jurisdictions into a "worst first" approach in which only the streets in the worst condition are repaired and preventive maintenance is foregone. This approach is increasingly expensive over time, since the cost of major repairs is about five times that of routine maintenance.

- MTC estimates a current, cumulative backlog of $2.9 billion for local street and road repairs in the Bay Area. This represents the cost of upgrading pavement to the point where it is cost-effective to maintain, typically when PCI scores fall within the range of 75 to 85.

Pavement Conditions for Local Roadways, 2001 – 2003 (total pavement miles)



Excellent (PCI = 90–100) or Very Good (PCI = 75–89)
Pavements that have no distress and require mostly preventive maintenance

Good (PCI = 60–74) or Fair (PCI = 45–59)
Pavements in this middle range offer acceptable ride quality, though road surfaces are becoming worn to the point where rehabilitation is needed to prevent rapid deterioration.

Poor (PCI = 25–44) or Very Poor (PCI = 0–24)
Pavements that have extensive amounts of distress and require major rehabilitation or reconstruction

No Data

2003 Bay Area PCI = 63
The regional PCI score is an average of the scores of all participating jurisdictions, weighted by centerline miles.

Source: Metropolitan Transportation Commission

97 cities and nine counties reporting

PCI = pavement condition index, a measure of pavement distress

55 of 106 jurisdictions provided updated databases to MTC for 2003. For other jurisdictions, MTC used its pavement management system software to project 2003 conditions based on the latest data available.

A Closer Look at Bay Area Jurisdictions with the Best and Worst Pavement Conditions

- The cities and counties with the best and worst average pavement conditions in 2003 are listed here.
- The cities of Belvedere and Dublin each made their first appearance in the top 10.
- The cities of Petaluma and Sausalito, which ranked near the bottom in previous reports no longer appear in the bottom 10.

A Closer Look – The Bay Area jurisdictions with the best and worst average pavement conditions are shown below. Often a jurisdiction's low average pavement condition rating is the result of a roadway maintenance budget that is insufficient to cover a backlog of needs.

Bay Area Jurisdictions With Best and Worst Pavement Conditions, 2003

	Best	2003 PCI[1] (out of 100)		Worst	2003 PCI (out of 100)
1.	Oakley	87	96	Larkspur	55
2.	City of Santa Clara	86		San Mateo	55
	Contra Costa County (unincorporated)	86		City of Napa	55
				Half Moon Bay	55
4.	Sunnyvale	84	100	Vallejo	54
5.	Los Altos	83	101	Marin County (unincorporated)	53
6.	Brentwood	82		Richmond	53
	Belvedere	82	103	Monte Sereno	52
8.	Dublin	81	104	Colma	50
9.	Fairfield	80		Hillsborough	50
10.	**Foster City**	**79**	106	Sonoma County (unincorporated)	47

Source: Metropolitan Transportation Commission

106 of 109 jurisdictions reporting

[1] PCI = pavement condition index; PCI of 100 = Excellent

Streets and Waterways Division

CITY OF OXNARD ■ PUBLIC WORKS DEPARTMENT ■ STREETS AND WATERWAYS DIVISION ■ UPDATED APRIL 16, 2004

PAVEMENT *Management*

Program Description

The Streets and Waterways Division performs an annual assessment of streets and alleys within the City limits. The results of this evaluation are used to develop the ongoing street maintenance Five Year Capital Improvement Project (CIP) Plan. This plan prioritizes street maintenance and repair (M&R) projects based on the Division's pavement management system (PMS).

Definition of Pavement Management

Pavement management is the process of evaluating and tracking the conditions of streets, identifying when streets require maintenance and choosing the appropriate maintenance for those streets. It also includes budgeting for street maintenance funding and conducting inventories of street assets. It provides a systematic and objective method for determining priorities and the optimal time for repair.

Purpose of a Pavement Management System (PMS)

All streets deteriorate over time and will eventually require some form of maintenance. The timing and type of maintenance needed for any given street depends on several variables including the condition of the street, the type of traffic on the street and the structural properties of the street. A pavement management system tracks and quantifies these factors. This provides the Division with helpful information used to decide which streets require maintenance, when to perform the maintenance and how much it will cost. The primary uses of a PMS are planning and budgeting; other tools are used to design projects.

Pavement Management Software

The Division uses software developed by the American Public Works Association (APWA) called MicroPAVER. This software is a modified version of the Army Corp of Engineers' PAVER software that was developed for the management of pavement on military bases. MicroPAVER is widely used by cities as a PMS.

Pavement Condition Index

The basis for the pavement management system is the Pavement Condition Index (PCI). Streets are ranked on a PCI scale of 0 to 100. New pavements with no defects receive a score of 100. From this score, the MicroPAVER software deducts points based on the type and severity of defects identified during a visual inspection. After the initial PCI for a street segment is calculated, MicroPAVER predicts future PCI by reducing the PCI on an annual basis using deterioration curves. Photographs of streets with various PCI's are shown below in Figure 1 and typical deterioration curves are shown in Figure 3 on page 2.

Figure 1
Typical street condition for various PCI ranges.

City of Oxnard
Public Works Department
Streets and Waterways Division

Paving the Way

(805) 385-8051
1060 Pacific Ave., Bldg. 2
Oxnard, California 93030-7337

·w Streets are Rated

On each street, a representative area of approximately 2,500 square feet is chosen. The area is examined for any of eight typical defects. If a defect is present, its severity is rated (Low, Medium or High) according to predetermined standards. The severity of the defect(s) is entered into MicroPAVER and it calculates a PCI for the street.

Pavement Defects

Pavement defects are caused by fatigue, aging and construction activities. Vehicles passing over the pavement cause fatigue that can lead to alligator cracking, rutting and shoving. Over time, water and sun cause aging that can lead to block cracking, longitudinal and transverse cracking, weathering, and raveling. A combination of fatigue and aging can cause bumps and sags. Construction activities and utility repairs often involve patching and utility cuts. All of these defects affect the quality of the pavement and reduce the PCI rating.

Types of Streets

Each street in the City is categorized as residential, collector, 'erial, industrial or alley based on use and traffic volume. .sidential streets are those streets within residential developments and neighborhoods. These streets tend to have low traffic volume and deteriorate mostly from aging. Residential streets can last 25 to 30 years* before requiring resurfacing. Collector streets are those streets connecting residential areas to the arterial streets. These streets have medium traffic volume and deteriorate from both aging and fatigue. Collector streets require resurfacing every 20 to 25 years*. Arterial streets are the major streets running across the City and have high volumes of both automobile and truck traffic. These streets tend to deteriorate from fatigue and can last 15 to 20 years*. Because of higher traffic volume and higher speeds, arterial streets need to be maintained at a higher PCI. Industrial streets are located in industrial areas and have characteristics similar to collector streets. Alleys have characteristics similar to residential streets. Figure 2 lists some characteristics of each type of street.

**Lifetime figures assume regular maintenance. Useful life without regular maintenance will be 5 to 10 years shorter.*

Typical Street Condition Deterioration Curve

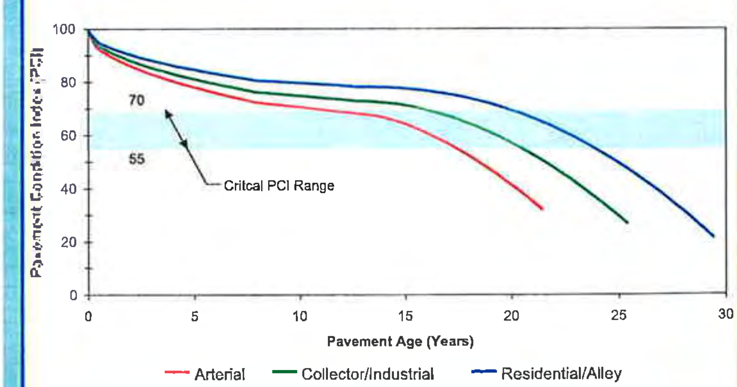
The life of a street can be represented by a curve on a graph in Figure 3. Time is on the horizontal X-axis and the PCI is on the vertical Y-axis. The condition of the street drops from "Brand New" to "Very Good" quickly but then levels off for some time (represented by the relatively flat part of the curve). As the street continues to age, the condition reaches a point where the PCI decreases more quickly (the curve begins to get steeper). This critical point ranges from a PCI of 55 to 70. If a street is maintained at or before it's condition reaches this point, the condition of the street will improve and the curve will flatten out again. Typically, maintenance procedures at this point are more cost effective. If nothing is done to the street in the critical range, the deterioration progresses more rapidly and, in a short time, the cost to fix the street goes up by four or five times.

Figure 2
Characteristics of types of streets.

Street Type	Traffic Volume	Major Cause of Deterioration	Life* (years)
Arterial	High	Fatigue (from vehicle loads)	15-20
Collector/Industrial	Medium	Fatigue & Aging	20-25
Residential/Alley	Low	Aging (from Weather & Time)	25-30

*Assumes regular maintenance. Useful life without regular maintenance will be 5 to 10 years shorter.

Figure 3
Typical deterioration curves for different types of streets.



aintenance and Repair (M&R) Techniques

There are several types of maintenance and repair (M&R) techniques that fall into three categories; Localized, global and major repair. Localized maintenance techniques can be used as preventative maintenance or as stopgap measures when adequate funding is not available. These include pothole filling, patching and crack sealing. Global preventative maintenance techniques include fog seal, slurry seal, chip seal and cape seal. These preventative maintenance techniques will slightly improve the quality of the street, but more importantly, they will reduce the rate of deterioration and prolong the life of the street. Major repair techniques include cold milling, overlay and reconstruction. These techniques are used when a street has reached the end of its useful life to restore it to "Brand New" condition.

Choosing M&R Techniques

The M&R technique chosen to maintain a street depends on the type and condition of the street. Figure 4 lists various M&R techniques and the appropriate PCI ranges for -ing them on each type of street. For example, slurry als are generally appropriate for arterial streets with a PCI of 76-90, while collector streets with a PCI of 41-70 might receive a light overlay and residential streets with a PCI of 51-70 might receive a cape seal.

M&R Cost Trend

Figure 5 gives the cost for various M&R techniques as of November 2003. Comparing Figures 4 and 5, notice that the cost of M&R increases significantly as pavement condition worsens. This can be seen clearly in Figure 6. The X-axis of the graph in Figure 6 is the pavement age. The Y-axis is the PCI and the cost to repair. The green curve is a typical pavement deterioration curve, showing how the PCI decreases as the pavement ages. The red curve gives the cost to maintain that pavement as it ages. For example, at 15 years, the PCI is about 70 (green curve) and the M&R cost is about $13 per 10 SF (red curve), at 20 years, the PCI is 55 and the cost is $29 and at 25 years, the PCI is 30 and the cost is $72. As the condition of the street deteriorates, the M&R cost increases exponentially. The most cost effective time to perform maintenance is when he pavement condition is between 55 and 70, before the st begins to rise rapidly.

Figure 4
Typical PCI ranges for M&R techniques.

Maintenance & Repair Technique	Street Condition	PCI Range* Arterial	Collector	Residential
No Maintenance Required	Very Good	91-100	91-100	86-100
Slurry Seal	Good	76-90	71-90	71-85
Cape Seal	Fair	NA	NA	51-70
Light Overlay		56-75	41-70	41-50
Heavy Overlay	Poor	31-55	26-40	21-40
Reconstruction	Very Poor	0-30	0-25	0-20

*Ranges vary depending on factors including street maintenance history, subgrade conditions and drainage pattern.

Figure 5
Cost for various M&R tecnniques.

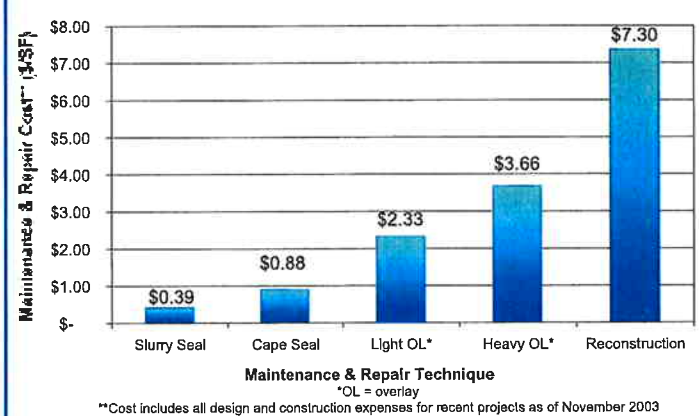
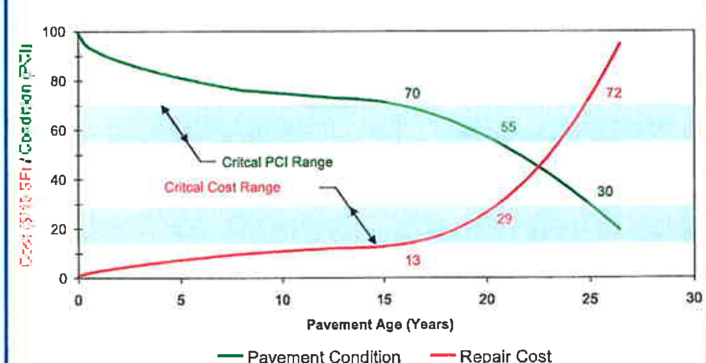


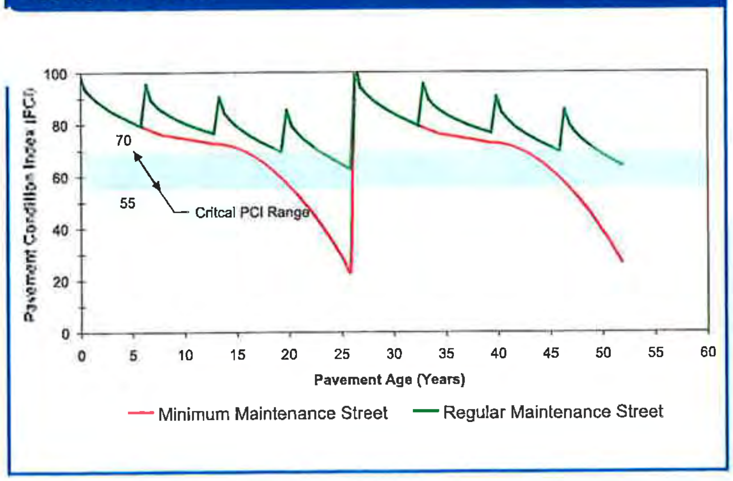
Figure 6
Repair cost increases greatly as PCI decreases.



M&R Life Cycle Cost (LCC)

e best measure of M&R cost effectiveness is the life cycle cost CC) defined as the present value of an M&R program over the life of a street. Figure 7 shows the pavement condition over time for two different M&R programs on a typical residential street. The red curve shows the condition of a street with minimum maintenance and the green curve shows the condition of a street with regular maintenance. In this example, the street represented by the red curve deteriorates for 26 years until its condition reaches a PCI of 25. At that point, the street is reconstructed. The green curve shows the condition of a street that receives two slurry seals and a cape seal at equal intervals over 26 years. Its PCI is then 64, at which point, the street receives a light overlay. This process is repeated over the next 26 years. The LCC over 52 years for the street represented by the green curve is $2.85 per SF and the LCC for the red curve is $4.54, which is 59% higher. This example shows that performing regular maintenance is actually much less expensive in the long run. The curves also show that the condition of the street represented by the green curve is much better. Its average PCI is 79, whereas, the street represented by the red curve has an average PCI of 68. So, performing regular maintenance is not only less expensive, it also provides higher quality streets.

Figure 7
Street maintenance life cycle comparison for a typical residential street.



Pavement Management Approaches

The three main approaches to pavement management are ad hoc, present condition and life cycle. For the ad hoc approach M&R techniques are chosen based only on past practice. Techniques that have been successfully used in the past on similar streets are selected. This technique is fast and requires little analysis, but may not give the most cost effective solution. In the present condition approach, the pavement is first evaluated. Then, based on the condition analysis, an M&R technique is selected. This approach is better at identifying M&R techniques est suited for the street, but it still may not produce the most st effective solution in the long run. The life cycle approach requires not only an evaluation of the current condition of the pavement, but also a prediction of its future condition. This approach not only selects the best M&R alternative, but also indicates the optimal time to perform it. Properly using this approach will produce the lowest LCC maintenance program.

Pavement Management Strategies

Three different strategies may be used to implement a pavement management approach. The first two are interim strategies used when adequate funding is not available for a comprehensive M&R program. These are Best First and Worst First. In the Best First strategy, streets are prioritized based on PCI. The streets with the highest PCI's are maintained first. The objective here is to keep the best streets in good condition until adequate funding is available to maintain all of the streets. This strategy works well when the poor condition streets are already in the PCI range requiring the most expensive maintenance. When this is the case, waiting to repair these streets will not significantly increase the cost. In the Worst First strategy, streets with the lowest PCI's are maintained first. The objective is to put all available resources into the streets that need the most M&R. This strategy works well when additional funding will be available soon so that good streets will not have time to deteriorate below the critical range, which would greatly increase their repair cost. In the third strategy, Critical PCI, M&R techniques are selected for streets at the critical point in each PCI range. The critical point is the lowest PCI at which an M&R technique will be effective. For example, for a residential street, Figure 3 shows that the critical point for a slurry seal is a PCI of 71, the critical point for a cape seal is 51 and the critical point for a light overlay is 41. In the Critical PCI strategy, only streets with conditions near a critical point are maintained. This strategy is used with the life cycle approach to produce the lowest LCC maintenance program.

Practical Considerations

There are two practical considerations in implementing a pavement management system. First, evaluating street conditions is time consuming and costly and, therefore, not all streets are inspected every year. A common schedule is to evaluate all arterial streets every year and to evaluate one-third of the rest of the streets each year, so that every street is evaluated in a three-year period. Another consideration is economy of scale. It is less expensive to perform M&R on groups of streets in the same area than on individual streets spread throughout an entire city. Therefore, streets requiring maintenance in similar time periods are often grouped together into neighborhood projects. This saves on contractor mobilization costs and reduces inconvenience to residents.

Street Maintenance Five Year Capital Improvement Project (CIP) Plan

The Division performs a pavement assessment each year and updates the ongoing Five Year CIP Plan based on projected street maintenance revenue. The CIP plan is used to develop specific street repair projects about two years before scheduled start of construction.

YUMA
YUMA

Fay, Jerry

From: LaFronz, Nicholas J.
Sent: Friday, September 16, 2005 11:15 AM
To: Fay, Jerry
Subject: Pavement Degradation Curves - Yuma County Public Works
Attachments: Donahue_paper_Yuma_County_Pavement_Asset_Mgmt_2001.pdf

Jerry,

Attached is the paper by Donahue Consultants in Yuma, from a 2001 annual conference (Geospatial Information and Technology Assoc, or GITA).

Based on my read of the paper, Yuma County has in fact developed pavement degradation curves for one or more classes of County roadways.

I never did follow-up, however, to try and locate an individual within the County Dept of Public Works who might know more or have access to the curves and supporting data.

- Nick

JASON PHIPPS - YUMA COUNTY
- UTILIZE 8 FACTORS TO RATE PAVEMENT
- SCALE 0 - 100
- DESIRED 100% > 75

Print

Yuma county, AZ. Public Works Department Automated Asset Management System

James G. Donahue
Donahue Consultants
2755 South Mesa Avenue, Yuma, AZ 85364

Introduction

The Yuma County Department of Public Works has embarked upon the information super highway by bringing computer-based technology into the County Asset Maintenance Management System. The former manual system was cumbersome and needed modernization in order to optimize expenditures for County asset maintenance. A study was performed and a "Pilot Project" was completed in 1998, which demonstrated that an off-the-shelf computer-based software package, utilized to establish a database of the current condition of all public works physical assets, will "in fact" save tax dollars over the old manual system at a Cost/Benefit ratio of at least 3:1.

Yuma County DPW Statistical Items 1500 miles of gravel or dirt roads 500 Miles of paved highway Yearly Maintenance Includes 50 miles of Chip Sealing 10 Miles of Slurry Sealing and 10 Miles of Plastic Sealing 300 Miles of Striping and Hole Patching Maintains 12,000 Signs and 3,000 Bridges and Canal Crossings, all with six Clerks, two Administrators, four Technicians, 4 Foreman, and 80 Maintenance personnel.

Project Definition

Land Base Design: In setting up specifications for the accomplishment of the "Pilot" Study, both the City and County of Yuma Mapping/GIS Units were contacted to make sure that "Land Base" integration would be accomplished as a "by product" when the entire AMS Project was completed. This integration is needed to make sure that all geographic-based information generated by one agency can be utilized by others without rigorous and time-consuming transformations between unlike systems. The land Base being used by both the City and County Mapping Units is based on the United States Public Land Survey System of Sections, Townships, and Ranges from the Initial Point on the GILA MERIDIAN AND BASELINE, which governs land descriptions in Yuma County. The PLSS is digitally integrated to the Arizona State Plane Coordinate System (NAD 1927). This coordinate system has been used due to the fact that most cadastral data now available, without doing new control surveys over the entire County, was identified earlier by other agencies of government for mapping purposes.

It is highly recommended that this project be fully integrated with the ASPCS/NAD'83 when it is adequately densified on the ground by Global Positioning System (GPS) technology.

Public Land Survey Identification: In order to utilize the PLSS, the ASPCS, and the Asset software modules (ASM) requirements, all at the same time, a digital system of numbering is being utilized to identify Section and Quarter Section corners of the PLSS that will tie directly to the ASM requirements for line segmentation and identification. The known coordinates of the ASPCS/NAD'27 are input within the ASM line segments, with node identification input fields. This is a beneficial aid in the identification of cadastral parcels on the current Assessment Rolls and located along any given road or highway. Also, current GIS software can easily be implemented within the AMS for specific spatial analytical tasks related to geography.

Asset Management Modules

Pavement Management Module: The Pavement Management Module provides a systematic, consistent method for determining maintenance needs, priorities and the optimal time of repair. Early detection and repair of a roadway distress are extremely important in reducing long-term maintenance costs. Most pavements exhibit a deterioration rate that accelerates as they reach advanced age. When examining deterioration curves, it becomes clear that significant maintenance costs can be saved if remedial action is undertaken prior to a roadway reaching the steep decline in condition. The Pavement Management Module is used to track the life cycle of road segments in the network and to highlight segments in need of attention. In Network-Level–In Network-Level management, the entire roadway network is considered for budgeting, planning, scheduling, and selection of maintenance projects. Sufficiency Inspections are periodically conducted for all segments in a network. These inspections are fast and easy observations of condition, geometry, safety, ride, etc. Ideally, inspections should occur before the segment begins the sharp decline in condition and at a point where timely maintenance can still be scheduled. The Critical Pavement Condition Rating (PCR) value can be used to evaluate the need for preventive and major maintenance. The critical PCR value occurs at the point where the condition of a segment begins to deteriorate at an accelerating rate. Typically, the maintenance costs increase dramatically once a segment reaches this point. It is advantageous to begin maintenance efforts before the Critical PCR is reached.

Today, upper management is more demanding of management techniques that consider the needs of the entire network. With money in short supply, it is imperative that the greatest benefits are achieved from each dollar expended. Network-Level analysis complements Project-Level analysis to arrive at the required conclusions.

Deterioration : The Deterioration Matrixes within the AMS allows you to define a Deterioration Curve that is associated with each Pavement Class. Once defined, these Deterioration Curves can be referenced elsewhere in the PMS application. You may create one Deterioration Curve for each Pavement Class.

A Deterioration Curve is a model of how the condition of segments that belong to a Pavement Class will deteriorate over time (on the average). With a Deterioration Curve defined for a Pavement Class, individual road segments can be compared to the curve to determine performance/ life expectancy.

The Deterioration Curves are most accurate when they are developed from local historical data.

Pavement Analysis Module: Assists in creating multiple CIP planning models and "what if" type scenarios and Generates multi-year budgets and maintenance profiles. Also assists in the preparation of MR&R decision trees, calculating cost vs. Benefit scenarios, predicting performance of individual assets, and aids in projecting funding to achieve overall agency goals.

Safety Signage and Markings: Is a complete inventory of signs, mountings and pavement markings. It yields a complete GPS/GIS location and identification for spatial analysis and mapping of individual assets. It supplies a complete history log of events with attached images and videos. It also supplies queries, reports, and cost of materials analyzes along with access to predefined sign and marking libraries.

Bridge and Culvert Module: It provides a complete bridge and culvert inventory along with inspection records by category. It provides a complete structure history with database rollback queries and reports. Also, provides full English and Metric support, while maintaining a complete structure inventory and appraisal information (si&a). It also supplies complete support for FHWA, NBI and PONTIS data.

Asset Manager Module: It is the "Workhorse" of all of the AMS for it serves as a clearing house for all managed assets. Records labor, equipment and material costs. It relates work activities to specific work orders. It projects and tracks maintenance schedules. It furnishes customized queries and reports while tracking inventory levels. It also tracks public complaints and generates work requests/orders. It may contain standard operating procedures (Cook Book) for most all types of maintenance work. This is truly the "work horse" of the system.

New Techniques and Developments

Voice Activated Data Collection: It provides vocabulary building capabilities and GPS on the fly locations. Captured data downloads data directly into predefined data bases with no more manual data input except for QA/QC. This technology speeds up the data collection and data processing by about 3x.

Voice Recognition Technology 101: It interprets spoken words and converts it to text while associating an asset or other item with their exact physical location via GPS/GIS. It stores data in an RDBMS using key fields to relate one record with another. One simply tells the laptop field computer what you see and it will record the field data as defined in the vocabulary dictionary. In the office one downloads the data to your office computer and performs QA/QC to check the accuracy of data being exported to the proper asset management module.

Advantages of Desktop Asset Management

- ***Low Cost:*** $1000 To $15000 depending on the number of Modules.
- ***Short Learning Curve:*** 1 TO 6 Months for an intermediate computer operator with a technical background, depending on the number of modules being implemented at one time.
- ***Software Technology:*** Windows Based in 16 bit or 32 bit versions.
- ***Predefined Forms:*** For any amount of Data collected.
- ***Predefined Tools:*** For Editing, Analysis and Reporting.
- ***Ease of Integration:*** With GIS and other Mapping tools

After Thoughts/Lessons Learned

When undertaking an Asset Management project like this, be aware that several months research and study must be done before buying into any particular software. Unless your agency is a very large agency, an off-the-shelf software package will probably yield the best results for the time and money spent. Also, one should "Bench Mark" test the top 3 packages identified to see which one will perform the best in your specific environment. We did not do this and we suffered the consequences of a lot of down time to fix problems we didn't know we were going to have. By doing a "Pilot Project" one can better make a more intelligent judgment on the best package to use. Once the decision is made to buy a specific package, a decision as to how to best implement the system is a major item to consider. We at Yuma County did this one module at a time because of a lack of in-house resources to do anything else. However, if the money and the physical resources are available, and can be utilized, it is strongly suggested that the most needed modules be implemented at the same time to save duplicating trips into the field to gather data for one module without getting everything needed for several modules. Inspecting Roads, Bridges, Culverts, and Traffic signs can be done at the same time, on the same segment of highway, using two technicians. By implementing only one module at a time, both time and effort is duplicated.

Thirdly, it has been found that a stand alone Asset Management Server is the best solution to avoiding down time. Having data base sets out on a large Network, tends to slow done production and often corrupts certain types of data. This means daily backup is mandatory and become very time consuming to reset back to a certain date and time. Lastly, make sure your vendor offers great technical support. The 1-800 phone number does not usually give you the timely response needed to identify specific remedies to problems that can arise without warning at times. Using Internet (EMail) messaging can be faster when attached digital files can be immediately examined by technical support personnel. Even a faxed document showing the problem you are having is better than trying to explain everything over the phone. Sometimes a combination of all three methods is required to solve problems as quickly as possible.

Conclusion

One thing is clear to all who manage Public Works Assets--maintenance funds are becoming increasingly difficult to come by. As a result, improved methods for determining maintenance needs and priorities are required. It is no longer acceptable to focus on short-term repair techniques. Greater emphasis must be placed on selection of remedies that provide the greatest long-term benefits. Today, upper management is more demanding of management techniques that consider the needs of the entire set of Assets. With money in short supply, it is imperative that the greatest benefits are achieved from each dollar expended. Network-Level analysis complements Project-Level analysis to arrive at the required conclusions.

Street Maintenance

Events | Forms
Jobs | Maps
e-Services
Departments & Divisions

- About Us
- FAQs
- Getting Around
- Planning & Project Review
- Public Transit
- Street Maintenance
- Traffic Calming
- Traffic Engineering Guidelines
- Traffic Management
- Report Street Damage
- Transportation Home

The Field Operations staff is responsible for maintaining city streets. This includes repairing street infrastructure, sidewalks, curbs and handicap ramps, performing street sweeping services, maintaining alleys, shoulders, streetlights, street signage and striping, and providing street patching and overlay service.

Want to know just how far your tax dollars actually stretch in terms of street maintenance services? Read about what street maintenance crews are able to do with only $3 per resident, per month!

Contract Administration

The Contract Services Group monitors service contracts with private vendors for landscape maintenance, mainline street sweeping, asphalt and concrete repair, and bus shelter cleaning. Outside vendors competitively bid for City of Mesa contracts, allowing the Division to cost-effectively supplement City staff operations.

Pavement Management System

Report:

Report a Problem

Pothole
480-644-3038

Streetlight Outage
480-644-3191

Street Sign Missing/Damaged
480-644-3038

Traffic Signal Outage
480-644-2160

Graffiti
480-644-3083

After Hours
480-644-2262

One of the street maintenance functions of the Field Operations group is to preserve the condition of paved streets in the best possible state. Pavement Management is the key to developing preventative maintenance strategies and operational activities. The Pavement Management Program is an Information Management System, which allows staff to track the changing inventory levels, history, surface condition and distresses of every street in the City.

Pavement condition surveys are performed each year on over 1,200 miles of streets by our Pavement Management technicians. Information from the annual surveys identifies specific areas where various types of preventive maintenance treatment, such as slurry seal, acrylic seal or other sealcoats, can be applied. The surveys also identify areas requiring more aggressive rehabilitation projects like a rubberized asphalt overlay or partial reconstruction. Each year over 6,000,000 square yards of needed work is identified, prioritized and delegated. One goal of the Pavement Management group is to establish a balanced treatment forecast plan for the street repair and preventive maintenance program that will help to maintain targeted pavement condition levels. These levels are based on a Pavement Condition Index (PCI) of 0 to100, with 100 being excellent and 0 being failed. The PCI is calculated from data collected during the annual pavement condition survey. The Pavement Management Group has been collecting pavement condition, inventory, and maintenance history information on Mesa streets for over 18 years with details and quality of data improving with each year.

Learn more about our various pavement maintenance programs.

Report:
What can we do with $3 a month?
Streetlight Facts
Pavement Maintenance Facts

Right-of-Way Maintenance

City right-of-ways are also maintained by Field Operations crews. Maintenance of rights-of-way includes landscaping, storm drainage, and graffiti abatement. An emergency response crew is always on duty to keep the streets and right-of-ways clear and safe throughout Mesa.

Street Sweeping

Fay, Jerry

From: Ted.Stalder@cityofmesa.org
Sent: Tuesday, January 03, 2006 4:21 PM
To: Fay, Jerry
Cc: Lenny.Hulme@cityofmesa.org; Transportation.Info@cityofmesa.org
Attachments: UserOptions.pdf

Mr. Fay,

We do have goals set for minimum desired pavement condition levels and have established these levels for each classification of street in our network. We also have minimum acceptable levels for each class. The goal is to remain at the minimum desired level (MDL) but to not allow the condition of the pavement to drop below the minimum acceptable level (MAL). These targeted levels are listed in the MDL and MAL figures included in the attached PDF file. If you have any questions about the information included, please give me a call.

Classification description;

A = Arterial Street, C = Collector Street, I = Intersections, R = Residential, P = Paved Alleys, L = Parking Lots.

MDL = Minimum Desired Level
MAL = Minimum Acceptable Level

Ted W. Stalder
Chief Engr. Technician
City of Mesa
Transportation Field Operations
480-644-3511
Ted_Stalder@cityofmesa.org

User Options

Tuesday 3 Jan 2006

Classification: Arterial

Fiscal Year: July

Copy Path: T:\AVHOME\TABLES\

Net Path: T:\MPAV\

User Defined Fields

	User 1	User 2	User 3	Latitude	Longitude
Visible:	[_]	[_]	[_]	[_]	[_]
Label:	Bus Route	School Zone	Industrial Area		
FieldName:	USER1	USER2	USER3		
Length:	20	20	20		

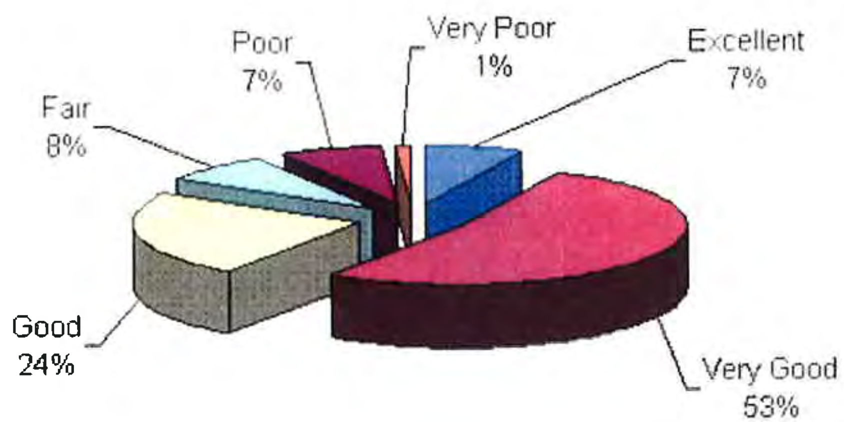
Classification:	A	C	D	I	L	M	O	P	R	U	F	H	T
MDL:	85	70	0	85	65	0	0	65	70	0	0	0	0
MAL:	60	55	0	60	45	0	0	30	50	0	0	0	0
Group Name:	[_]	[_]	[_]	[_]	[_]	[_]	[_]	[_]	[X]	[_]	[_]	[_]	[_]
						R							
Network:	[X]	[X]	[X]	[X]	[X]	[_]	[_]	[X]	[X]	[X]	[_]	[_]	[_]
						ACDILPRU							
Use:	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[_]	[_]	[_]
						ACDILMOPRU							

Reports	ERA		PCI		RIDE	
Maximum:		100		100		100
9:		0		100		0
8:		0	EXCELLENT	85		100
7:		0	VERY GOOD	70	FAILED	90
6:		100	GOOD	55	VERY POOR	75
5:	EXTREME	81	FAIR	40	POOR	60
4:	HIGH	61	POOR	25	FAIR	45
3:	MEDIUM	31	VERY POOR	10	GOOD	30
2:	LOW	1	FAILED	1	VERY GOOD	15
1:	GOOD	0	ZERO	0	EXCELLENT	0

YAMHILL COUNTY
ROAD PAVEMENT CONDITION INDEX
2001

CATEGORY	MILES	% OF TOTAL
Excellent	25.51	7%
Very Good	198.17	53%
Good	87.97	24%
Fair	31.20	8%
Poor	26.98	7%
Very Poor	4.12	1%
Total Miles of Paved Road	**373.95**	

COUNTY ROAD PAVEMENT CONDITION INDEX - 2001



Resolution No. ____________

Board of Supervisors, County of San Mateo, State of California

* * * * * *

Resolution Revising the Standard Used to Evaluate the Condition of the County Maintained Road System

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RESOLVED, by the Board of Supervisors of the County of San Mateo, State of California, that

WHEREAS, Government Accounting Standards Board Statement No. 34 (GASB 34) requires governments to capitalize their eligible infrastructure assets; and

WHEREAS, GASB34 also requires governments, where the Modified Approach is used in the financial reporting of any such assets, to document that these assets are being preserved at or above a condition level established and disclosed by the government; and

WHEREAS, this Board previously established minimum percentages of primary and secondary roads that would be maintained at specific Pavement Condition Indices (PCI) as defined by the Metropolitan Transportation Commission's Pavement Management Program; and

WHEREAS, due to funding constraints, the minimum percent of secondary roads cannot be sustained at the standard previously adopted by this Board; and

WHEREAS, the Director of Public Works has recommended that the minimum percentage of secondary roads meeting a specific PCI be reduced in order for the County to continue to use the Modified Approach to meet GASB34 requirements, and this Board concurs with the recommendation of the Director of Public Works.

NOW, THEREFORE, IT IS HEREBY ORDERED AND DETERMINED that:

1. Seventy Five Percent (75%) of the County's primary roads as defined in the County's Pavement Management System shall continue to be maintained at the Metropolitan Transportation Commission's Pavement Management Program Pavement Condition Index of 55 or better; and

2. The percentage of the County secondary roads as defined in the County's Pavement Management System, maintained at the Metropolitan Transportation Commission's Pavement Management Program Pavement Condition Index of 40 or better, is hereby reduced from Seventy Five Percent (75%) to Sixty Five Percent (65%).

* * * * * *

The City of Indianapolis has about 3,000 centerline miles of streets and about 1,000 miles of thoroughfares and 2,000 miles of residential streets. We recommend street segments to be included in our resurfacing and curb and sidewalk programs on an annual basis. The plan development process for bidding these type of projects is a matter of months.

Resurfacing Program

Pavement repair projects are generally selected on 2 main factors, the Pavement Condition Index (PCI) and the International Roughness Index ((IRI). The PCI is a measure of the pavement condition (developed by the Army Corp of Engineers) and is generally the engineering evaluation of pavement distresses (ruts and cracks). The ranges of PCI ratings is from 0-100. The following is a breakdown of that range.

PCI	Pavement Condition
0-10	Failed
10-25	Very Poor
25-40	Poor
40-55	Fair
55-70	Good
70-85	Very Good
85-100	Excellent

In Indianapolis we generally are selecting pavement repair projects that are in the 30 range.

The other main factor, IRI, is a measure of the rideability of the pavement. There is not a scale (per se) here. The ratings are established specifically to each city they are used in. In Indianapolis, the minimum and maximum IRI on thoroughfares, is .88 and 32.92 respectively. The lower the number, the better the ride. The minimum and maximum IRI on residential streets is .88 and 46.91 respectively. In Indianapolis, if the rating is over 5 we should be planning on doing something to the pavement in the very near future.

There are also other factors that weigh into the project selection criteria. A listing of the other main factors are listed below.

Focusing the location selections on the thoroughfares. More 'bang for your buck' is achieved with this strategy because of the comparison between the investment level and the high number of vehicular users. We strive for a 75 per cent thoroughfare 25 per cent residential mix of street segments each year.

Missing segments connecting up previous projects.

Attempting to balance the project workload across all 9 townships is also a factor as well as across other geographic boundaries such as City-County Council Districts.

Economic development or other type of commitments that are made.

SARATOGA, CA

CITY INFRASTRUCTURE & FACILITIES NEEDS ASSESSMENT

INFRASTRUCTURE TYPE	ANNUAL OPERATING NEED	DEFERRED MAINTENANCE	NOTES
STREETS (INCL. CURBS/GUTTERS/STORM DRAINS)	$950,000	$14,000,000	1
SIDEWALKS	$100,000	$700,000	2
BRIDGES	N/A	$620,000	3
MEDIANS	$50,000	$250,000	4
CITY FACILITIES	$200,000	$2,430,000	5
TOTAL	$1,300,000	$18,000,000	

NOTES:

1. STREETS:

Pavement Management

- Centerline length of public streets: 135.2 miles
- Approximate replacement value of City owned streets: $75 Million
- Annual Operating Shortfall: $850,000
- Current Maintenance Backlog: $10 Million

Pavement condition is tracked by Public Works using both visual inspection and a computer program titled the MTC Pavement Management System (PMS). This program is administered, and continually being improved by the Metropolitan Transportation Commission. The Pavement Management System for the City of Saratoga provides a current pavement network inventory, current network conditions, maintenance recommendations, and a forecasting of the budget needs and funding scenario impact. This program combined with resident requests and engineering judgment, determines the year-to-year priorities of streets to be addressed by the City's annual Pavement Management Program and Pavement Maintenance Program.

The grading system used to determine the pavement's condition is a numerical scale from zero to one hundred (0-100), with 0 being completely failed and 100 indicating a new street. This scale is known as the Pavement Condition Index (PCI). PCI's for the City's pavement network are based on a distress rating calculated by an algorithm the Metropolitan Transportation Commission (MTC) Bay Area modified from algorithms the Army Corps of Engineers. For the purposes of mapping and general summarization of condition, the classifications are sometimes simplified to four categories:

Very Good 100-75, **Good** 74-50, **Fair** 49-25, **Poor** 24-0

Budget Scenarios are run on PMS to determine the funding levels required to maintain and/or improve the current level of overall condition and generate a work program for the next ten (10) years based upon actual road pavement conditions.

At the City's current funding level of $650,000 the overall network condition declines from a 72 PCI in the year 2001 to a 65 PCI in the year 2010 (PCI scores after suggested treatments applied). The backlog of deferred maintenance, valued at approximately $10 million in the year 2001, increases to about $20 million in the year 2010.

The Budget Scenario analysis shows that the $1.5 million annual budget level is required to maintain the overall network PCI and maintain the current level of deferred maintenance and a $2.5 million annual budget over 10 years is required to eliminate the current $10 million maintenance backlog.

<u>Curbs & Gutters</u>

- Approximately 87 percent of Saratoga's streets (235 miles) are bordered by curbs and gutters
- Approximate replacement value of City curbs & gutters: $50 Million.
- Annual Operating Shortfall: $50,000
- Current Maintenance Backlog: $2 Million

Most streets in the improved residential and commercial areas of Saratoga incorporate concrete curbs and gutters with a length of approximately 235 miles. These structures are designed to control and channel rainfall runoff, provide a wheel-stop for parked vehicles, and establish a physical border between the street and any adjacent property, landscaping, and/or sidewalk.

The overall condition of curb and gutter segments in Saratoga may be considered good, with damage at specific locations particularly adjacent to street trees. Curb and gutter uplifting and breakage tends to occur simultaneously with that of sidewalks where the two are adjacent, and where a root extends underneath both the sidewalk and curb section. On an annual basis the Concrete Repair Program addresses approximately 400 linear feet curb and gutter. The tracking of curb and gutter conditions is combination of Street Maintenance observations resident notifications.

The annual budget for curb and gutter repair is $25,000 with an average of <u>reported</u> repairs totaling twice that amount $50,000. It is estimated that 5% of the City's curbs and gutters are in need of repair, which equals $2.5 Million. The current CIP has

Lake Oswego Engineering

Street Maintenance Fee

Summary

Transportation funding is one of the most challenging issues facing cities. Over the past decade, the City of Lake Oswego has used a variety of funding sources to construct and maintain its transportation system valued at $177,000,000. These funding sources including State gas taxes, franchise fees, systems development charges, general fund monies, road transfer revenues and most recently, general obligation bonds, have either been spent or are diminishing in purchasing power relative to inflation and thus are not sufficient to protect the City's investment in its street system. Recognizir the Lake Oswego City Council established a goal in January 2002 of identifyin a sustainable funding source for street maintenance.

Pavement Management Program

In 1999 the City adopted a Pavement Management Program concurrent with t the City's first pavement condition assessment. This program required a com| pavement condition assessment for each street in the City. From this "on the assessment, City engineers rated the condition of each street using a "Pavem Index" (PCI) number from 0 to 100 with the value 100 representing the cond new street. The average PCI for the City's street system at that time was 69. remaining from the City's 1996 street bond measure and the advantage of a l construction market, the City was able to improve its street system and the 2 average PCI was 72.

Investment Fundamentals

Due to advances in construction techniques and materials quality, new aspha expected to last about 20 years before complete reconstruction is required. H each dollar spent for street maintenance before major deterioration begins, $ typical street could decline 40% in quality in as little as five years without nee

To maximize the return on our investment, the City's Pavement Managemen

- Prioritize maintenance investments to streets with PCI ratings less thar
- Strive to achieve and then maintain a system-wide average PCI of 80 t

Investment Options

One City Council goal was to identify a stable and equitable means to fund st City staff and the City Council evaluated options, including a local gas tax, a (registration fee, additional property taxes, and a street maintenance fee. Of a evaluated, the street maintenance fee was deemed the most equitable and st street funding.

Following a public hearing at the November 4, 2003 Council meeting, the stre fee proposal was approved for implementation. The adoption of the ordinance maintenance will remain a priority in the future by providing a mechanism for

Implementation

Starting in July, 2004, the monthly fees assessed to condominiums and apart to $2.68, for houses it was $3.75, and businesses are assessed a usage-base Nonresidential rates have been phased in at 50% starting in July 2004, and w 100% in July 2005. All funds collected from the fee will be used for maintenai roads.

What's Next

Because the passage of the State Transportation Investment Act III during th session provided new funding for local roads, the City's fee is actually less tha anticipated.

Additionally, if it is determined that pavement conditions have improved suffi program is in place, the fee may be adjusted.

Questions?

Do you have any other questions about the City's proposed street maintenan check out our Frequently Asked Questions page.

STOCKTON
CA.

June 4, 2004

PAVEMENT NETWORK CONDITION AND RESURFACING PLAN FOR 2004

Background

In October 1999, the City Council authorized the Public Works Department to initiate implementation of a computerized Pavement Management System. The City implemented the new system in August 2000. The system included an inventory of the condition of the City's street pavement network, undertaken by pavement consultant Harris and Associates. All streets were surveyed and the pavement condition ranked on a numerical scale (known as a pavement condition index or PCI) from 0 to 100. Streets are then grouped by PCI into categories to establish the type of maintenance treatment that is warranted. The following chart denotes these categories:

Treatment Strategy					
Arterials and Collectors			Local/Residential		
PCI	Category	Treatment	PCI	Category	Treatment
80-100	Very Good	None	80-100	Very Good	None
50-79	Good	Surface*	50-79	Good	Surface*
25-49	Poor	Overlay**	14-49	Poor	Overlay**
0-24	Very Poor	Reconstruction	0-13	Very Poor	Reconstruction

* --- Surface treatment options include microsurfacing or slurry seal.

** --- Overlay treatment options include cape-seal (chip-seal plus microsurfacing).

Streets with a PCI near or on the borderline of a treatment category are scrutinized at the project level to determine the actual treatment warranted. Streets requiring reconstruction are not considered "maintainable". Streets in this category need to be totally replaced, which is a very expensive and time consuming process.

Detailed information on the new system was provided to Council during a study session on Pavement Management on August 30, 2000. The objective of the pavement management system is: 1) to keep streets from falling into the expensive reconstruction category, 2) to give priority to streets in the PCI borderline areas so they do not fall into the next, more expensive, maintenance category, and 3) to eventually get all of the streets into the "good" category and keep them in that category. Since 2000, in accordance with the direction of Council, the City's preventative maintenance emphasis has been in alignment with these objectives. The following is a brief update on the types of projects that have been undertaken since 2000, and the results of a re-survey of the pavement network that was undertaken in 2003.

PAVEMENT CONDITION INDEX (PCI) METHOD

Background:

The Pavement Condition Index (PCI) method is used to obtain a Pavement Condition Index (PCI) value for airfield pavements through a visual survey of the pavement. The Pavement Condition Index (PCI) is a numerical rating of the pavement condition that ranges from 0 to 100, with 0 being the worst possible condition and 100 being the best possi condition. The Pavement Condition Index (PCI) method was developed by the Construction Engineering Research Laboratory of the U.S. Army Corps of Engineers. This method can be used on both asphalt surfaced as well as jointed portland cement concrete (PCC) pavements. This method has been adopted by Federal Aviation Administration to determine pavement condition (Advisory Circular No. 150/5380-6, Guidelines and Procedures for Maintenance of Airp Pavements).

Determination of PCI Value:

The following procedure is followed in the PCI method to obtain the PCI value of the pavement.

1. Divide pavement section into sample units and select sample units for inspection.

2. Identify and record pavement distress in sample units.

3. Compute PCI of sample units based on distress within sample unit.

4. Compute PCI of section.

A description of each of these steps is presented next.

1. Divide Pavement Section Into Sample Units and Select sample Units for Inspection:

For asphalt surfaced pavements, a sample unit consists of 5000 ± 2000 sq. ft. of pavement. The actual area of the sample units to be used is determined based on the geometry of the pavement section. For a PCC pavement, a sample unit consists of 20 ± 8 slabs. As for asphalt surfa pavements, the number of slabs to be included in a sample unit is determined based on the geometry of the pavement section. Once the sam unit size is determined, the pavement section is divided into sample units. Thereafter, the number of sample units for inspection is determin

The minimum number of sample units for inspection is determined based on the total sample units within the section, shown in the following table.

Number of sample units for inspection.

Total Number of Samples in Section	Number of Samples for Inspection
1 to 5	1
6 to 10	2
11 to 15	3
16 to 40	4
Over 40	10%

A much higher sampling rate than the minimum sampling rate shown in the above table was used during the inspectio that were carried out in 2002. Typically, a minimum sampling rate of 20% was used for all sections, irrespective of th number of total sample units within the section.

Once the number of sample units to be inspected has been determined, the spacing interval of the sample units to be inspected is determined. The spacing interval (i) of the sample units is calculated by the following formula and rounde the lowest whole number:

$$i = N/n$$

where,

N = total number of sample units in the section

n = number of sample units to be inspected

The first sample unit to be inspected is selected at random from sample units 1 through i. The sample units within the section that are successive increments of the interval i after the first randomly selected unit are also inspected. If thei are sample units within the section that are not representative of the section, such sample units are inspected in addit to the sample units that are selected at random. Such sample units include very poor or excellent samples that are not typical of the section, such as sample units that contain an unusual distress such as an utility cut.

2. Identify and Record Pavement Distresses in Sample Units:

The type, severity and quantity of pavement distress within each sample unit is determined by visual inspection of the pavement and recorded on data sheets. The procedures described in ASTM Standard D 5340 are used to determine the distress types, identify severity levels, and to measure the quantity of distress. Sixteen types of distresses are identifi on asphalt surfaced pavements, while fifteen types of distresses are identified on PCC pavements. The types of distres identified on asphalt surfaced pavements and PCC pavements are presented in the following tables.

Distress types for airfield pavements.

Distress Types on Asphalt Surfaced Pavements	Distress Types on PCC Pavements
Alligator Cracking	Blow Up
Bleeding	Corner Break
Block Cracking	Longitudinal, Transverse, Diagonal Cracks
Corrugation	Durability (D) Cracking
Depression	Joint Seal Damage
Jet Blast Erosion	Patching –Small
Joint Reflection Cracking	Patching Large and Utility Cuts
Longitudinal and Transverse Cracking	Popouts
Oil Spillage	Pumping
Patching and Utility Cut Patching	Scaling, Map Cracking and Crazing
Polished Aggregate	Settlement or Faulting
Raveling and Weathering	Shattered Slab/Intersecting Cracks
Rutting	Shrinkage Cracks
Shoving	Joint Spalling
Slippage Cracking	Corner Spalling
Swell	

3. Compute PCI of Sample Units Based on Distress Within Sample Unit:

The procedure to compute the Pavement Condition Index (PCI) of a sample unit is described in ASTM standard D 5340 This procedure has been implemented in PAVER to compute the PCI value of each sample unit when the distress data entered into PAVER. The following steps that are used to compute the PCI of a sample unit.

Determine Distress Quantities: For asphalt concrete surfaced pavements, the total quantity of each distress type at ea severity level is added up. For PCC pavements, the total number of slabs that have a particular distress type for a spe severity level are added up.

Determine Distress Density: For asphalt concrete surfaced pavements, the total quantity of each distress type at each severity level is divided by the total area of the sample unit and multiplied by 100 to obtain the percent density of eac

ress type and severity. For PCC pavements, the total number of slabs for each distress type at each severity level is divided by the number of slabs that are contained within the sample unit and multiplied by 100 to obtain the percent density of each distress type and severity.

Determine Deduct Value: The deduct value for each distress type and each severity level is determined by using the deduct value curve for that particular distress type. These deduct value curves are shown in ASTM Standard D 5340. T following figure shows a deduct value curve for linear cracking in asphalt surfaced pavements.

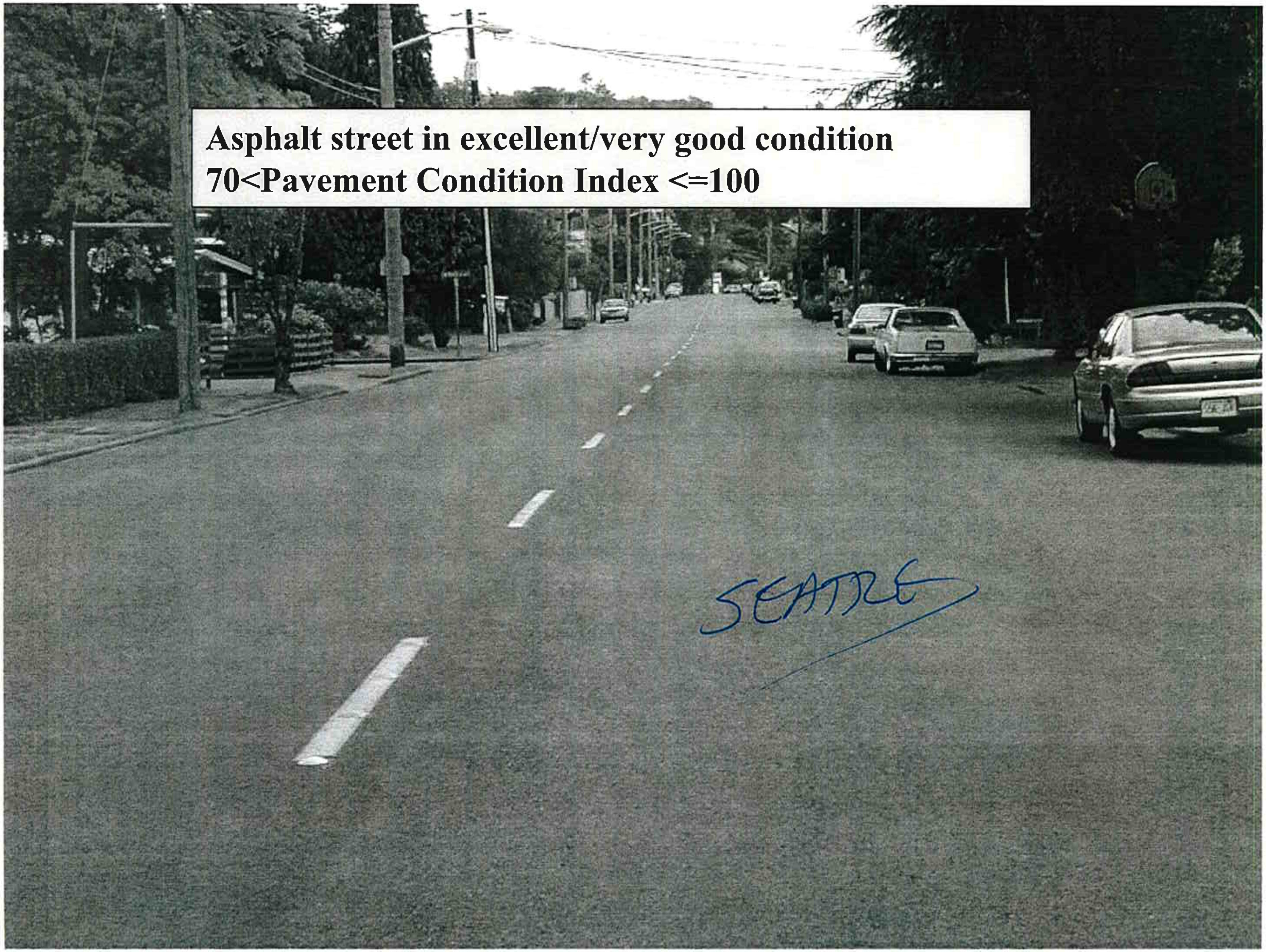
educt value curve for linear cracking on asphalt surfaced pavements.

Obtain Correct Deduct Value: If none or only one deduct value is greater than five, the sum of the deduct values is use obtain the total deduct value for the sample. Otherwise, a value called the corrected deduct value for the sample is computed using the deduct values obtained for the different distress types. This procedure is used because there is an interacting effect between different distress types, and if the deduct values were not corrected an unreasonable dedu value would be computed for the sample. The deduct values obtained for each distress type and each severity levels a combined using the procedure described in ASTM standard D 5340 to obtain the corrected deduct value for the sample

Obtain PCI of Sample Unit: Subtract the deduct value (or corrected deduct value if applicable) from 100 to obtain the F of the sample unit.

4. Compute PCI of Section:

If all surveyed sample units that were surveyed were selected randomly, or if all sample units within the section were surveyed, the PCI of the section is the average of the PCI values that were obtained for the samples within the sectior additional sample units were surveyed within the section, then a weighted averaging method is used to compute the F of the section. The details of this method are given in ASTM standard D 5340.



Asphalt street in excellent/very good condition
70<Pavement Condition Index <=100

OHIO DOT

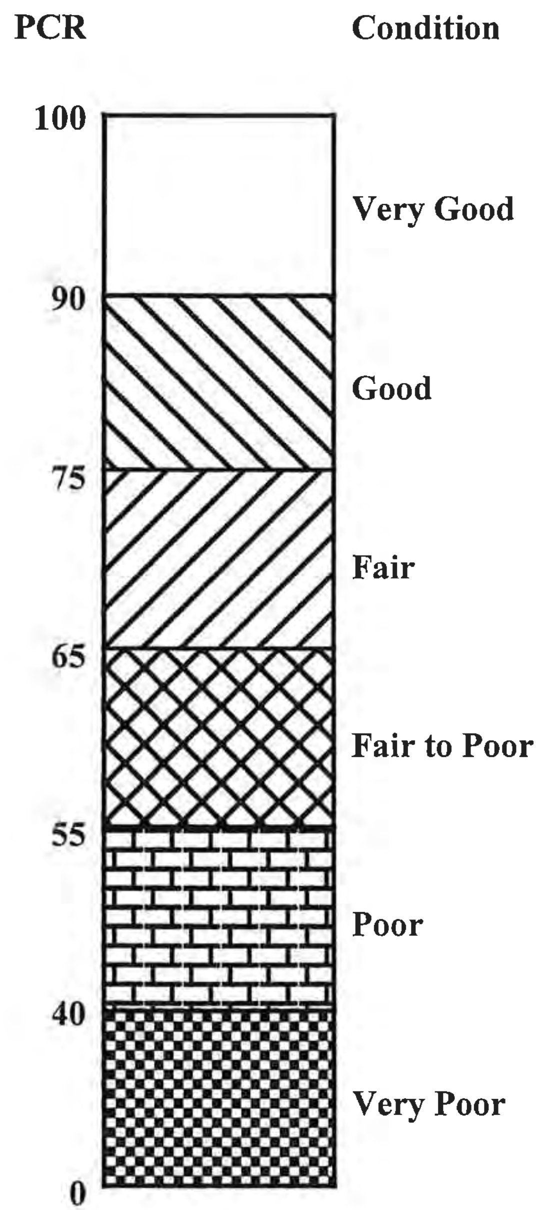


Figure 1. Pavement Condition Rating (PCR) Scale

Each Region was asked to report paving projects that were being conducted and completed in 1998 to the Pavement Management Group. This information was used to update the condition survey data to reflect the state of pavement conditions at the end of the construction season. The paving projects reported include both overlay and new construction projects. The 1998 paving projects for all state jurisdiction highways amounted to approximately 510 miles (directional miles for the Interstate and centerline miles for Non-Interstate highways). This total includes over 140 miles of paving from reallocation projects. The paving project lists provided by each Region are presented in Appendix F.

Historical pavement performance data has suggested that approximately 550 miles of state highway need to be rehabilitated annually due to normal pavement deterioration. If this deterioration rate is not matched by improvements completed by paving projects, the overall condition of the state highway system will decrease. In reality, the actual amount of paving required to maintain the network condition level for each specific year will vary from the typical 550-mile value. The amount of paving necessary depends on the age distribution of the pavements in the given year. To illustrate, if a large number of projects were constructed in one year, it would be expected that these pavements would need rehabilitation at approximately the same time in the future. In that future year, the amount of paving necessary to maintain the condition level would be expected to be higher than the typical 550 miles.

In 1998 the overall "fair-or-better" condition remained at 77%. Although the percentage remained the same, ODOT saw a drop in overall "fair-or-better" miles. In 1997 there were approximately 6297 miles of pavements in "fair-or-better" condition. In 1998 the total of pavements in "fair-or-better" condition dropped to 6273 miles. The continued loss of "fair-or-better" mileage will eventually result in a drop in the percent of pavements in "fair-or-better" condition.

ODOT has established a goal to have 90% of its pavements in "fair-or-better" condition. If this goal is to be obtained by the year 2010, the average amount of paving completed each year will need to be increased from 550 miles to approximately 640 miles. This is based on making a 13% improvement to the condition of the system over a 12 year period. Again, the actual mileage required to improve the condition level will vary from year to year based on the age distribution of the pavements in the network.

City of Bloomington
Public Works Department

Public Works working for you –

Pavement Management Program (PMP)

A better product at a lower cost!

Maintenance Office Hours:

7 a.m. - 3:30 p.m., Monday - Friday
Phone: 952-563-8760

Engineering Office Hours:

8 a.m. - 4:30 p.m., Monday - Friday
Phone: 952-563-4870

(TTY 952-563-8740) Leave a Message 24 Hours a Day

The Pavement Management Program (PMP) is a maintenance plan for streets that utilizes repair techniques at the optimum time. The results include:

- Prolonged pavement life.
- Reduced cost for streets.
- Reduced assessment rates for property owners.

Every street is continually investigated

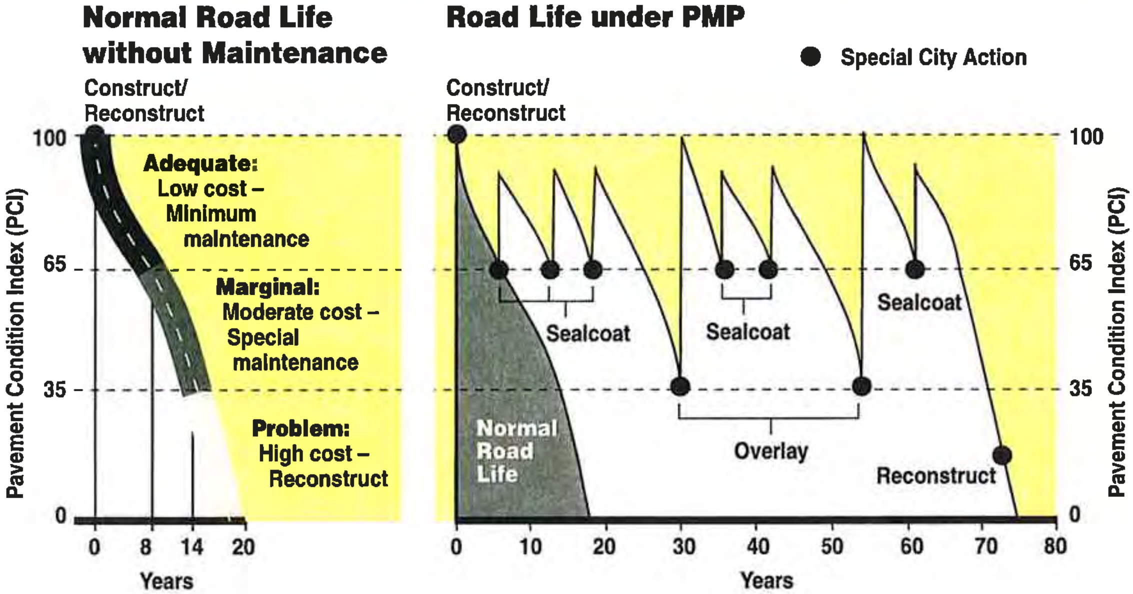
Bloomington has 360 miles of roadways valued at $168 million. That's a big investment and a lot of pavement – and the condition of all those road surfaces is in the City's PMP database.

How does the PMP work? Information such as the number of cracks, road thickness and maintenance history are entered into a database. The database outputs a Pavement Condition Index (PCI) number which is used for budgeting and as a guideline for suggested maintenance. Before any work is performed, the street is carefully inspected and assigned maintenance as appropriate. In general:

PCI	***Description***	***Probable Maintenance***
100	Newly reconstructed	None
99 - 66	Adequate	Sealcoat
65 - 36	Marginal	Mill and overlay
35 - 1	Problem	Reconstruct

Affordable price – PMP equals less costly roads

The typical street with little or no maintenance will last less than 20 years before it needs to be totally rebuilt. By performing periodic pavement sealcoats or overlays at the correct times, a street's lifespan can be more than tripled before costly reconstruction is needed.



Funding the PMP

The Public Works' Pavement Management Program has reduced the overall cost of keeping our streets in good condition. Sealcoating, the low-cost maintenance of roads, is funded from the City's General Fund. Overlay funds come from the Infrastructure Replacement Fund, distributed by the State of Minnesota from the fuel sales tax. Costly reconstruction of a street is funded from taxes and special assessments to property owners.

Lower assessment policy

Individual properties are only assessed for street reconstruction and, even then, only a portion of the costs. A single- or two-family residence only pays 25 percent of their portion of a project's cost. Other properties, such as commercial, industrial or multi-family residences, pay half the cost. Other funding sources make up the difference.

Assessment payment options

Road assessments may be paid with a one-time payment or over 10 years with a low simple interest charge.

Condition Rating Systems

Based on measurements of roughness, surface distress, skid resistance and deflection, pavement assigned a score that reflects their overall condition. This score, sometimes called a pavement c rating, quantifies a pavement's overall performance and can be used to help manage pavement r carefully choosing the rating scale (called the condition index), pavement condition scores can be (Deighton, 1998):

- *Trigger treatment*. For instance, once a pavement's condition rating reaches a certain l scheduled for maintenance or rehabilitation.
- *Determine the extent and cost of repair*. A pavement condition score is a numerical rep of a pavement's overall condition and can thus be used to estimate the extent of repair likely cost.
- *Determine a network condition index*. By combining pavement condition scores for an network, a single score can be obtained that gives a general idea of the network conditi whole.
- *Allow equal comparison of different pavements*. Since a pavement condition score accc types of pavement performance measures it can be used to compare two or more pave different problems on an equal footing.

A pavement condition index is simply the scale, or series of numbers, used to describe a paveme Typical pavement condition indices may be based on a scale of 0 to 5 or perhaps 0 to 100. The p pavement condition index depends upon the objectives of whatever system is used to manage a pavement network (called a Pavement Management System or PMS). This section will present tv pavement condition indices.

Present Serviceability Index (PSI)

The Present Serviceability Index (PSI) is a 0 to 5 scale that was originally based on a panel of rat between 1958 and 1960, rated various roads in the states of Illinois, Minnesota, and Indiana. PS 5 (excellent) to 0 (essentially impassable), and is still used today throughout the country. It is o choice for a smaller, less sophisticated pavement rating system.

WSDOT's Pavement Rating System

WSDOT uses a more sophisticated pavement rating system for its Pavement Management Syster system uses three different rating scales:

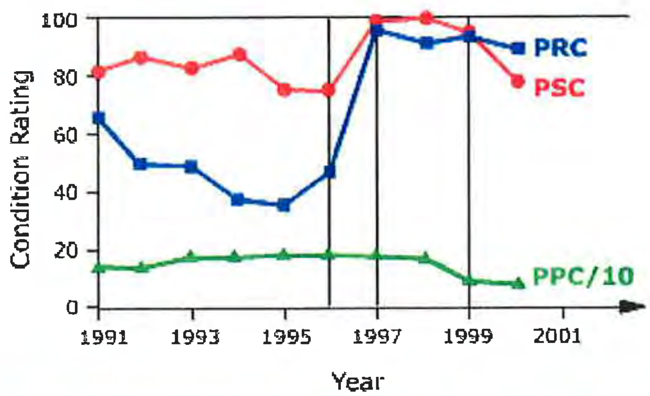
1. *Pavement Structural Condition (PSC)*. A measure of pavement distress such as crackin distress measures and ranges from 100 (no distress or very good condition) to zero (ex distress or very poor condition).

2. *Pavement rutting condition (PRC)*. A measurement of rut depth in inches. The scale ra 100 (no rutting) to 0 (0.70 inches of rutting).

3. *Pavement profile condition (PPC).* A measure of roughness using IRI.

Generally, as a pavement gets older and more worn its PSC and PRC decrease, while PPC increas

WSDOT PMS Condition Rating for:
I-90 Eastbound, milepost 126.40 - 136.76 in Kittitas County



PSC = Pavement Structural Condition. A rating of the pavement's structural ability to carry loads. Scale is from 100 (best condition) to 0 (worst condition).

PRC = Pavement Rutting Condition. Rated on a scale of 100 (0 inches rutting) to 0 (0.70 inches rutting).

PPC = Pavement Profile Condition. This graph shows IRI in inches/mile divided by 10.

Notes

1996 - 1997
Some time after the survey in 1996 the pavement was overlayed with 1.8 inches of Class A hot mix asphalt.

1999
After the 1998 survey WSDOT switched to from a sonic to a laser profiler. The decrease in IRI seen here is typical throughout the State as a result of this change in instrumentation.

Discssion
1. The individual measurements seem to jump around from year to year (which is normal), but PRC and PSC generally decrease until the resurfacing in 1996.

2. Generally PSC or PRC values of < 50 will trigger a resurfacing. It appears this portion of I-90 was resurfaced due to low PRC values.

Figure 1: An Example of the WSDOT Pavement Condition Rating System

◀ **Previous** | **Top** | **Next** ▶

Pavement Condition of Nebraska Highways

Activity Drivers: District Engineers

Data Owner & Collector: Dan Nichols : Classification, Needs, & Pavement Engineer : Materials & Research Division

Category : Transportation System Safety and Performance

Description:
Measurement of the quality of the highway surface.

Purpose:
This is a measure of the surface condition of the states' highways. [1] Surface condition ratings are based upon annual visual inspections and ride quality (smoothness). This information is used to determine appropriate strategies for either maintenance, rehabilitation, or reconstruction.

Goal:
82% of the highway system miles shall be rated at least good or very good *(NSI ratings >= 70.)*

Frequency of Reporting:
Annually, as of October each year.

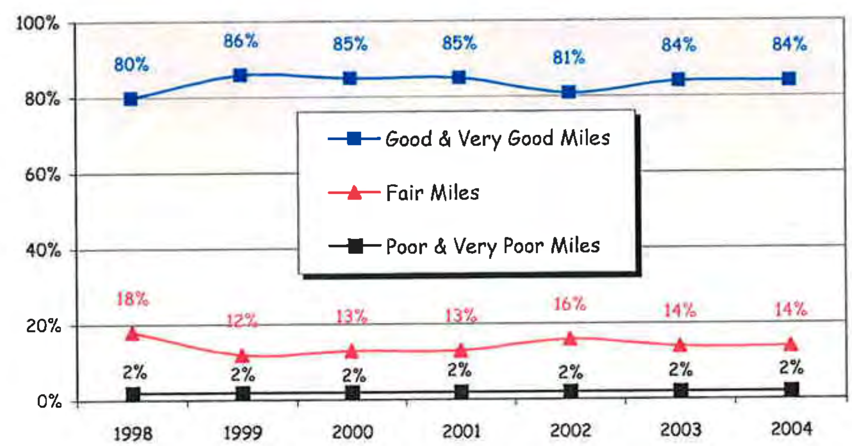
Revised Date:
October 21, 2004

Year 2004 Performance Data [2]

Pavement Condtion Ratings Miles	Interstate System	Expressway System [3]	Other State Highways	Total State Highway System
Very Good Miles	264	350	2,925	3,539
Good Miles	196	168	4,402	4,766
Fair Miles	15	72	1,252	1,339
Poor Miles	6	12	227	245
Very Poor Miles	0	0	27	27
	481	602	8,833	9,916

Pavement Condtion Ratings %	Interstate System	Expressway System [3]	Other State Highways	Total Highways
Very Good Miles %	55%	58%	33%	36%
Good Miles %	41%	28%	50%	48%
Fair Miles %	3%	12%	14%	14%
Poor Miles %	1%	2%	3%	2%
Very Poor Miles %	0%	0%	0%	0%

2004 Pavement Condition Ratings
(Nebraska Serviceablity Index)



Comments:
Surface condition ratings are based upon the NSI (Nebraska Serviceability Index):

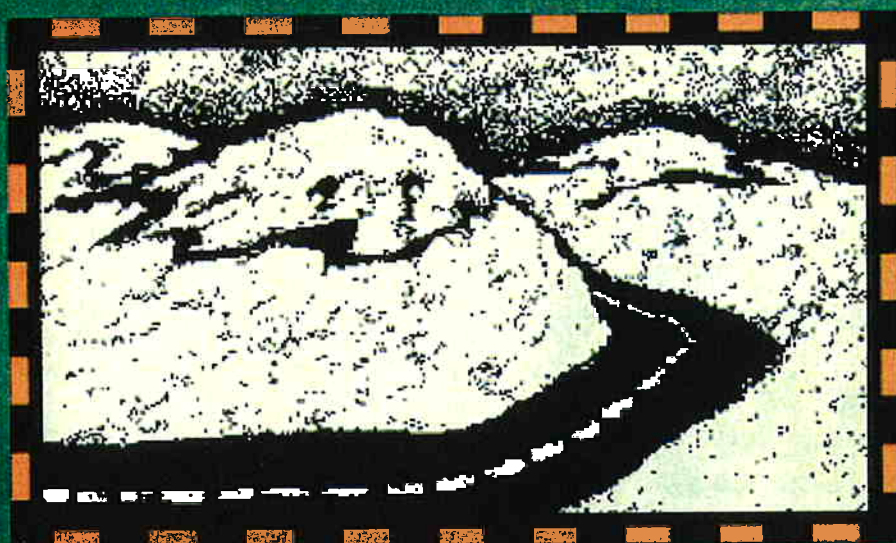
Very Good Rating:	90 to 100
Good Rating:	70 to 89
Fair Rating:	50 to 69
Poor Rating:	30 to 49
Very Poor Rating:	0 to 29

[1] *"Centerline"* miles of the state highway system, which includes Interstate and Expressway system miles.

[2] Data from the Materials & Research Division's Integrated Inventory (IHI) data base.

[3] An expressway is a 4-lane divided roadway with limited access.

Pavement Surface Condition
RATING MANUAL



Northwest Pavement Management Systems Users Group

Sponsored by:
Northwest Technology Transfer Center
Local Programs Division
Washington State Department of Transportation

Severity and Extent Summary

1. Rutting and Wear

Severity

The average rut depth in the wheel path for the segment or sample.

Low	1/4 in. to 1/2 in.
Medium	1/2 in. to 3/4 in.
High	over 3/4 in.

Extent

Assumed to be the full length of the surveyed segment.

2. Alligator Cracking

Severity

Low	Hair Line (< 1/4 inch)
Medium	Spalling
High	Spalling and pumping

Extent

Percentage of the length of both wheel paths.

Suggested ranges for estimating:

1% - 9%	of both wheel paths
10% - 24%	of both wheel paths
25% - 49%	of both wheel paths
50% or more	of both wheel paths

Old WSDOT ranges for estimating - prior to 1991:

1% - 24%	of both wheel paths
25% - 49%	of both wheel paths
50% - 74%	of both wheel paths
50% or more	of both wheel paths

3. Longitudinal Cracking

Severity

Low	< 1/4 in. wide
Medium	> 1/4 in. wide
High	Spalled

Extent

Percentage of the length of the surveyed segment.

Suggested ranges for estimating:
1% - 99% of the length of the segment
100% - 199% of the length of the segment
200% or more of the length of the segment

4. Transverse Cracking

Severity

Low	< 1/4 in. wide
Medium	> 1/4 in. wide
High	Spalled

Extent

Frequency, count per 100 feet.

Suggested ranges for estimating:
1 - 4 cracks per 100 ft.
5 - 9 cracks per 100 ft.
10 or more cracks per 100 ft.

FLEXIBLE PAVEMENT DISTRESSES

5. Raveling

Severity

Low	Slight
Medium	Moderate
High	Severe

Extent (estimated):

Localized
Wheel Paths
Entire Lane

6. Flushing

Severity

Low	Slight
Medium	Moderate
High	Severe

Extent (estimated):

Localized
Wheel Paths
Entire Lane

7. Patching

Severity

Low	Chip seal patch
Medium	Blade patch (cold or hot mix)
High	Dig-out, full depth patch (or repair)

Extent

Percentage of the length of both wheel paths.

Suggested ranges for estimating:

1% - 9%	of both wheel paths
10% - 24%	of both wheel paths
25% or more	of both wheel paths

8. Corrugation and Waves

Severity

The maximum deviation from a 10-foot straight edge

Low	1/8-in. to 2-in. change per 10 ft.
Medium	2-in. to 4-in. change per 10 ft.
High	Over 4-in. change per 10 ft.

Extent

The percentage of the affected surface area.

Suggested ranges for estimating:

1% - 9%	of the area of the segment
10% - 24%	of the area of the segment
25% or more	of the area of the segment

9. Sags and Humps

Severity

The maximum deviation from a 10-foot straight edge.

Low	1/8-in. to 2-in. change per 10 ft.
Medium	2-in. to 4-in. change per 10 ft.
High	Over 4-in. change per 10 ft.

Extent

The percentage of the affected surface area.

Suggested ranges for estimating:

1% - 9%	of the area of the segment
10% - 24%	of the area of the segment
25% or more	of the area of the segment

10. Block Cracking

Severity

Block Size:			
Low	12-ft. x 12-ft. blocks	(9 x 9 and larger)
Medium	6-ft. x 6-ft. blocks	(5 x 5 to 8 x 8)
High	3-ft. x 3-ft. blocks	(2 x 2 to 4 x 4)

Crack Size:	
Low	< 1/4 in. wide
Medium	> 1/4 in. wide
High	Spalled

Extent

Assumed to be the full length of the segment.

FLEXIBLE PAVEMENT DISTRESSES

11. Pavement Edge Condition

Edge Raveling Extent (Severity is undefined):

1% - 9%	of the length of the segment
10% - 24%	of the length of the segment
25% or more	of the length of the segment

Edge Patching Extent (Severity is undefined):

1% - 9%	of the length of the segment
10% - 24%	of the length of the segment
25% or more	of the length of the segment

Edge Lane Less Than 10 Feet Extent (Severity is undefined):

1% - 9%	of the length of the segment
10% - 24%	of the length of the segment
25% or more	of the length of the segment

12. Crack Seal Condition

Severity

Low	Hairline cracks in the sealant allow only minimal water passage.
Medium	The crack sealant is open and will allow significant water passage.
High	The crack sealant is very open or non-existent.

Extent

1% - 9%	of the total length of cracks or joints
10% - 24%	of the total length of cracks or joints
25% or more	of the total length of cracks or joints

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More Information

- LTPP FAQ's
- LTPP Library
- Pavement Contact List
- Related Links

Events

- **LTPP: Standard Data Release #20** scheduled for availability November 2005
- View all Upcoming Pavements Events

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United States Department of Transportation - **Federal Highway Administration**

PAVEMENT CONDITION RATING PROCEDURES

INTRODUCTION

The rating method is based upon visual inspection of pavement distress. Although the relationship between pavement distress and performance is not well defined, there is general agreement that the ability of a pavement to sustain traffic loads in a safe and smooth manner is adversely affected by the occurrence of observable distress. The rating method provides a procedure for uniformly identifying and describing, in terms of severity and extent, pavement distress. The mathematical expression for pavement condition rating (PCR) provides an index reflecting the composite effects of varying distress types, severity, and extent upon the overall condition of the pavement.

The model for computing PCR is based upon the summation of deduct points for each type of observable distress. Deduct values are a function of distress type, severity, and extent. Deduction for each distress type is calculated by multiplying distress weight times the weights for severity and extent of the distress. Distress weight is the maximum number of deductible points for each different distress type. The mathematical expression for PCR is as follows:

$$PCR = 100 - \sum_{I=1}^{n} Deduct_i \qquad (1)$$

Where:

n = number of observable distresses, and
Deduct = (Weight for distress) (Wt. for severity) (Wt. for Extent)

The Appendices A-D that follow describe various distresses for rigid, flexible, and composite pavements and current guidelines for establishing their severity and extent. Three levels of severity (Low, Medium and High) and three levels of extent (Occasional, Frequent, and Extensive) are defined. The definition for distress type, severity, and extent must be followed closely and be clearly understood by field personnel if the rating method is to provide meaningful data. To illustrate the method for calculating PCR, consider the distress "Faulting" in a hypothetical jointed concrete pavement. If the severity of this distress in the pavement is "Medium" and extent is "Frequent", then, the deduct points for "Faulting" in the pavement would be equal to [(10) (0.7) (0.8)] or 5.6 (see Table on page 11 for the weights of this distress). If an extensive amount of medium severity "Surface Deterioration" is also observed the deduct points for this distress would be equal to [(10) (0.7) (1)] or 7.0. The PCR for the pavement based upon these 2 distresses would equal to:

$$PCR = 100 - (5.6 + 7.0) = 87.4 \qquad (2)$$

The deduct weights for each pavement type have been developed on the basis of the review of the rating methods developed in the United States, Europe, and Canada and the experience gained from the rating methods developed by the Resource staff as a result of studies conducted in this connection. Two premises were considered when assigning the weights:

1. Overlaying and/or rehabilitation of high type (multi-lane) roadways should be considered when the PCR drops within the range of 65 to 55.

2. Deteriorated pavements normally exhibit several different types of distress. Rarely is only a single type of distress observed for a particular pavement.

The first premise is useful in establishing a target value for the proper PCR of pavements that are in a certain state or condition. Roadways scheduled for rehabilitation and resurfacing have to be rated by the PCR procedure.

A Pavement Condition Rating (PCR) Scale was developed to describe the pavement condition using the PCR numbers calculated from Equation (1). This scale has a range from 0 to 100; a PCR of 100 represents a perfect pavement with no observable distress and a PCR of 0 represents a pavement with all distress present at their "High" levels of severity and "Extensive" levels of extent. Figure 1 illustrates the PCR Scale and the descriptive condition of a pavement associated with the various ranges of the PCR values.

FIELD MONITORING PROCEDURE

The pavement condition rating is intended to apply to the entire pavement section being monitored. Section lengths are established by the monitoring procedure, with the average length being from 3 to 5 km (2 to 3 miles). Directional lanes of multilane roadways are considered separate roadways by the monitoring procedure. On multilane roadways the heaviest traveled lane (usually the outside lane) should be rated. For two lane roadways, rating one direction is sufficient unless a significant difference in condition is observed between the two lanes. The monitoring procedure checks the variance of the Pavement Serviceability Index (PSI) within a section to limit section length. This limitation should produce sections that have a fairly constant visual condition. If a definite variation in condition is observed within a section, the section should then be subdivided for condition rating. Recording of visible distress for the PCR calculations involves three steps:

Step 1. The rating team (the rating team should consist of a Driver and a Rater) should ride the predetermined roadway section at a speed of about 60 km (40 MPH). During this step, readily visible distresses such as potholes, bleeding, settlement, faulting, spalling, and surface deterioration should be rated. Also the need for subdividing the section should be evaluated in step 1.

Step 2. A second pass along the roadway section should be made with stops at approximately 1.5 km (1 mile) intervals. For example, a 3 km (2-mile section) would require 2 stops to be made. At each stop the raters should evaluate the roadway by viewing 30 m (100') of the pavement. Close inspection of pavement cracking, crack sealing, rutting, raveling, joint spalling, D-cracking, and other visible distress should be made by viewing the pavement from the roadway shoulder.

Step 3. Complete the PCR form. The final rating form for the roadway section should represent the observed average of visible distress for the entire section. Separate rating forms based upon the step 1 observations and the individual stops made during step 2 are not required. However, raters may wish to use additional rating forms for each stop, simply for note keeping purposes.

Using the pavement distress data collected by the Objective condition surveys, condition index values are mathematically calculated. These values are then used to determine the condition rating of specific highway segments. For 1998, six condition index values were calculated for each pavement section: a rut index, a raveling index, a patching index, a fatigue index, a no load index, and an overall section index. All indices range from zero to 100 with a larger value indicating a better pavement condition. The overall section index is used to categorize the condition of the pavement section as good, fair, poor, etc. as shown in Table 2. The calculations used to determine the index values are described in detail in Appendix D.

Table 2 - Index Category

Overall Section Index	Condition Category
99-100	Very Good
76-98	Good
46-75	Fair
11-45	Poor
0-10	Very Poor

To remain consistent with the historical reporting of condition data, only the "add" mileage information has been used to determine the "fair-or-better" statistical summary for the Non-Interstate highways. For the Interstate highways, both the "add" and "non-add" rating results were included in the statistical summary.

NON-NATIONAL HIGHWAY SYSTEM (Non-NHS)

The subjective Good-Fair-Poor (GFP) Rating procedure was used to rate the state jurisdiction highways excluded from the National Highway System. For 1998, personnel from the ODOT Operations Support Section and Bridge Section conducted the GFP ratings. The raters used to conduct the 1998 Non-NHS condition survey are shown in Table 3.

The basic GFP Rating method has been used since its inception in 1970. Ratings are conducted by two person crews. This method involves driving a highway and conducting a visual inspection of the pavement surface. Highways are rated according to previously defined pavement management sections. Each section is given a condition score ranging in value from 1.0 to 5.0 based on the ride quality and surface distresses. Definitions of the rating categories are provided in Appendix E.

Table 3 - 1998 Non-NHS Condition Raters

Rater	Rater
Henry Ng	Danny Hori
Tom Satchell	Shivinder Singh
Karen Scott	Jeff Gower
Cole Mullis	Kevin Brophy

Rating scores are reported to a tenth of a point in order to indicate the relative condition of a pavement within a general condition category. The numeric ratings have the descriptive terms of very good (1.0 to 1.9), good (2.0 to 2.9), fair (3.0 to 3.9), poor (4.0 to 4.9), and very poor (5.0). Smaller values indicated better pavements. For example, a section rated as 1.0 would be in better condition than a section rated as 1.9.

The GFP surveys for 1998 were conducted on all "add" and "non-add" roadbeds. To be consistent with historical reporting of condition information, only the "add" mileage data was used to determine the "fair-or-better" statistical summary for the Non-NHS highways.

PAVEMENT CONDITION RATING FORMS AND KEY FORMS

Note: The Key forms summarize data presented in Appendices A through D. These key forms will aid field personnel in establishing distress severity and extent while performing the PCR surveys.

SUMMARY

The 1998 pavement condition surveys indicate that the overall condition of the state highway system is approximately the same as in 1997. The statewide overall "fair-or-better" mileage for 1998 remains at 77%. No progress was made toward the goal of having 90% of the state jurisdiction highways in "fair-or-better" condition.

The overall statewide pavement conditions remained nearly the same. The Interstate highway system "fair-or-better" mileage dropped from 87% in 1997 to 86% in 1998. The remainder of the National Highway System excluding the Interstate system "fair-or-better" mileage improved from 79% in 1997 to 81% in 1998. The Non-NHS highways dropped in "fair-or-better" mileage from 71% in 1997 to 70% in 1998.

Although 1998 saw no change in the overall conditions, some dramatic changes took place at the Region and District level. Region 1's Interstate drop from 89% to 80% while their Non-NHS improved from 76% to 81%. Region 2's Non-NHS fell from 56% to 51%. Region 4's Interstate improved from 68% to 74%. And Region 5's NHS w/o Interstate improve from 80% to 84%.

However the most dramatic changes took place at the District level. District 14's Interstate had the largest drop, decreasing from 97% to 70%. District 2C's Interstate also suffered severely, dropping from 74% to 50%. District 5's Non-NHS fell from 74% to 51%. The most improved Interstate went to District 9, whose Interstate improved from 68% to 74%. Other major improvements were District 8 whose NHS w/o Interstate improved from 80% to 90% and District 12's NHS w/o Interstate improving from 75% to 84%. A summary of the percentage of pavements in "fair-or-better" condition is presented in Table 4.

Table 4 - 1998 % Fair -or-Better Pavement Condition Summary

REGION	INTERSTATE	NHS W/O INTERSTATE	NON-NHS	ALL HWY 1998 *	ALL HWY 1997 *
1	80%	85%	81%	82%	83%
2	100%	82%	51%	69%	71%
3	86%	81%	78%	81%	82%
4	74%	78%	72%	75%	73%
5	87%	84%	76%	81%	81%
TOTAL	86%	81%	70%	77%	77%

* "All Hwy" consists of Interstate, NHS without Interstate, and Non-NHS highways.

Table 5 shows Statewide paving over the past four years. In 1996 the paving goal of 550 miles per year was nearly met with construction on approximately 535 miles. In this year the statewide "fair-or-better" condition remained constant with the previous year. In 1995 the paving goal of 550 miles was well short with construction only on approximately 385 miles. In this year the statewide "fair-or-better" condition dropped 2% from the previous year. In 1997 approximately 480 miles of paving took place and the statewide "fair-or-better" condition dropped 1%. In 1998 approximately 510 miles of paving took place and the statewide "fair-or-better" condition remained constant with the previous year.

Table 5 - 1998 % Fair -or-Better Pavement Condition Summary

YEAR	MILES PAVED	% FAIR-OR-BETTER	% CHANGE FROM PREVIOUS YEAR
1998	510	77	0%
1997	480	77	-1%
1996	535	78	0%
1995	385	78	-2%
1994		80	

Trend graphs for statewide and Region pavement conditions are presented in Appendix A. Detailed mileage summaries are also provided by pavement condition category for each Region and District. Appendix B provides the pavement condition rating information for all state highways by pavement management section.

APPENDIX A

1998 PAVEMENT CONDITION SUMMARIES

The results of the 1998 pavement condition survey are summarized in this appendix. Graphs displaying pavement condition distribution and historical pavement condition trends are included. The trend graphs track pavement condition for All State Highways and for each Region.

Tabular summaries of the pavement condition information are also included in this section. The tabular summaries present mileage of highway that is in each condition category. This information is grouped in various ways and organized by Region and District. The various grouping categories include All State Highways, Interstate Highways, NHS Highways excluding the Interstate, Non-NHS Highways, and Access Oregon Highways.

International Roughness Index (IRI)

This page describes the International Roughness Index (IRI) used to describe road roughness. It is part of a set of Web pages related to road roughness, and is provided as a service of The University of Michigan Transportation Research Institute (UMTRI).

Background

Almost every automated road profiling system includes software to calculate a statistic called the International Roughness Index (IRI). Since 1990, the Federal Highway Administration (FHWA) has required the states to report road roughness on the IRI scale for inclusion in the Highway Performance Monitoring System (HPMS).

The IRI was proposed by The World Bank as a standard roughness statistic.

The World Bank sponsored several large-scale research programs in the 1970's that investigated some basic choices facing developing countries: should the governments borrow money to build good, expensive roads, or should they save money with poor, cheap roads? It turns out that poor roads are also costly to the country as a whole, due to user costs such as damage to vehicles. Road roughness was identified as a primary factor in the analyses and trade-offs involving road quality vs. user cost. The problem was, roughness data from different parts of the world could not be compared. Even data from the same country were suspect because the measures were based on hardware and methods that were not stable over time.

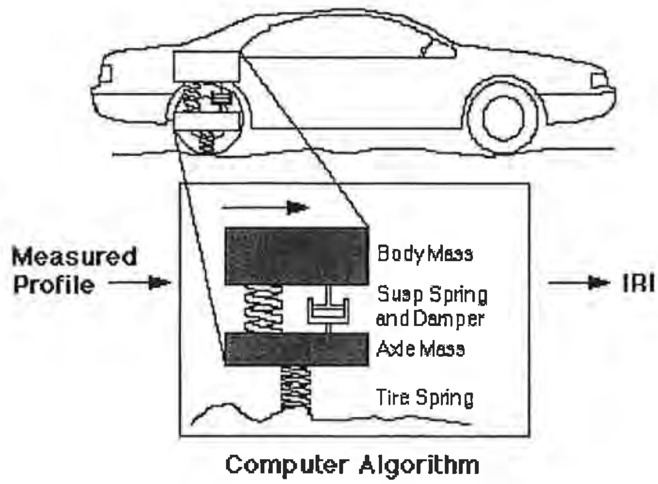
In 1982, the World Bank initiated a correlation experiment in Brazil to establish correlation and a calibration standard for roughness measurements. In processing the data, it became clear that nearly all roughness measuring instruments in use throughout the world were capable of producing measures on the same scale, if that scale were suitably selected. From that point on, an objective of the researchers was to develop the IRI.

The IRI is reproducible, portable, and stable with time.

The IRI is the first widely used profile index where the analysis method is intended to work with different types of profilers. It is defined as a property of the true profile, and therefore it can be measured with any valid profiler. The analysis equations were developed and tested to minimize the effects of some profiler measurement parameters such as sample interval. Example computer programs were published by The World Bank and have been used by profiler developers and others to test new software that computes IRI.

The IRI simulates a standard vehicle with a perfect road meter.

At the time of its development, response-type road roughness measuring systems were common, so the index was tailored to correlate well with the output of these systems. The filter in the IRI is based on a mathematical model called a quarter-car. The quarter-car filter calculates the suspension deflection of a simulated mechanical system with a response similar to a passenger car. The simulated suspension motion is accumulated and divided by the distance traveled to give an index with units of slope (m/km, in/mi, etc.).



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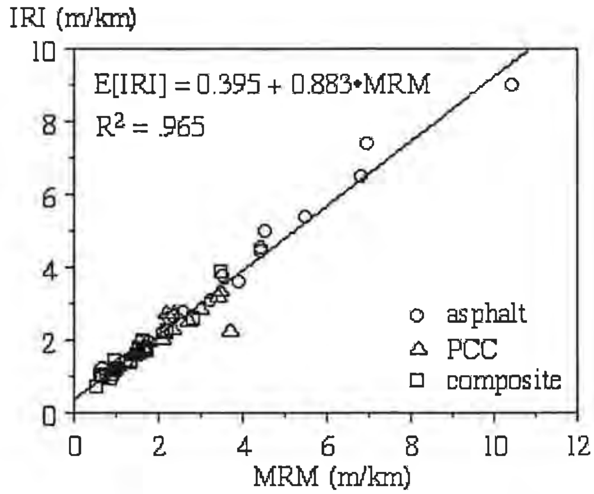
Properties of the IRI Analysis

The quarter-car model used in the IRI algorithm is just what its name implies: a model of one corner (a quarter) of a car. The model is shown schematically in the above figure: it includes one tire, represented with a vertical spring, the mass of the axle supported by the tire, a suspension spring and a damper, and the mass of the body supported by the suspension for that tire.

The quarter-car model was tuned to maximize correlation with response-type road roughness measuring systems.

This quarter-car simulation is meant to be a theoretical representation of the response-type systems in use at the time the IRI was developed, with the vehicle properties adjusted to obtain maximum correlation to the output of those systems. Considerations in its design are described in NCHRP Report 228. The model was called "The Golden Car" at the time, because it was intended to serve as a reference for response-type systems.

The parameters used in the quarter car give it simulated response properties typical of most highway vehicles with one exception: the damping is higher than most cars. This keeps the IRI from "tuning in" to certain wavelengths and degrading correlation with other vehicles. The figure below shows how IRI values from profile data relate to raw measures from a response-type system.



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The response of the IRI to sinusoids is intentionally very similar to measured physical response of highway vehicles. It was mainly developed to match the responses of passenger cars, but subsequent research has shown good correlation with light trucks and heavy trucks. The IRI has become recognized as a general-purpose roughness index that is strongly correlated to most kinds of vehicle response that are of interest. Specifically, IRI is very highly correlated to three vehicle response variables that are of interest:

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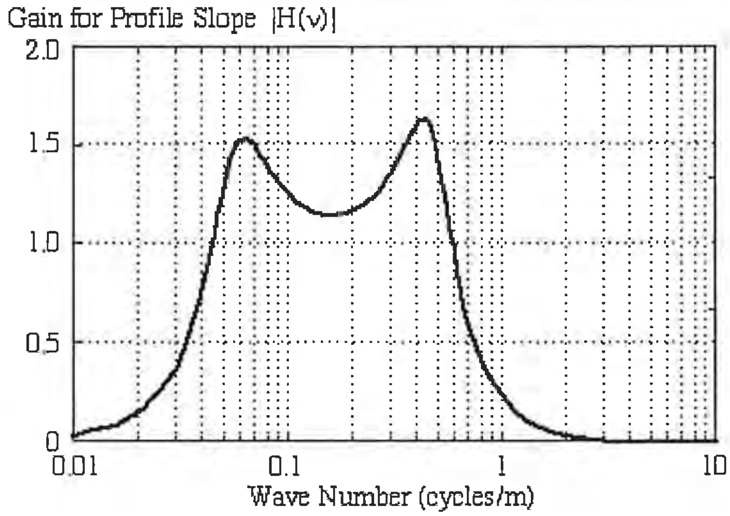
The fact that IRI correlates well with both road meter response and passenger acceleration is no coincidence: the correlation between road meter response and passenger acceleration was certainly a factor in the decades of acceptance of the road meter as a useful tool for measuring roughness.

IRI is influenced by wavelengths ranging from 1.2 to 30.5 m (4 to 100 ft).

The wave-number response of the IRI quarter-car filter is shown in the next figure. The amplitude of the output sinusoid is the amplitude of the input, multiplied by the "gain" shown in the figure. The gain shown in the figure is dimensionless. Thus, if the input is a sinusoid with an amplitude that is slope, the output is the product of the input amplitude and the value taken from the plot.



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The IRI scale is linearly proportional to roughness.

If all of the elevation values in a measured profile are increased by some percentage, then the IRI increases by exactly the same percentage. An IRI of 0.0 means the profile is perfectly flat. There is no theoretical upper limit to roughness, although pavements with IRI values above 8 m/km are nearly impassable except at reduced speeds.

The IRI was the first highly portable roughness index that is stable with time.

The IRI is not the first profile-based roughness index. When it was introduced, profilers from different countries and different manufacturers were each used with profile analyses developed for their specific hardware. Most of the analyses were not intended to work with true profile. Those that did had specific requirements for the interval between elevation measures, and gave significant errors when applied to profiles that had a different interval.

The software published by The World Bank was tested by new users, who found that under controlled research tests, they could obtain nearly identical IRI values using different profilers.

Definition of the IRI

The above descriptions of the IRI background and properties are intended to give an idea of what the IRI computer software is intended to simulate, and how you can interpret the IRI scale. However, the IRI is rigorously defined as a specific mathematical transform of a true profile. The specific steps taken in the computer program to compute IRI are listed below.

The IRI is calculated for a single profile.

If your profiler measures several profiles simultaneously, then you can get the IRI for each. The

IRI standard does not specify how you locate the line on a road that defines the profile. Any possible line on the ground has an associated IRI statistic.

The standard does not specify how you combine IRI values for different profiles taken for the same road. They can be averaged, but the result is not IRI--it is the average of several IRI's.

The profile is filtered with a moving average with a 250-mm base length.

The moving average is a low-pass filter (it attenuates short wavelengths) that smoothes the profile. It has no effect unless the profile sample interval is shorter than 167 mm (6.6 in).

The 250-mm moving average filter should be omitted for profiles obtained with some systems.

This step should be omitted if the profile has already been filtered by a moving average or with an anti-aliasing filter whose cut-off attenuates wavelengths shorter than 0.6 m. Profilometers by K.J. Law detect elevation values at intervals of 25.4 mm, apply a 300 mm moving average filter, and store the result at 152.4-mm intervals. It is important to skip the 250-mm filter when processing profiles from these systems.

The profile is further filtered with a quarter-car simulation.

The quarter-car parameters are specified as part of the IRI statistic, and the simulated travel speed is specified as 80 km/h (49.7 mi/h). The output of the filter represents suspension motion of the simulated quarter car.

The filtered profile is accumulated by summing absolute values of the filtered point, and divided by the profile length.

The resulting IRI statistic has units of slope. As a user, you can express the slope in any appropriate units. The most common choices are in/mi and m/km (1 m/km = 63.36 in/mi).

Summary: IRI is a profile index.

The IRI is a specific profile index. The analysis is applied to a single profile, the profile is filtered (twice), the filtered result is accumulated, and finally divided by the length of the profile. The IRI is linearly related to variations in profile, in the sense that if all of the elevation values in the profile are doubled, the resulting IRI will also be doubled.

Software

Two programs are available for the calculation of the IRI. The first is a free user-friendly Windows-based software package called RoadRuf for interpreting longitudinal road roughness profile data, including the calculation of IRI. The second is a sample Fortran program for calculating IRI and RN (Ride Number). It is meant to give developers of profilers and profile analysis software a stripped-down program for getting IRI. Download the IRI source code.

Bibliography

A few of the following documents can be downloaded via FTP. The documentation is in Adobe Acrobat's Portable Document File (pdf) format which can be read by the Adobe Acrobat Reader. For information about Adobe Acrobat Reader, including free copy of the software, visit Adobe's web site: Steps to Downloading the Free Acrobat Reader.

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Program Manager: T.J. Freeman

About the Program
The Pavement Management Program focuses on improving pavement management through the analysis of pavement data. One recent project was to develop a Guide for Pavement Management, for consideration and adoption by AASHTO, that discusses technologies and processes pertaining to selection, collection, reporting, management, and analysis of data used in pavement management. Because much of the material needed for Guide development is currently available, the work will focus on compiling, reviewing, and documenting relevant information.

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NAPA

National Asphalt Pavement Association

About NAPA

NAPA is the only national trade association that exclusively represents the Hot Mix Asphalt (HM industry.

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NAPA's professional staff

NAPA Partners
NAPA connects to the Hot Mix Asphalt industry through partnerships with other associations, universities, and government agencies.

What is NAPA?
The National Asphalt Pavement Association is the only trade association that exclusively represents the interests of the Hot Mix Asphalt producer and paving contractor on the national level with Congress, government agencies, and other national trade and business organization: NAPA supports an active research program designed to answer questions about environmental issues and to improve the quality of HMA pavements and paving techniques used in the construction of roads, streets, highways, parking lots, airports, and environmental and recreational facilities. The Association provides technical, educational, and marketing materials and information to its members, and supplies technical information to users and specifiers of paving materials. The Association, which counts more than 1,100 companies as its members, v founded in 1955.

What does NAPA do?
NAPA's staff consists of professionals ready to help its members learn the latest technology, understand environmental issues, gain market share, and receive training. NAPA is the most valuable resource in the Hot Mix Asphalt industry.

Where is NAPA located?
NAPA is conveniently located just outside the Washington Capital Beltway, and just minutes frc downtown Washington, DC. The NAPA office is convenient to all three Washington-area airport: (BWI Airport , Reagan National Airport, Dulles International Airport). For directions to the NAPA office, please [click here].

Who are NAPA Members?
Companies or individuals in the HMA industry that operate on a for-profit basis which include H producers, paving contractors, equipment and materials manufacturers, materials suppliers, equipment distributors, engineering firms, and consultants.

What is Hot Mix Asphalt (HMA) pavement?

Asphalt pavement refers to any paved road surfaced with asphalt. Hot Mix Asphalt is a combination of approximately 95% stone, sand, or gravel bound together by asphalt cement, a product of crude oil. Asphalt cement is heated aggregate, combined, and mixed with the aggregate at an HMA facility. The resulting Hot Mix Asphalt is loaded into trucks for transport t the paving site. The trucks dump the Hot Mix Asphalt into hoppers located at the front of pavin machines. The asphalt is placed, then compacted using a heavy roller, which is driven over the asphalt. Traffic is generally permitted on the pavement as soon as the pavement has cooled.

For questions about NAPA, please e-mail Margaret Cervarich.

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NAPA National Asphalt Pavement Association
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Office of Highway Policy Information

Pavement Surface Condition of the NHS and Interstate System (Rural and Urban)

NHS

IRI 95-170: 39.0%

IRI < 95: 54.5%

IRI > 170: 6.5%

INTERSTATE

IRI 95-170: 33.4%

IRI < 95: ~~3.2%~~ 63.2

IRI > 170: 3.4%

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This page last modified on February 14, 2003

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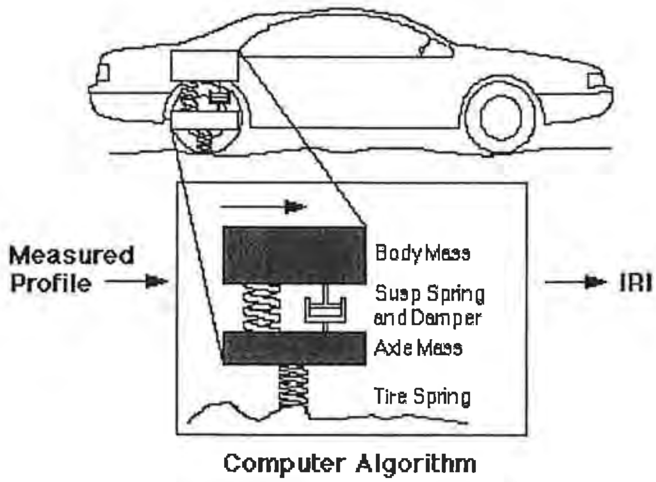

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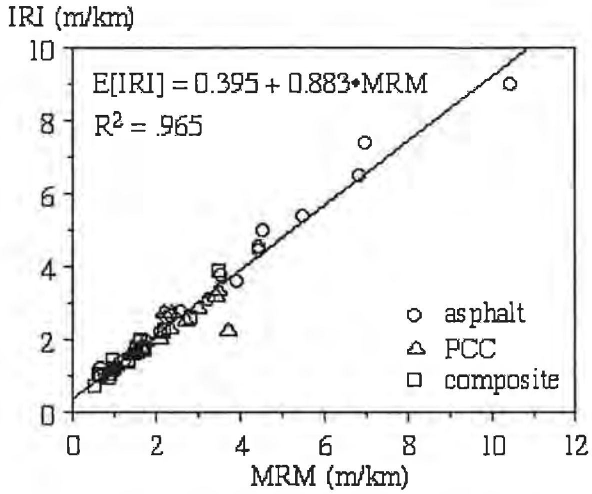

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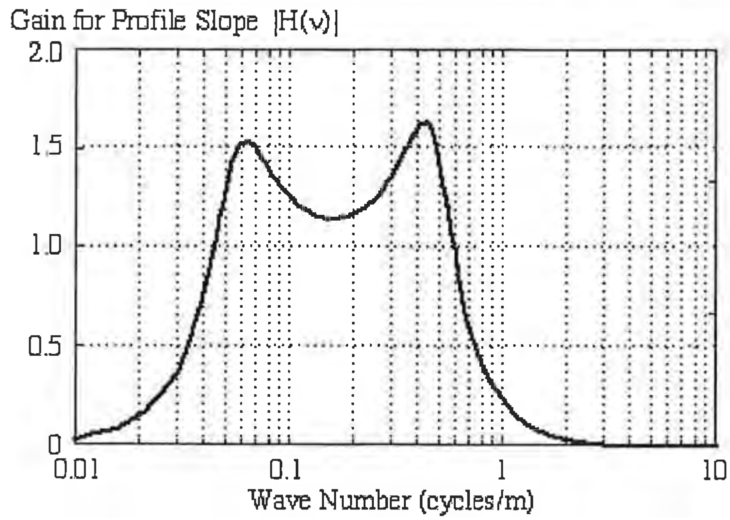

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If all of the elevation values in a measured profile are increased by some percentage, then the IRI increases by exactly the same percentage. An IRI of 0.0 means the profile is perfectly flat. There is no theoretical upper limit to roughness, although pavements with IRI values above 8 m/km are nearly impassable except at reduced speeds.

The IRI was the first highly portable roughness index that is stable with time.

The IRI is not the first profile-based roughness index. When it was introduced, profilers from different countries and different manufacturers were each used with profile analyses developed for their specific hardware. Most of the analyses were not intended to work with true profile. Those that did had specific requirements for the interval between elevation measures, and gave significant errors when applied to profiles that had a different interval.

The software published by The World Bank was tested by new users, who found that under controlled research tests, they could obtain nearly identical IRI values using different profilers.

Definition of the IRI

The above descriptions of the IRI background and properties are intended to give an idea of what the IRI computer software is intended to simulate, and how you can interpret the IRI scale. However, the IRI is rigorously defined as a specific mathematical transform of a true profile. The specific steps taken in the computer program to compute IRI are listed below.

The IRI is calculated for a single profile.

If your profiler measures several profiles simultaneously, then you can get the IRI for each. The

IRI standard does not specify how you locate the line on a road that defines the profile. Any possible line on the ground has an associated IRI statistic.

The standard does not specify how you combine IRI values for different profiles taken for the same road. They can be averaged, but the result is not IRI--it is the average of several IRI's.

The profile is filtered with a moving average with a 250-mm base length.

The moving average is a low-pass filter (it attenuates short wavelengths) that smoothes the profile. It has no effect unless the profile sample interval is shorter than 167 mm (6.6 in).

The 250-mm moving average filter should be omitted for profiles obtained with some systems.

This step should be omitted if the profile has already been filtered by a moving average or with an anti-aliasing filter whose cut-off attenuates wavelengths shorter than 0.6 m. Profilometers by K.J. Law detect elevation values at intervals of 25.4 mm, apply a 300 mm moving average filter, and store the result at 152.4-mm intervals. It is important to skip the 250-mm filter when processing profiles from these systems.

The profile is further filtered with a quarter-car simulation.

The quarter-car parameters are specified as part of the IRI statistic, and the simulated travel speed is specified as 80 km/h (49.7 mi/h). The output of the filter represents suspension motion of the simulated quarter car.

The filtered profile is accumulated by summing absolute values of the filtered point, and divided by the profile length.

The resulting IRI statistic has units of slope. As a user, you can express the slope in any appropriate units. The most common choices are in/mi and m/km (1 m/km = 63.36 in/mi).

Summary: IRI is a profile index.

The IRI is a specific profile index. The analysis is applied to a single profile, the profile is filtered (twice), the filtered result is accumulated, and finally divided by the length of the profile. The IRI is linearly related to variations in profile, in the sense that if all of the elevation values in the profile are doubled, the resulting IRI will also be doubled.

Software

Two programs are available for the calculation of the IRI. The first is a free user-friendly Windows-based software package called RoadRuf for interpreting longitudinal road roughness profile data, including the calculation of IRI. The second is a sample Fortran program for calculating IRI and RN (Ride Number). It is meant to give developers of profilers and profile analysis software a stripped-down program for getting IRI. Download the IRI source code.

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Everything You Always Wanted to Know about the IRI, But Were Afraid to Ask!

by

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The University of Michigan Transportation Research Institute

Presented at the
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Abstract

The International Roughness Index has become the standard scale on which road roughness information is reported both here in the United States [1]* and in many countries of the world. Procedures for determining the IRI are well developed and reliable, yet many users are unaware of the history of its development and the physical significance of this measure of roughness. This paper describes the history of roughness measurement from which the IRI evolved, and explains the physical meaning of the index.

Roughness Measurement in the Past

"Ever since roads and highways have been constructed, the people who use them have been keenly aware of the relative degrees of comfort or discomfort experienced in traveling" [2]. The evidence that remains today from the paved roads of the Roman Empire (see Fig. 1) suggests that roughness must have been a concern for chariot travel. Even in the 1800s, high-speed travel in this country by stage coach had a reputation for rigor directly resulting from roughness of the roadway.

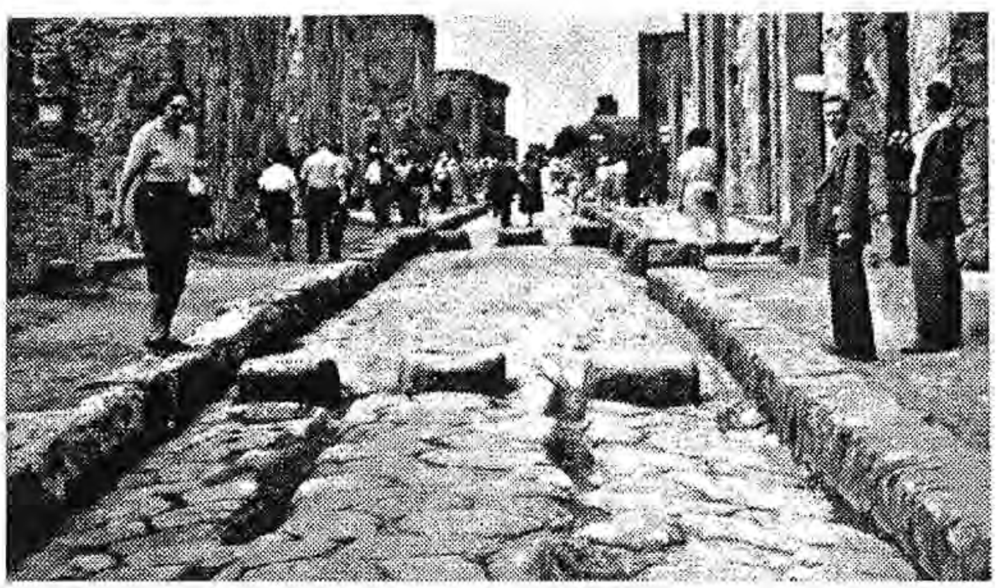

Fig. 1 Photograph of an early Roman road [2]

* Numbers in brackets refer to references at end.

With the introduction of the gasoline-powered motor vehicle at the turn of the Twentieth Century, more people had access to means of high-speed personal travel and the travel speeds rapidly surpassed the limits practical with horses. The increase in speed placed even greater premium on building and maintaining roads with a smooth travel surface.

Those early years saw the first rudimentary attempts to measure the roughness properties of a road. A sliding straightedge, known as the "Viagraph," (see Fig. 2) was one of the first methods to measure roughness by recording the deviation at the center point of the straightedge [2]. The measurement response of the straightedge is indicated by the gain shown in the figure. Long wavelengths (low wavenumbers) produced no response, whereas the gain approached unity at wavelengths equal to or less than the base length of the straightedge. Interestingly enough, the roughness measured by this device was reported in feet of deviation per mile, with 15 feet/mile (180 inches/mile) recommended as the standard for construction.

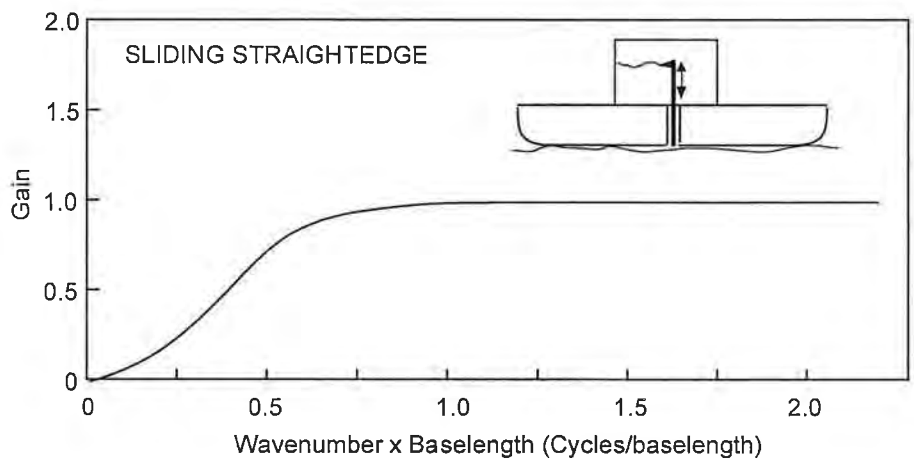

Fig. 2 Response of the sliding straightedge road roughness measuring device

With the obvious disadvantages of the effort to move the sliding straightedge and the wear and tear that resulted, it was not surprising to see development of the rolling straightedge (see Fig. 3). This device had its own unique response to roughness that was different from the sliding straightedge, characterized by the fact that it recorded every bump three times—once when the front wheel passed over, a second time when the measuring wheel passed over, and a third time when the rear wheel passed over. Because the straightedge contacted the road surface at three points, bumps of certain wavelengths recorded at twice amplitude, while others did not record at all. Thus the rolling straightedge "tuned" to certain wavelengths of roughness in the road, while ignoring others.

To overcome this problem the rolling concept was subsequently improved by adding an array of wheels to establish a reference plane from which to measure deviations (see Fig. 4), and remains with us today memorialized as the Profilograph. Bogey attachments for the array of wheels averaged the elevation of all points under the wheels, and roughness was measured as deviation of the center wheel from this reference. With a large number of wheels the response approaches the theoretical limit shown in the figure.

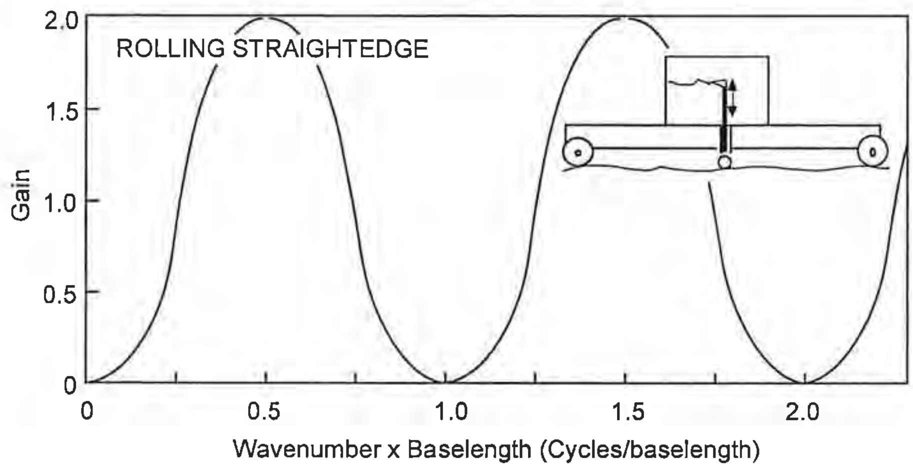

Fig. 3 Response of the rolling straightedge road roughness measuring device

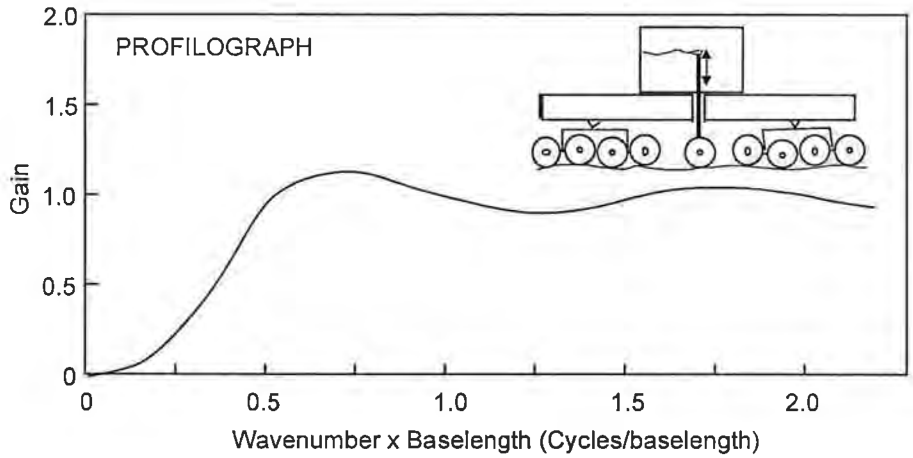

Fig. 4 Response of the Profilograph

With the variation in response properties for each of these measurement devices, it is clear that progress was not being made toward consensus on a universal and standardized measure of road roughness.

By the 1920s highway engineers recognized that roughness properties in a road of greatest importance were those responsible for causing vibrations of motor vehicles. The "Via-Log" developed by the State of New York evidenced this thinking by measuring the suspension travel of a passenger car as an indication of the roughness level. The first devices recorded the suspension motion, but were soon modified to sum the motion on a mechanical counter and measure an "inches/mile" statistic.

Over the next decades the difficulty of obtaining consistent measurements by this method, due to the variations in dynamics of motor vehicles, led to the attempt to "standardize" the vehicle. The Bureau of Public Roads (BPR) Roughometer (later adapted in similar form as the Bump Integrator by the Transport and Road Research Laboratory in

England) was born in 1941. The Roughometer was a single-wheel trailer (see Fig. 5) in which all dimensions, mass properties, and tire and suspensions properties were standardized in an effort to achieve comparable performance on all devices.

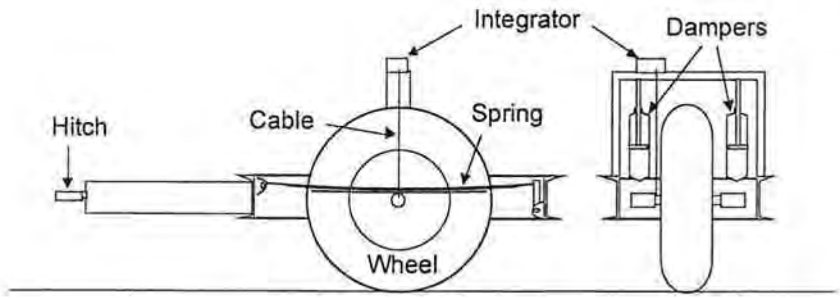

Fig. 5 The BPR Roughometer

One other important roughness measurement device developed at the time of the AASHO Road Test [3] was the CHLOE (an acronym formed from the first letters of the inventors' names). The CHLOE (see Fig. 6) consisted of a trailer towed at a low speed on which was mounted two small wheels 9 inches apart with instrumentation to measure and record the local road slope. The signal recorded was the slope deviation (or slope variance), which is generically an "inches/mile" statistic. The slope variance measured by the CHLOE is of particular significance to highway engineers today as it was the historical reference for roughness used in development of the Pavement Serviceability concept [4]. Despite this special status, the CHLOE is no longer in routine use today.

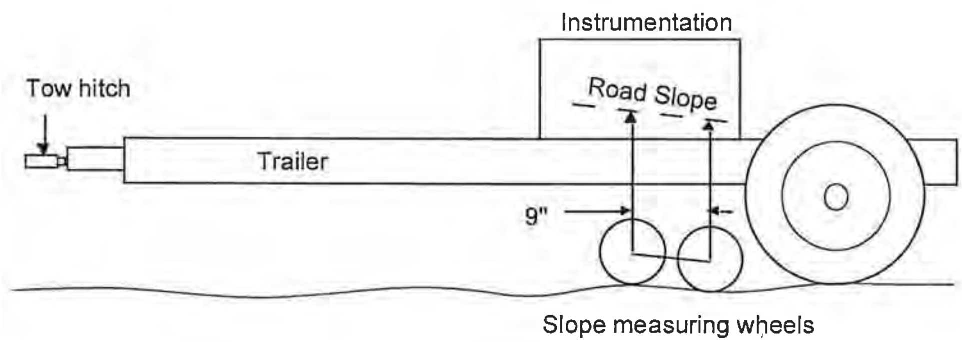

Fig. 6 Illustration of the CHLOE

By the 1960s the attraction of being able to measure roughness properties from a moving vehicle motivated development of "roadmeters" (sometimes called "ridemeters") in the form of the Mays Meter [5], the PCA Meter [6], and other comparable devices. The relatively inexpensive devices could be mounted in any available automobile as shown in Figure 7, and would measure the axle displacement as the vehicle traversed a test section. Most of the roadmeters measured accumulated axle displacement, which is the "inches/mile" deviation of the road surface colored by the dynamics of the vehicle. (The PCA Meter differed in that it would give greater weight to large displacements, but could also be used to simply accumulate displacements like the other meters.) This general class of devices became known as Response-Type Road Roughness Measurement Systems (RTRRMS).

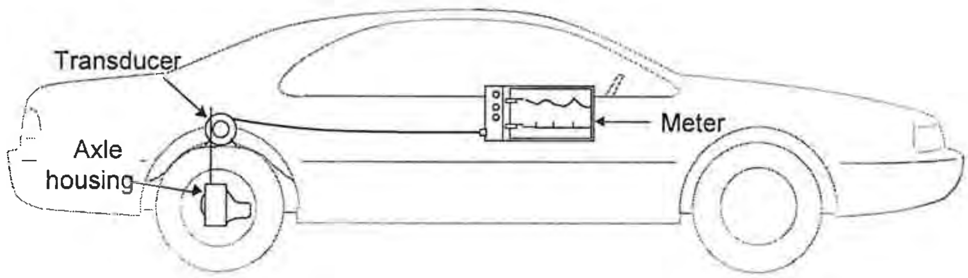

Fig. 7 Illustration of an RTRRMS

Because of their simplicity and low cost, RTRRMS were acquired by the highway departments of approximately half of the states by the late 1970s. Although they reliably measured high "inches/mile" on bad roads and lower numbers on smooth roads, they were not accurate enough for most engineering applications. As might be expected, no two roadmeters gave identical measurements because of differences in the dynamics of the vehicles, and consistent performance from day-to-day with individual roadmeters was also difficult to achieve. Such routine actions as adding fuel or passengers, adjusting tire pressure, balancing tires, etc. changed the "calibration" of the device. As a result it was difficult to develop and maintain a database of road roughness conditions without extensive effort at controlling or compensating for vehicle changes by frequent calibration exercises.

This problem was addressed by the National Cooperative Highway Research Program in 1978 in the Project 1-18 [7], "Calibration and Correlation of Response-Type Road Roughness Measuring Systems," which began the work eventually leading to development of the International Roughness Index (IRI).

The NCHRP project examined the sources of variability in roughness measurement with RTRRMS and identified calibration procedures to compensate for each so that measurements would be consistent and correlatable between different systems. Concurrently, the World Bank faced a similar though broader problem of obtaining comparable measurements of roughness (for data input to highway cost models) in the many countries in which it was providing loans for development of road systems. Although RTRRMs were used in many of these countries, to achieve consistent measurement performance rigorous calibration methods were needed that could be based on technology available at these sites. Equally important was the need for a standard scale of roughness that would be stable over time and transportable throughout the world to allow comparison of measurements on a worldwide basis. To address this problem the International Road Roughness Experiment was organized and conducted in Brazil in 1982 [8].

The outcome of these efforts was the identification of a standard scale now known as the International Roughness Index (IRI). Many factors were considered in its selection:

- The index had to be related to the vibration response of motor vehicles, as most roughness indices were either directly or indirectly linked to motor vehicle performance

- The scale had to be mathematically related to road profile in order to be stable with time (as all attempts to standardize hardware had been unsuccessful)

- It had to be measurable by a widest possible range of hardware (i.e., rod and level, RTRRMS, profilometers, etc.)

- It had to be transportable (i.e., procedures and hardware requirements had to be defined so that it could be reliably reproduced throughout the world).

The Rationale behind the IRI

The International Roughness Index (IRI) is a scale for roughness based on the response of a generic motor vehicle to roughness of the road surface. Its true value is determined by obtaining a suitably accurate measurement of the profile of the road, processing it through an algorithm that simulates the way a reference vehicle would respond to the roughness inputs, and accumulating the suspension travel. Thus it mathematically duplicates a roadmeter.

In virtually all of the measuring systems described above the roughness is quantified by some measure of vertical deviations over a section of road. The cumulative deviations per mile (i.e., "inches/mile") are a summary measure of road slope deviations. Nearly all roughness measurement systems—from the early straightedge devices, to the CHLOE of the AASHO Road Tests, to the roadmeters—measure a slope statistic. However they don't obtain identical measurements because each device has unique sensitivities to different wavelengths in the road as illustrated in the previous figures. There is no such thing as a "true" measure of slope deviations, because over the full range of wavelengths the value is infinite. Finite values are obtained only by limiting the band of wavelengths over which measurements are made. This happens naturally with every measurement system because each has limits to its response, although the limits are often ill-defined and response is variable with wavelength.

In the case of roadmeters, the cumulative stroke of the automobile's suspension is measured over a section of road colored by the particular response characteristics of the automobile. This is what is done in computation of the IRI. The relevant response properties of an automobile are captured by a simple dynamic model known as the quarter-car model shown in Figure 8. At each wheel position the vehicle behaves as a sprung mass sitting on a suspension with stiffness and damping, which in turn is attached to the unsprung mass of the wheel, brake, and suspension components. The wheel contacts the road by a tire which acts like a spring. Road inputs to the car flex the tire, stroke the suspension, and cause the sprung and unsprung masses to vibrate in the vertical direction.

Whether the roughness is viewed as deviations in elevation (displacement inputs), slope (velocity inputs), or change of slope (acceleration inputs) the quarter car responds in a defined manner. The response can be mathematically described with a relatively simple set of dynamic equations known as a quarter-car simulation. At very low frequencies (corresponding to long wavelengths in the road) the suspension response is zero because the wheel and the vehicle body move up and down together. Road inputs at frequencies near one Hertz cause the sprung mass to resonate on the suspension producing stroke that is slightly greater than the road input. The response is maintained up through frequencies near 10 Hertz where axle resonance occurs. Above the axle resonant frequency the response again drops to zero as the road bumps simply deflect the tire without producing significant suspension stroke.

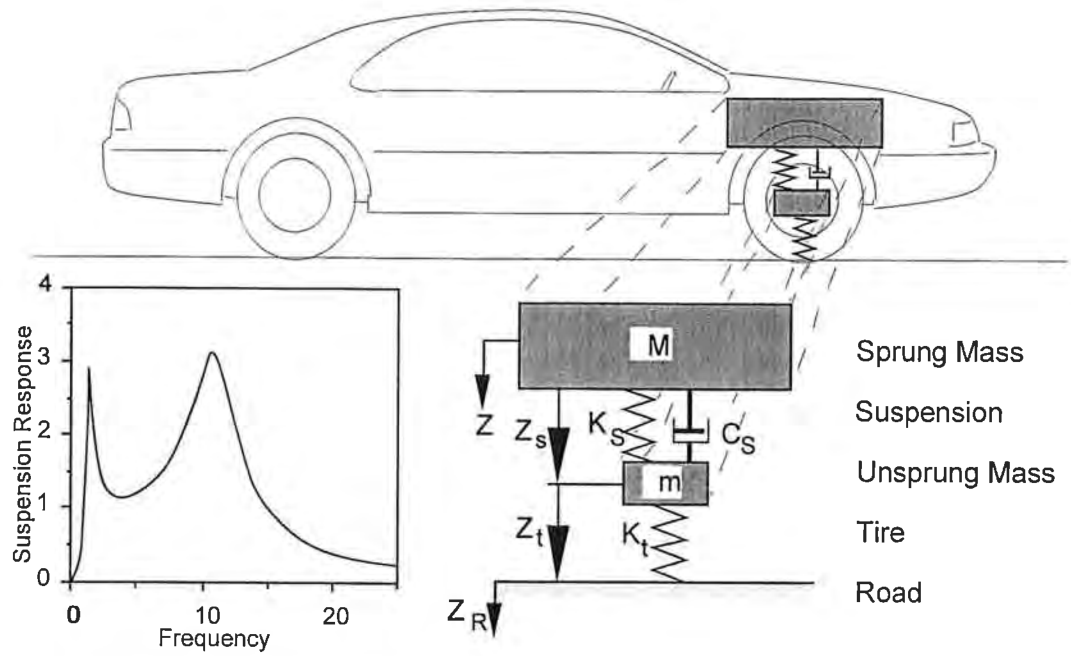

Fig. 8 The quarter-car model

The frequency response of the quarter car extends from approximately 0.5 to 20 Hz. with some emphasis on roughness at the body bounce frequency and the axle resonance frequency. Although this differs from the response properties of the other devices shown earlier, it is more uniform in the waveband of measurement than many of the devices; and more importantly, it is characteristic of motor vehicle dynamics. The rationale favoring the quarter car is the fact that it covers the appropriate frequency range responsible for exciting vehicle vibrations and emphasizes those that excite modal resonances.

The measurement of suspension stroke as the roughness response was chosen for convenience back in the early development period of the "Via-Log" and roadmeters. Although it was not known at that time to be a valid measure of "ride" it turns out to be a reasonable approximation. The "ride" of a motor vehicle is most commonly measured by the acceleration on the body. On a typical road this turns out to be a body acceleration spectrum (a power spectral density, or PSD) similar to that shown in Figure 9. Also shown in the figure is the PSD from which the IRI accrues. Although slightly different in shape, they both cover the same frequency range and both place emphasis on the one Hertz body resonance and the 10 Hertz axle resonance.

Roughness is also significant to motor vehicle performance in other ways. The existence of roughness necessitates suspension systems on motor vehicles to reduce the vibration exposure of passengers. A primary consideration in design of suspension systems is the stroke necessary to accommodate the displacements caused by roughness. (Ride improves with stroke. The more generous suspension stroke in a luxury car is the primary factor that allows it to ride better than compact cars.) Thus, the likely stroke in the suspension must be rationalized with available package space in a vehicle. A relevant roughness measurement should therefore encompass the qualities that determine suspension stroke requirements. The PSD for suspension stoke shown in Figure 9 reveals that the body resonant mode, which is captured by the IRI, is dominant.

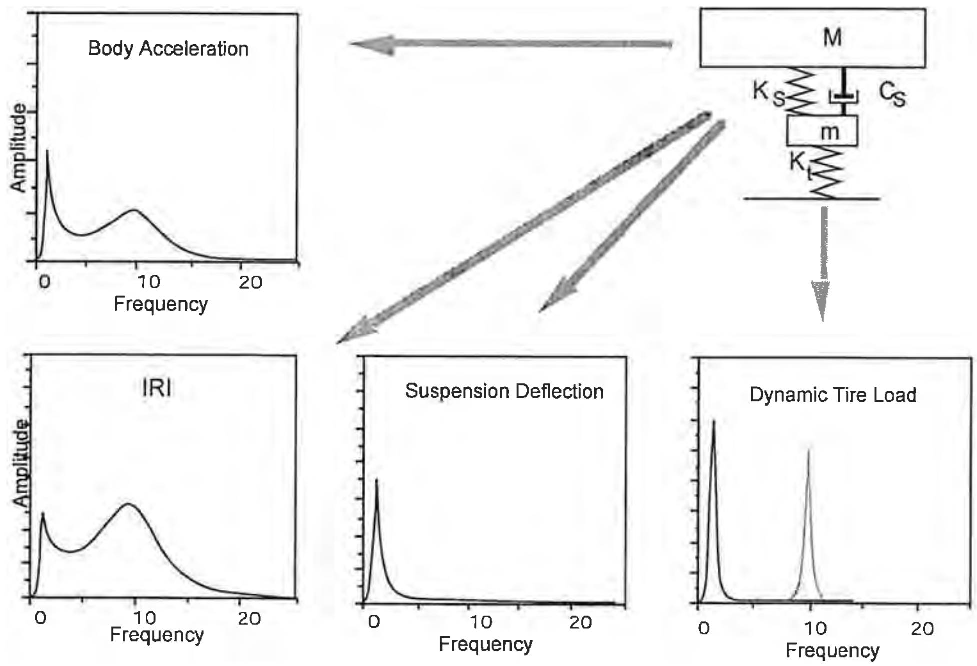

Fig. 9 Comparison of IRI with other vehicle responses

Finally, the dynamic load variations caused by roughness reduce the road holding ability of tires and contribute to road damage from heavy trucks. The PSD of dynamic tire load shown in Figure 9 is dominated by motions at the body resonant frequency for most vehicles. One exception of special concern to the highway community is the truck with a walking-beam tandem suspension which may also generate dynamic loads at about 10 Hz (the light curve in the figure).

Because of the similarity in the response between these various modes of vehicle performance, roughness measured on the IRI scale is closely related to each mode of performance. Figure 10 shows data from the International Road Roughness Experiment [9] relating Pavement Serviceability Index (PSI) to IRI. Inasmuch as serviceability ratings are dominated by vehicle ride perception [4], a close correlation with IRI roughness is expected. The data in the figure show a precise relationship which is approximated by the simple equation:

$$PSI \approx 5.0 - IRI/100 \qquad \text{for } 0 < IRI < 300 \text{ (in/mile)}$$

Other research looking specifically at the correlation of ride ratings and roughness wavelengths in the road [10, 11] have concluded that the quarter-car response is less than optimal. The best correlation was obtained when roughness measurement is limited to wavelengths corresponding to the axle-hop resonance of the car. While the correlation coefficients were higher for this limited band of wavelengths, those for the quarter-car reflected in IRI measures were still quite high. Limiting the band of wavelengths to achieve slightly higher correlation with ride has the disadvantage that it excludes roughness that excites body motions important to dynamic loading. I.e., the roughness measurement specifically "tuned" to ride misses other important roughness qualities in the road.

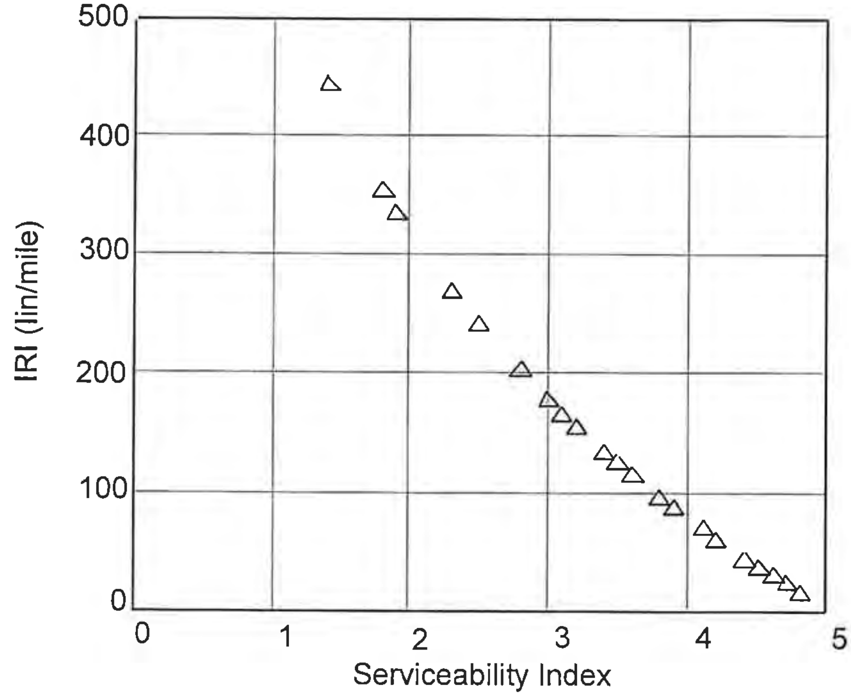

Fig. 10 Correlation of IRI with Serviceability Index [9]

The ability of IRI to measure roughness important to dynamic loading was demonstrated in a research project in which dynamic loads were measured on trucks with three different suspensions [12]. Figure 11 shows the relationship between roughness and the dynamic load expressed as a Dynamic Load Index. The Dynamic Load Index (DLI) is defined as the standard deviation of the load normalized by the static load. Thus, an index of zero implies the load is its static value, whereas an index of 0.25 represents load variation for which the standard deviation is 25% of the static load.

As seen in the figure, the dynamic load for the torsion-bar and walking-beam suspensions increases in direct proportion to the IRI roughness. This is as expected because the IRI scale includes roughness wavelengths that excite body bounce and pitch motions in trucks that are responsible for most of the load variation. (Although not proven here, dynamic loads for the walking-beam suspension are higher due to the strong axle-hop resonance in this suspension [13]. The wavelengths that excite this motion are also captured in the IRI, so it is an appropriate index of roughness for this vehicle as well.)

The relationship between IRI and the DLI for the leaf-spring suspension is not as linear as for the other suspensions. This arises from the fact that leaf-spring suspensions have high levels of coulomb friction. On smooth roads these suspensions exhibit high stiffness and little damping (accounting for the high initial increase of DLI with roughness). On rough roads, however, the suspension softens and increases damping, which limits the increase in DLI as the roads get rougher.

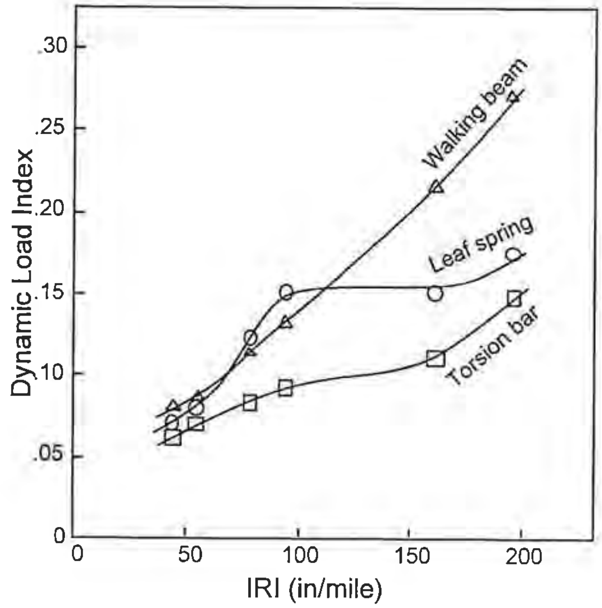

Fig. 11 Relationship of RTRRMS roughness to truck dynamic load [12]

Finally, Figure 11 illustrates one other important aspect of the precision that can be achieved by using the IRI roughness scale. Although there were no "perfectly" smooth roads (zero IRI) in these tests the slopes of the curves nominally project to a DLI value of about 0.05 at zero roughness. This corresponds to dynamic loads generated not by the road, but by nonuniformities (imbalances and runouts) in the tires of the trucks under test. Specifically, it is evidence that a typical truck has dynamic load variations on its axles of about 5% of the static load due to the truck itself, not road roughness.

Speed and Wheel Track Options of the IRI

While the discussion above presents the rationale that drove the choice of a quarter-car based roughness scale, the fact that it emulates a vehicle leaves choices as to how it is implemented, specifically with regard to the travel speed assumed for the calculation and the option for evaluating roughness of individual wheel tracks or combined left and right tracks.

Speed—On any road the level of roughness to which a vehicle is exposed depends on the travel speed. The perceived roughness generally increases with speed. This arises from the fact that the forces and accelerations imposed on a wheel by a bump increase with the speed at which it must "follow" the bump. Thus, roughness to the road user is not a constant, but may be judged differently on low- and high-speed roads. However, to the highway community roughness is a geometric property of the road. The geometry is constant, therefore a road should have a single roughness value.

To accommodate the differences in these viewpoints, the IRI is based on quarter-car response at 50 mph (80 km/h). A fixed speed for evaluating IRI ignores the fact that the prevailing travel speed varies with different types of roads. Thus, the choice of a fixed speed is a compromise between needs of the highway engineer and the realities of the physics governing vehicle behavior.

However, it should be recognized that the compromise is not unique to the IRI. Any geometrically based measurement of roughness—specifically measures that depend on a particular band of wavelengths—do exactly the same thing. The choice of allgeometrically-based measures has been driven by the goal of evaluating a quantity that is closely correlated to vehicle response. Thus the band of wavelengths selected is implicitly linked to an assumed vehicle travel speed, although that bias is usually unrecognized. The only difference is that the IRI explicitly reflects a chosen speed.

Single- vs. dual-track measurement—Another aspect of IRI measurement that can be confusing to the user is the choice of single- versus dual-track measurement. The common roughness measurement practices in use differ in treatment of wheel tracks. All profiling devices and all single-wheel RTRRMS (e.g., the BPR Roughometer) can measure single-track roughness. However, RTRRMS that use an automobile for the host vehicle are dual-track measurement devices. This arises from the fact that the roadmeter measures the average displacement of the left and right wheels.

The "minor" difference in methods, however, is not trivial in its consequences. Each wheel track has unique roughness features that contribute to bounce and roll of a motor vehicle. Measurements of individual wheel tracks quantify the total magnitude of the surface deviations. A car-based RTRRMS only measures the bounce component associated with the average deviation of the two wheel tracks. Thus, the IRI value from an car-based system is inherently 10% to 20% lower than the average of the IRI values of the two wheel tracks, and this factor must be taken into account in the calibration process.

The IRI calculation method has the flexibility to allow measurement in either fashion, however the single-track measurement has been selected as the standard. (Dual-track measurements from an RTRRMS are duplicated by the half-car simulation and should be denoted as HRI values rather than IRI values [14].) The single wheel track method provides more complete information about a road at the cost that two numerical values must be recorded. The unfortunate aspect is that averaging the IRIs from two wheel tracks is not identical to the average obtained with a car-based RTRRMS. This is not a fault of the IRI, but a consequence of the physical differences in the measurement process. IRI computed from an "average" left and right elevation duplicates car-based RTRRMS measurement, but at a loss in information about the road. Inasmuch as most roads deteriorate more rapidly in the right wheel track, the single track values provide a more precise indication of road condition.

Closure

The objective of this paper was to point out for those who must use the IRI today the historical basis from which it evolved. Roughness measurement technology developed around the conviction that imperfections in the surface geometry of a road were primarily important because of the vibrations induced in road-using vehicles. That conviction later transformed into a principle when Carey and Irick [4] identified roughness as the most important component in Present Serviceability. With that proof it was natural to see measures of vehicle response emerge as roughness indices. The development that led to the IRI was simply a formalization of the existing practice used by the highway community for measuring road roughness.

In the course of the development, consideration was given to alternative measures of vehicle response. For example, root mean square (RMS) of suspensions stroke was considered in lieu of the average rectified value (used by roadmeters) because of its greater mathematical utility. Likewise, the RMS body acceleration was considered in place of suspension stoke because of its more direct link to ride. However, no significant advantage was gained from the alternatives. The average rectified stroke was so similar to the others that it was incorporated in the IRI, thereby allowing highway agencies to maintain continuity of their roughness data bases.

The IRI is unique among roughness indices in the ease of measurement and the extent to which its measurability has been demonstrated. The World Bank experiments have validated that it can be measured by an extensive range of equipment including rod and level, Mays Meter cars, NAASRA car, French APL, BPR Roughometer, TRRL Bump Integrator, TRRL Beam, Swedish Road Surface Tester, ARAN, Face Dipstick, GMR-type Profilometers, South Dakota-type Profiling System and others. For each type of hardware, required procedures have been defined along with the level of accuracy to be expected, and these principles have been tested throughout the world. The rod and level method for measuring profiles from which to calculate IRI is now reduced to a standard method [15]. Thus, the IRI today provides highway engineers with a proven and robust basis for comparing roughness information across institutional boundaries.

The IRI is often criticized because it is not the "best" index for quantifying specific road roughness qualities or does not conform to local preferences for a roughness index. The most notable example of this comes from the extensive research that has been done to develop a roughness index that specifically relates to ride. The work by Janoff [10, 11] has identified profile wavelengths of 1 to 16 feet as most closely linked to passenger car ride, resulting in a Ride Number index that is the mean square amplitude of the profile in this range. Yet, from our knowledge of the broader issues in vehicle dynamics it is expected that Ride Number will prove inferior to other indices, particularly the IRI, in quantifying roughness relevant to truck ride and dynamic loads.

The fact that one index is better at quantifying a specific profile quality should not impede the acceptance of the IRI as a current measurement standard. As knowledge and technology develops for roughness measurement, it should be expected that a number of specialized profile indices will emerge as the "best" measure of specific roughness qualities. The development of new indices should not serve to discredit others. Rather, we need to recognize that each roughness index adds to our knowledge of road surface condition, and be prepared to maintain data bases of multiple indices as technology develops. At this time the IRI is the roughness measure of broadest utility (because it encompasses all wavelengths significant to motor vehicles) and should be the cornerstone of a roughness data base. Eventually, other indices should be added, as developed, to quantify surface profile properties related to specific performance qualities such as passenger-car ride, truck ride, dynamic loads, damage potential from dynamic loads, road holding, cracking and such. As it turns out, the highway engineers who developed the roughness measurement methods now in use and formalized by the IRI, made a choice that was not only rational then, but will remain so for the decades ahead.

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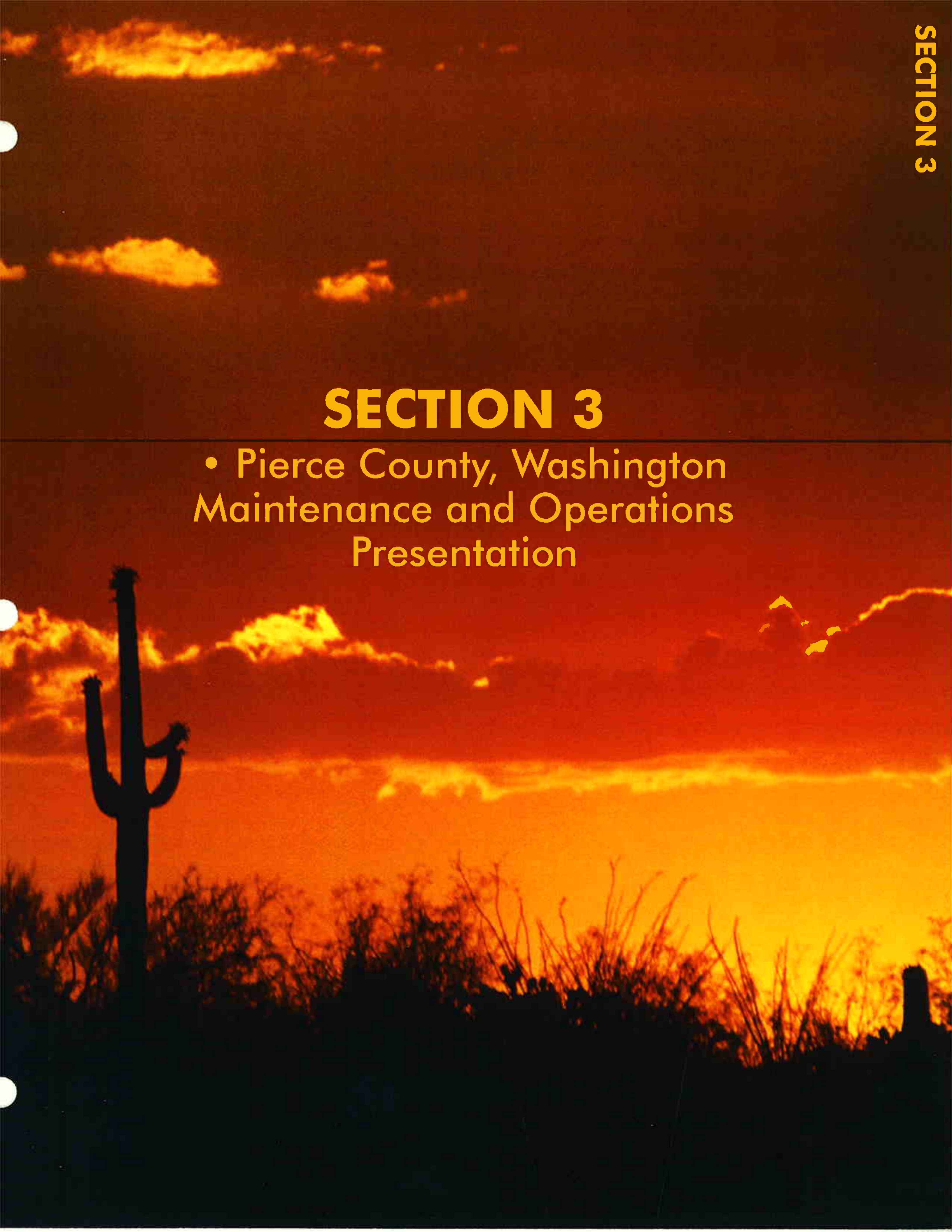
SECTION 3

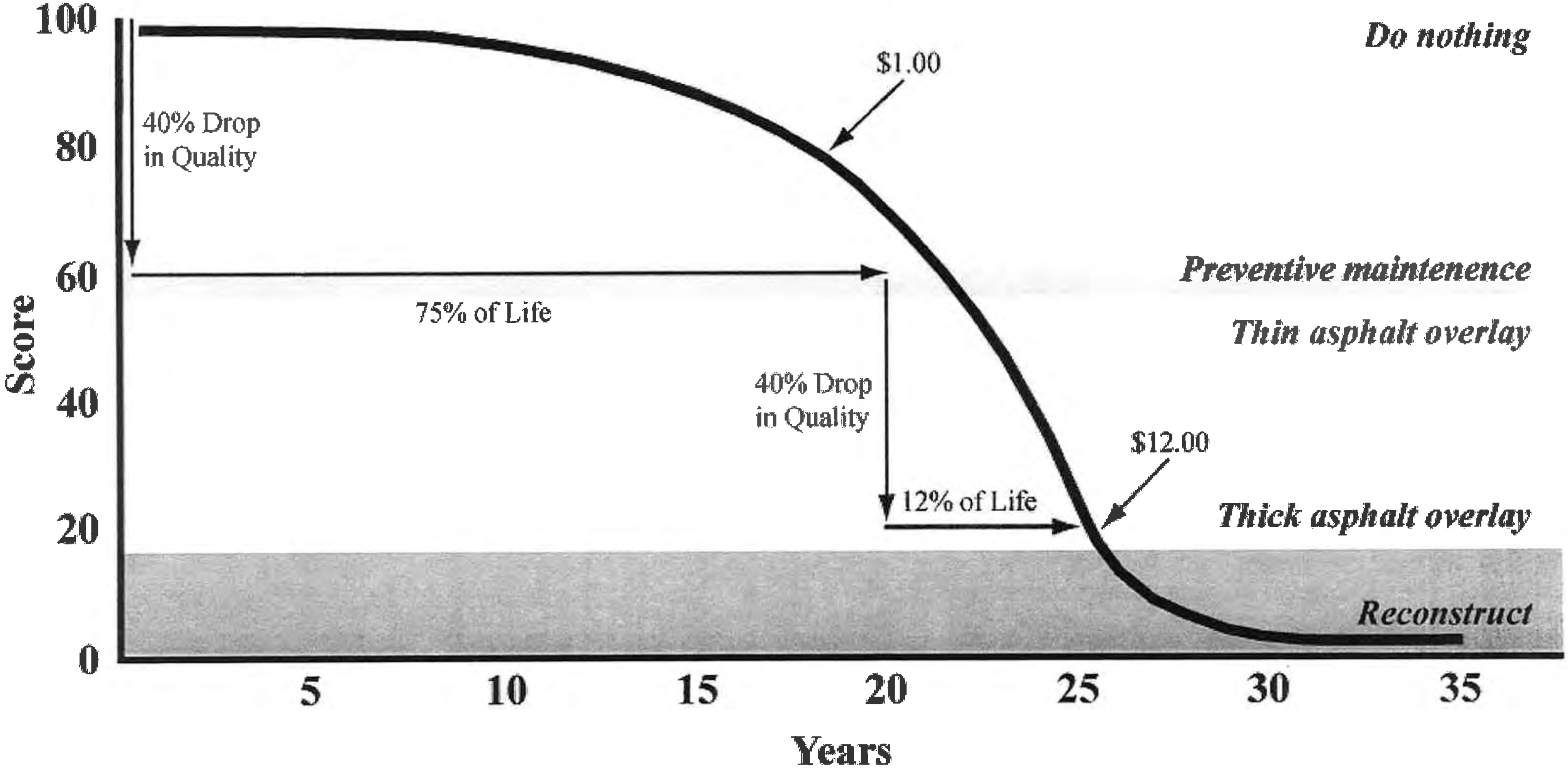
• Pierce County, Washington Maintenance and Operations Presentation



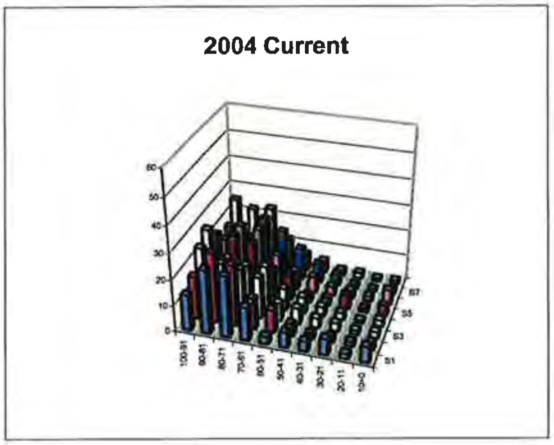
Who Are We & What Do We Do?

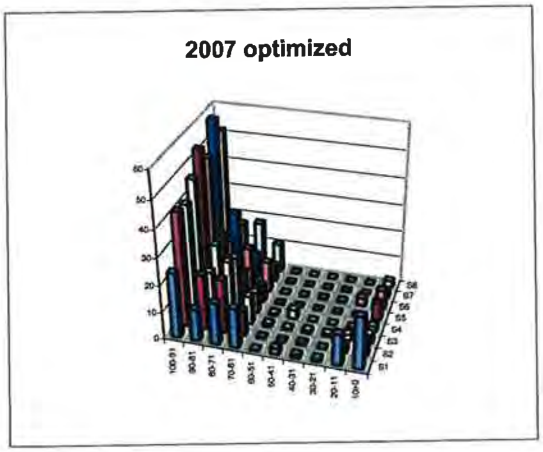
- Mission & Goals of Pierce County Roads
  - Maintenance
  - Operations
  - Preservation
  - Improvements
  - Administration

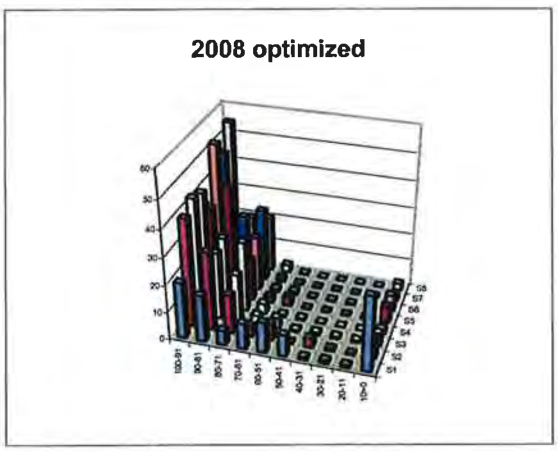
Typical Pavement Life Curve

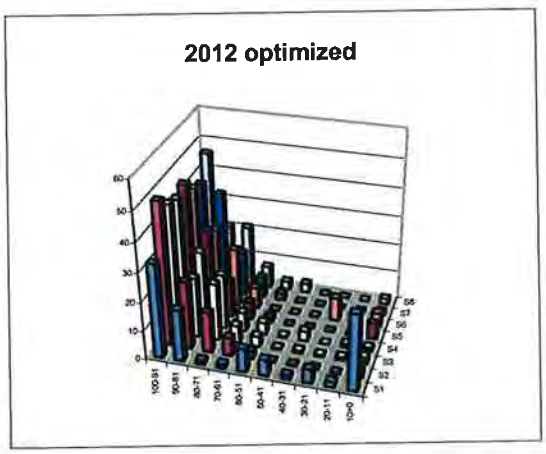


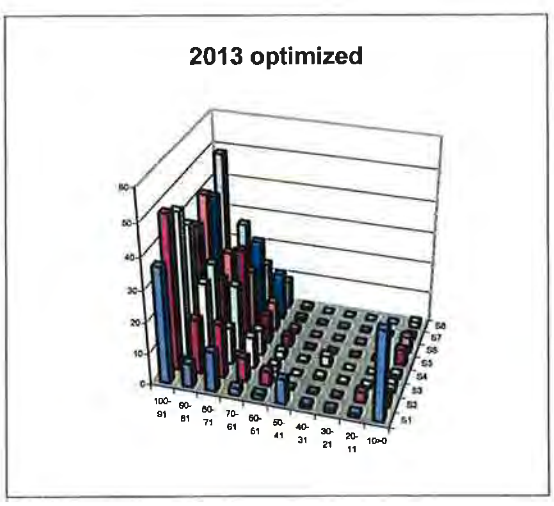
Current Deferred Maintenance in 2004 = ıction in 2004 = $28,049,353
Deferred Maintenance in 2013 = 2013 = $27,389,385







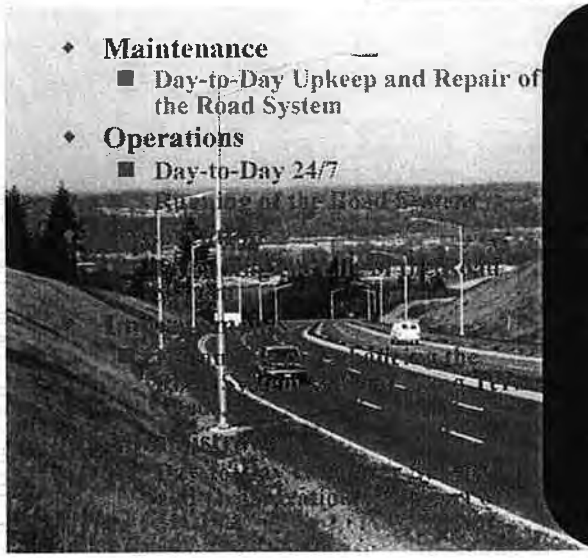




nance		Total Lenths in Feet	
Total	Deferred		
Costs	Costs	Select	Defer'd
ı,499,958	$7,204,059	425.48	1445.51
ı,499,960	$8,687,177	439.96	1463.83
ı,499,977	$7,637,898	443.15	1238.39
ı,499,360	$6,068,241	426.51	1197.19
ı,499,604	$5,498,916	423.24	1185.81
ı,499,382	$4,094,357	417.25	1263.85
ı,499,842	$3,450,678	402.43	1266.74
ı,499,030	$3,578,173	422.71	1279.94
ı,499,637	$6,041,585	431.66	1291.51
ı,497,834	$4,618,799	401.64	1316.74
:14,994,584			

Who Are We & What Do We Do?

Mission & Goals of Pierce County Roads



- **Maintenance**
  - Day-to-Day Upkeep and Repair of the Road System
- **Operations**
  - Day-to-Day 24/7 Running of the Road System

- Maintenance
  - Cleaning the gutters / mopping the floor
- Operations
  - Heating and cooling the house / responding to emergencies
- Preservation
  - Painting the house / Re-roofing the house
- Improvements
  - Adding on a room for the new baby / major remodeling of the kitchen
- Administration
  - Planning for the future / putting together the monthly budget

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Who Are We & What Do We Do?

Mission & Goals of Pierce County Roads

- **Maintenance**
  - Day-to-Day Upkeep and Repair of the Road System
    - Pothole patching and crack sealing
    - Roadside vegetation management
    - Shoulder grading
    - Roadside litter removal
    - Street sweeping
    - Stormdrain cleaning and repair
    - Bridge cleaning and repair

8/6/2004

7

Who Are We & What Do We Do?

Mission & Goals of Pierce County Roads

- **Operations**
  - Day-to-Day 24/7
    Running of the Road System
    - Traffic signs
    - Signals and illumination
    - Pavement markings
    - Traffic counting
    - Traffic studies
    - Crash records and analysis
    - Snow and ice removal
    - Disaster response

8/6/2004

8

Who Are We & What Do We Do?

Mission & Goals of Pierce County Roads

- **Preservation**
  - Extending the Life of the Road System
    - Pavement overlays
    - Chip seals
    - Slurry seals
    - Bridge Painting

8/6/2004

9

Who Are We & What Do We Do?

Mission & Goals of Pierce County Roads

- **Improvements**
  - Expanding or Enhancing the Road System to Serve Long Term Needs
    - Congestion / Concurrency
    - Design Standards / Safety
    - Efficiency
    - New Corridors
    - Economic Development

8/6/2004

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The Five P's of Decision Making

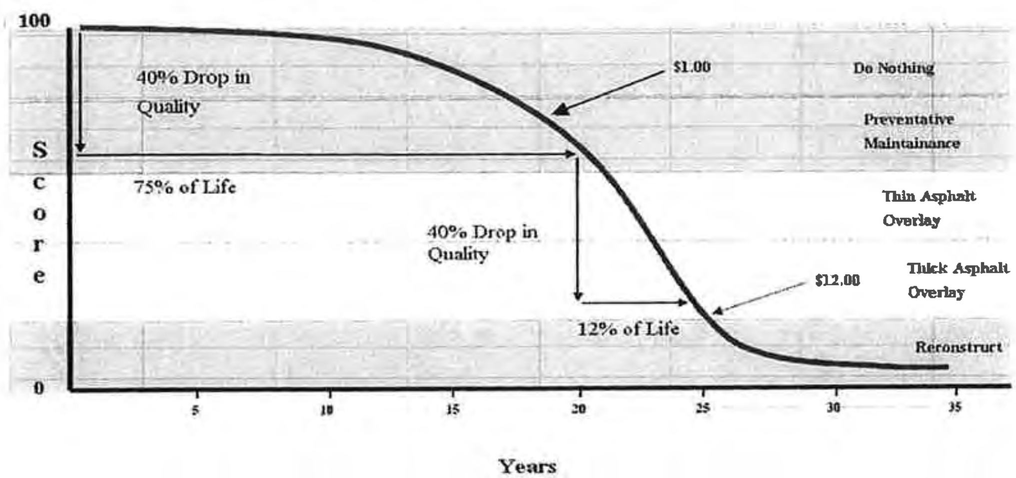
	Maintenance	Operations	Preservation	Improvements	Administration
Policies	-CRAB Standards of Good Practice -Maintenance Quality Standards	-MUTCD -County Rd Standards -Snow & Ice Removal -Policy/Procedures Manual	-CRAB Standards of Good Practice -Pavement Management System	-State Law (RCWs) -CRAB Standards -County Code -Comp. Plan-Transp. Element -Capital Facilities Element	-State Law (RCWs) -CRAB Standards -Pierce County Code -Comprehensive Plan -PC Admin. Guidelines -State BARS -B & F Policy Manual
Plans	-Road Maintenance Management System (RMS) -Vegetation Management Plan	- Road Maintenance System (RMS) -Snow and Ice Plan -Hazardous Materials Response Plan -All Hazards Response Plan	-Pavement Management System -Surface Treatment Plan	-Comprehensive Plan	-Comprehensive Plan -Title VI - Civil Rights Act of 1964
Prioritization Systems	-Road Maintenance Management System (RMS) -Pavement Management System	-Guardrail -Signalization -Limited Sight Distance -Snow and Ice Plan -Hazardous Materials Response Plan -All Hazards Response Plan	-Pavement Management System -Surface Treatment Plan	-Existing Roadways -Concurrency -Traffic Signals -Bridges -Limited Sight Distance	
Programs	-Vegetation Management Program -Budget -Road Sweeping Program - Adopt-a-Road	-Traffic Signs -Markings -Striping -Signals -Illumination -Snow & Ice Removal	-TIP -Chip seal program -Slurry seal program -Asphalt overlay program	-TIP - 6 year -Grants	-CTR
Projects	-Maintenance Accountability Program Development	-Controller Replacement -Sign Face Upgrade -Ped Head Conversion -Liquid De/Anti-icer Research	-Annual Element -Rubberized chip seal evaluation	-Annual Road Program Budget	-Planning Studies -Traffic Impact Fee Development -Time Track Project Cost System Support of RMS Virtual Vault Records System

14

Who Are We & What Do We Do?

The Five P's of Decision Making

Typical Pavement Life Curve



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Who Are We & What Do We Do?

The Five P's of Decision Making

- ✓How do we decide what to do with pavement preservation and when?
- ✓What is lowest lifecycle pavement cost?

Pierce County Road Operations
Pavement Preservation Life Cycle Summary
Total Hard Surface Lane Miles = 3 092

Unit Cost Per Lane Mile:
Asphalt Overlay = $52K
Chip Seal = $ 6K
Chip/Slurry = $13K
Slurry = $7K

Urban Life Cycle		
Arterial Major Life Cycle = 18 Years	**Arterial Minor/ Collector Life Cycle = 20 Years**	**Local Access Life Cycle = 12 Years**
Year One - Asphalt Overlay	Year One - Asphalt Overlay	Year One - Chipseal/ Slurryseal
Year Twelve - Chipseal	Year Fourteen - Chipseal	Year Six - Slurry Seal
Year Eighteen - Asphalt Overlay (New Cycle)	Year Twenty - Asphalt Overlay (New Cycle)	Year Twelve - Chipseal (New Cycle)
608 Lane Miles	337 Lane Miles	1187 Lane Miles

Rural Life Cycle		
Rural Arterial Major Life Cycle = 20 Years	**Rural Arterial Minor/Collector Life Cycle = 6 Years**	**Rural Local Access Life Cycle = 8 Years**
Year One - Asphalt Overlay	Year One - Chipseal	Year One - Chipseal
Year Fourteen - Chipseal	Year Six - Chipseal (New Cycle)	Year Eight - Chipseal (New Cycle)
Year Twenty - Asphalt Overlay (New Cycle)		
123 Lane Miles	377 Lane Miles	460 Lane Miles

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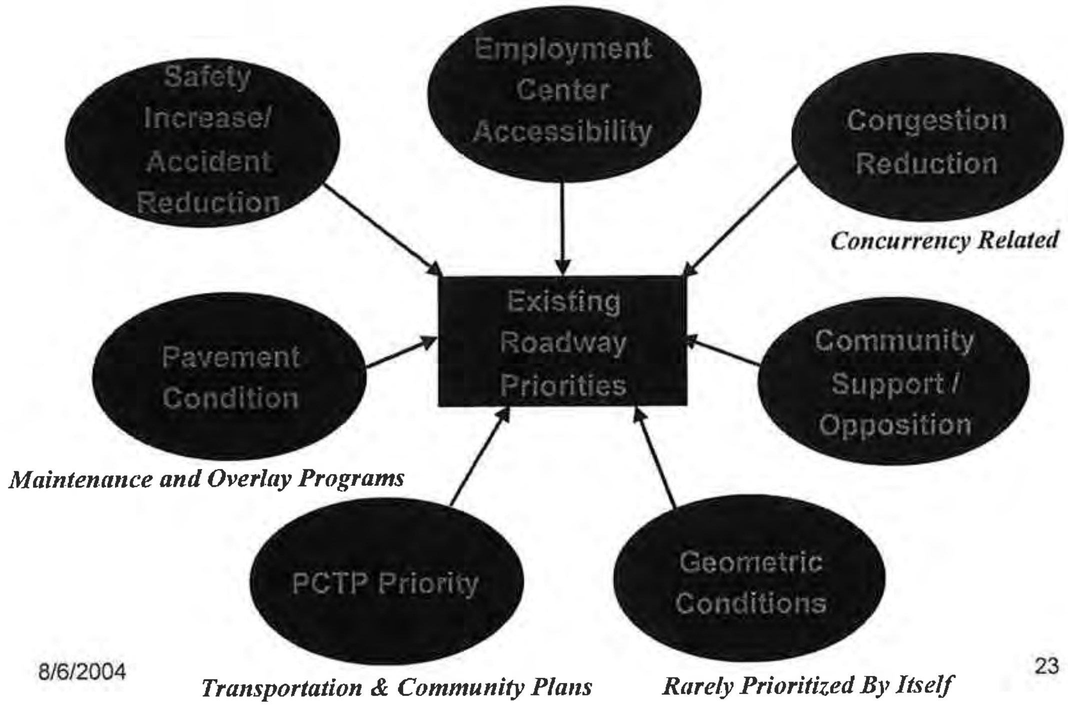
Existing Roadway Priority Criteria

Much of this Criteria Similar to TIB and RAP Criteria



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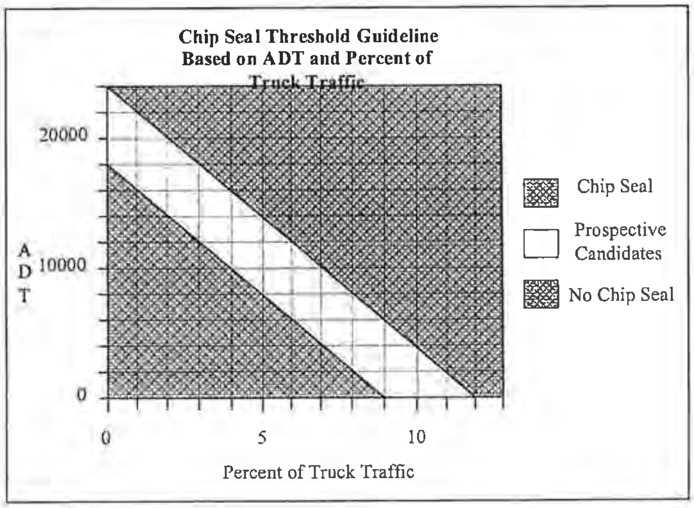
Who Are We & What Do We Do?

The Five P's of Decision Making

If chip sealing is more affordable, why not chip seal all the roads?



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Who Are We & What Do We Do?

Standards

- **Operations**
  - Road Maintenance System
    - Routine preventive maintenance
    - Repairs & operational enhancements
    - Sign & signal emergency response
  - Manual On Uniform Traffic Control Devices
  - Policy 922 – Traffic Impact Review

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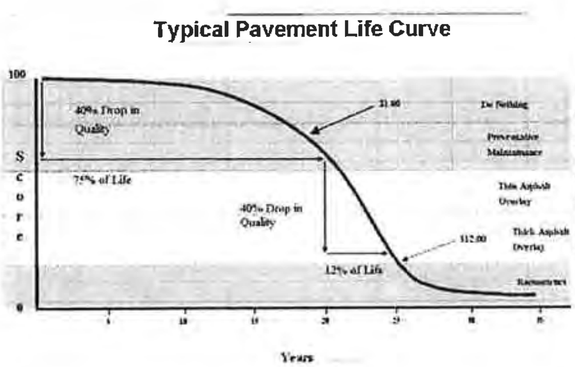
Who Are We & What Do We Do?

Standards

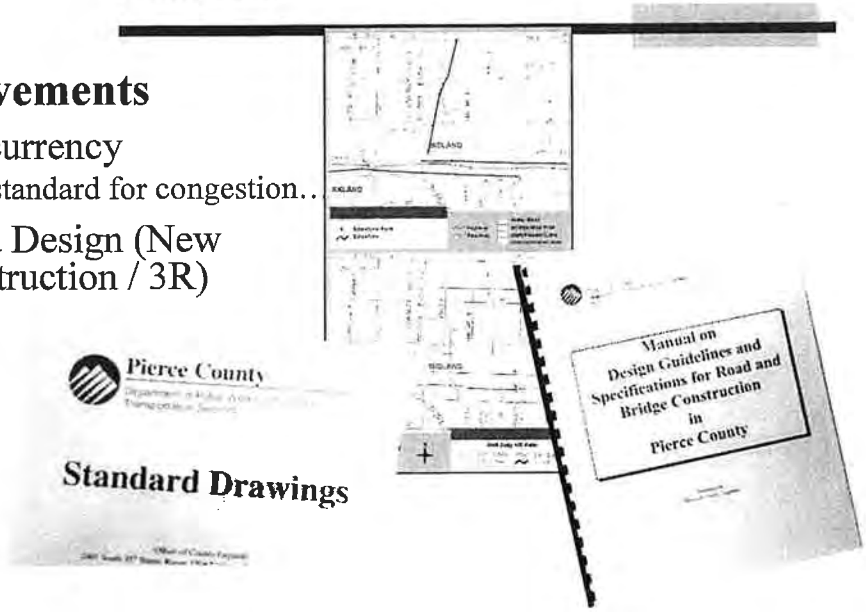
- **Preservation**



Who Are We & What Do We Do?

Standards

- **Improvements**
  - Concurrency
    - A standard for congestion…
  - Road Design (New Construction / 3R)

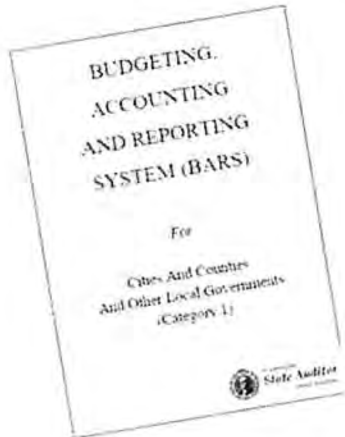


Who Are We & What Do We Do?

Standards

- **Administration**
  - GASB (Governmental Accounting Standards Board)
  - BARS (Budgeting, Accounting and Reporting System)

GASB
Governmental Accounting Standards Board


BUDGETING, ACCOUNTING AND REPORTING SYSTEM (BARS)

For

Cities And Counties
And Other Local Governments
(Category 1)

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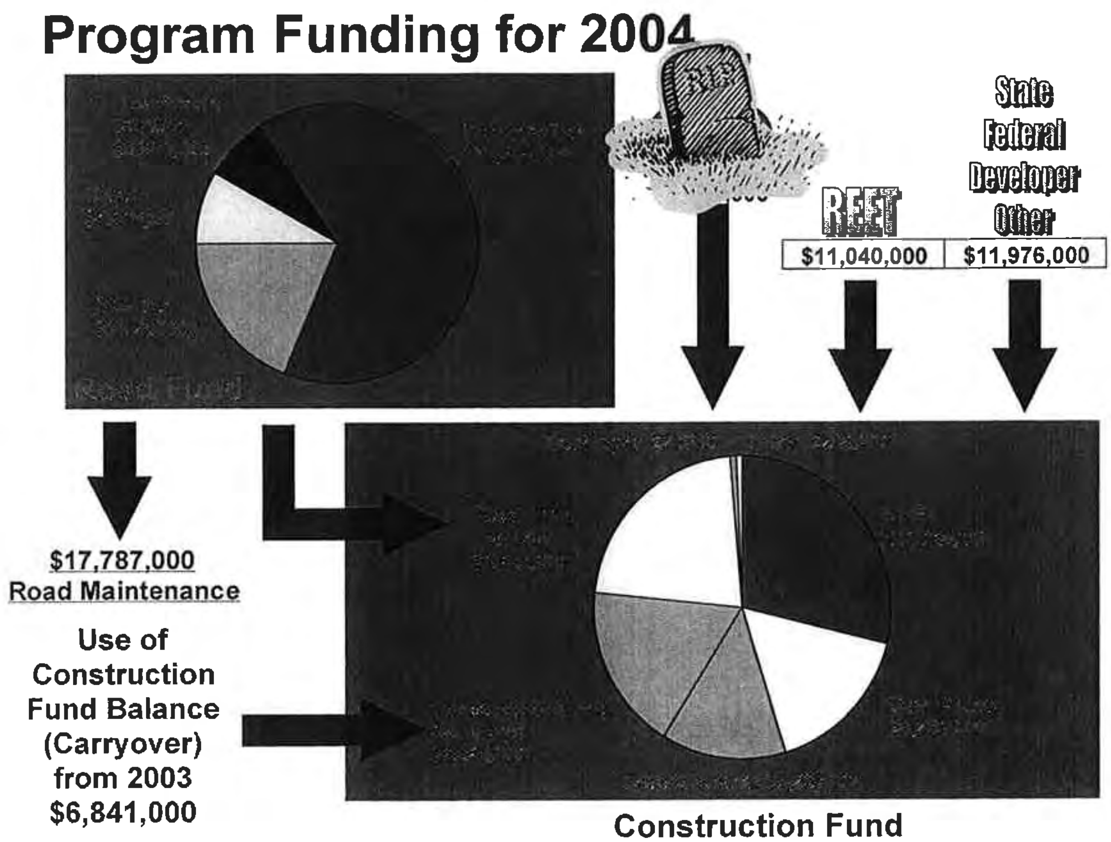
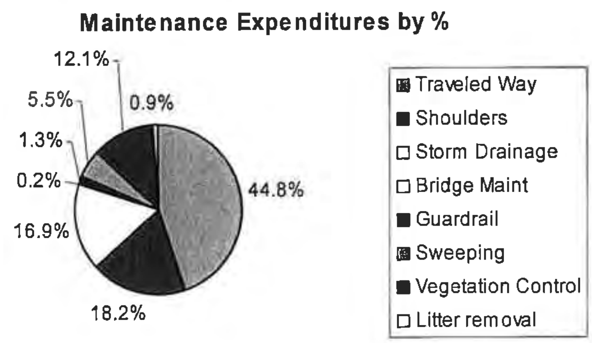

Program Funding for 2004
State
Federal
Developer
Other
REET
$11,040,000
$11,976,000
$17,787,000
Road Maintenance
Use of
Construction
Fund Balance
(Carryover)
from 2003
$6,841,000
Construction Fund

Where Have We Been & What Have We Accomplished?

Maintenance Accomplishments

(Annual work based on 5 year average)

- Over 30,000 tons of asphalt repairs
- Over 900 miles of shoulders graded
- Over 65,000 feet of pipe cleaned
- Over 4,000 lane miles swept
- Over 2,400 shoulder miles mowed
- 500,000 lbs of roadside litter removed



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Where Have We Been and What Have We Accomplished?

Operations Accomplishments (Traffic)

(Annual work based on 5 yr average)

- **1,800 line miles striped**
- **120,000 sign inspections**
- **20,000 sign repairs**
- **4,000 signal indications relamped**
- **900 preventive signal maintenance checks**
- **1,000 traffic counts**
- **2,200 accident reports coded**
- **200 development traffic impact reviews**
- **300 citizen concerns reviewed**

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Where Have We Been & What Have We Accomplished?

Preservation Accomplishments

(Annual amount based on 5 yr average)

- **Over 270 lane miles chip sealed**
- **Over 30 lane miles slurry sealed**
- **Over 17 lane miles asphalt overlaid (Approximately 170 miles over 10 years)**

8/6/2004

Where Have We Been & What Have We Accomplished?

Improvements Accomplishments (1993-2004)

- $94.1 million Roadway Construction including Traffic Signals
  (Includes Construction and Engineering Related Costs)
- $48.6 million Bridge Construction/Rehabilitation
  (Includes Construction and Engineering Related Costs)
- $5.9 million Ferry Boat Construction
- Other
  - $29.5 million in Right of Way Acquisition
  - $7.1 million in Corridor Studies / Establishments
  - 200 Lane-Miles of Base Stabilization
  - 41,200 Lineal Feet of Guardrail Replacement
  - 34 Acres of Wetland Creation / Enhancement / Banking

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Where Have We Been & What Have We Accomplished?

Administration Accomplishments

- 10 Transportation Improvement Programs
- Transportation Plan
- Non-motorized Transportation Plan
- 4 Community Plans
  - Gig Harbor, Parkland Spanaway Midland, South Hill, Frederickson
- Transportation Concurrency Management Systems
- CTR Program
  - Increased Annual Participation from 87 to over 350
  - Total # of participants = 900
- Proposed Traffic Impact Fee Program
- Annual Maintenance and Update of County Road Log System
- Acquisition of over $70 million of outside grants for projects

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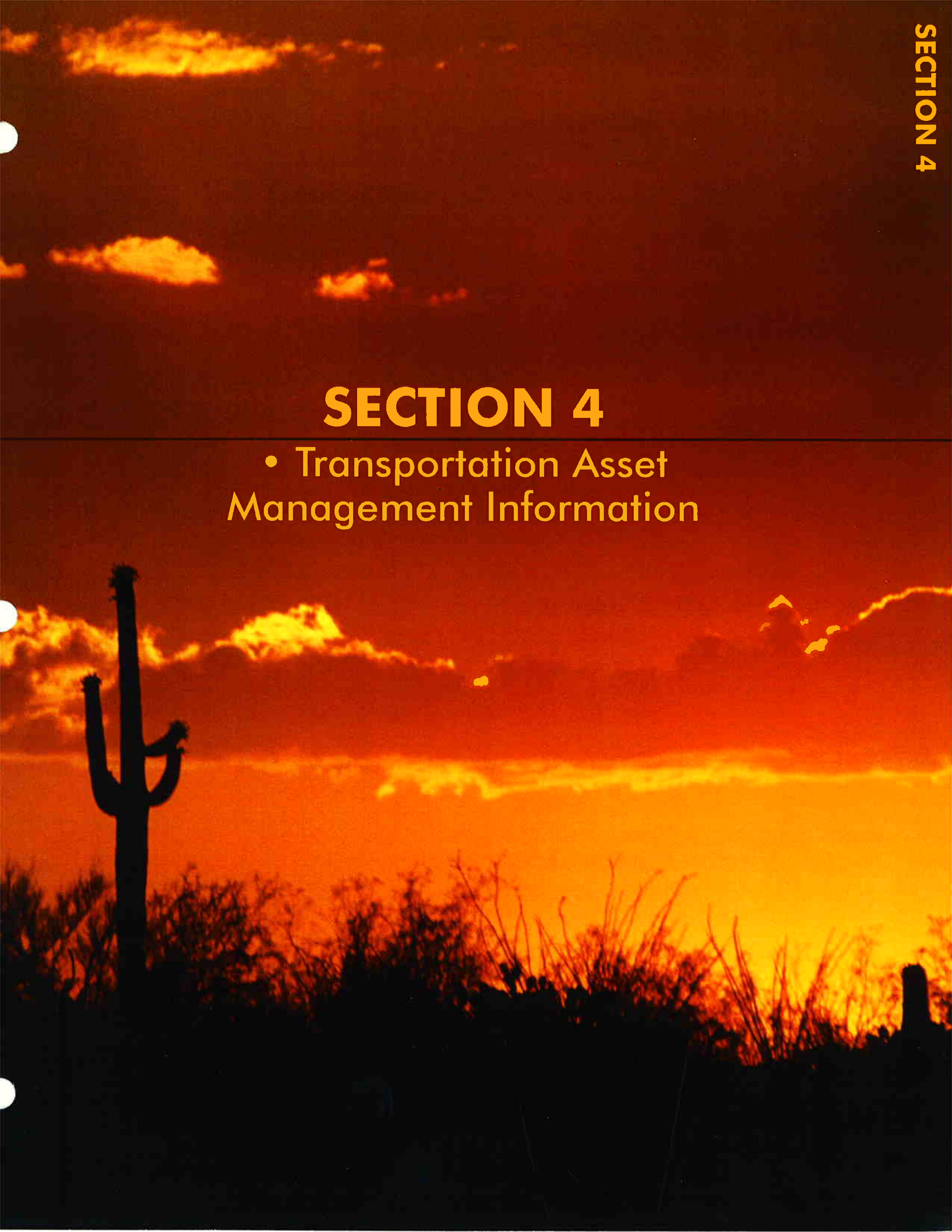
SECTION 4

• Transportation Asset Management Information



Transportation Asset Management Guide

November 2002

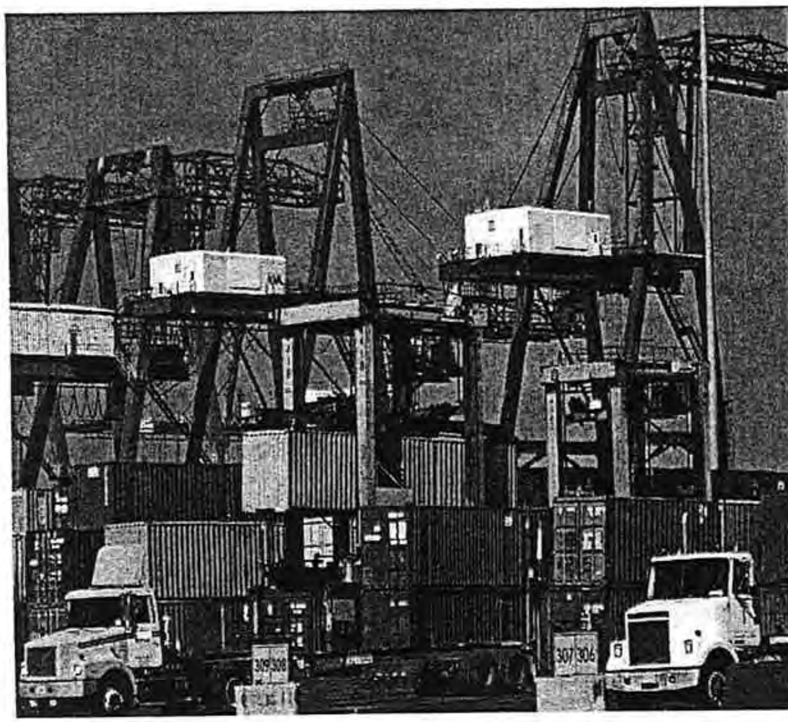
prepared for

National Cooperative Highway Research Program (NCHRP) Project 20-24(11)

American Association of State Highway and Transportation Officials
444 North Capitol Street, NW
Suite 249
Washington, DC 20001

Pub Code: RP-TAMG-1

TRANSPORTATION ASSET MANAGEMENT



HOW ARE
YOU DOING?

OPEN AND
FIND OUT...

Introduction

Transportation infrastructure provides critical national lifelines for commerce, commuting and pleasure travel, support of national defense, and disaster response. Transportation facilities account for a major share of public-sector investment, and are among the most highly valued financial assets of state and local governments. The U.S. highway infrastructure alone represents an estimated $1 trillion in replacement value. Expenditures to build, operate, preserve, and improve transportation infrastructure are critical to meeting national goals of economic progress, social welfare, domestic security, environmental protection, and emergency preparedness. Transportation officials at all levels are faced with the challenge of making the best possible use of limited resources to manage a wide range of transportation assets in a way that responds to these important objectives and satisfies the needs of transportation users – their customers.

Transportation asset management promotes more effective resource allocation and utilization, based upon quality information, to address facility preservation, operation, and improvement. This concept covers a broad array of DOT functions, activities, and decisions: e.g., transportation investment policies and priorities; relationships and partnerships between DOTs and other public and private groups; long-range, multimodal transportation planning; program development for capital projects and for maintenance and operations; delivery of agency programs and services; and real-time and periodic system monitoring and data processing. All of these actions are accomplished within the limits of available funding.

The following self-assessment exercise has been developed as part of the Transportation Asset Management Guide as part of the National Cooperative Highway Research Program (NCHRP) Project 20-24 (11) Asset Management Guidance for Transportation Agencies. This Guide helps you to examine, strategically and systematically, how investment decisions affecting your transportation infrastructure are made. It helps you to identify areas and priorities for possible improvement. It provides ideas, methods, and examples to accomplish more effective resource allocation and utilization. It does all of this by developing and applying the principles and practices of what is referred to as "transportation asset management."

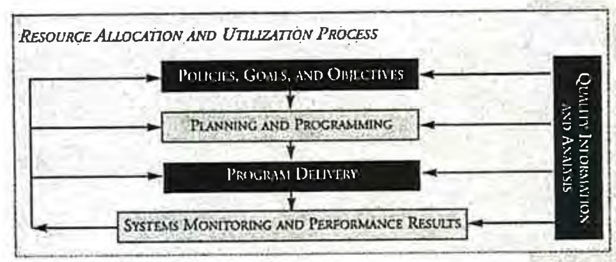
Transportation asset management is defined as a strategic approach to managing transportation infrastructure.

Transportation Asset Management Guide

"Good asset management" involves applying general principles smartly, effectively, and tactically to resource allocation and utilization – the heart of asset management. Core elements include:

- Well-defined policies that can be related to clear objectives and measures of performance.
- Organizational roles and responsibilities and business processes that reflect these policy and performance objectives.
- A reliance on good information at all stages of infrastructure management, and the capability to develop and continually update this information base.
- Examination of a range of options for solving infrastructure problems.
- A comprehensive decision-making approach to transportation investment, viewing the transportation system as an integrated whole, and considering tradeoffs among modes and categories of investment.
- An ability to deliver capital, maintenance, and operations programs in terms of time, cost, engineering quality, and effective use of departmental and outside resources.
- Management emphasis on customer service and accountability for system performance and cost-effectiveness.

The following diagram illustrates the key components of the asset management framework. This is the foundation for the self-assessment.



A Way of Doing Business

Asset management can touch nearly every aspect of a transportation agency's business, including planning, engineering, finance, programming, construction, maintenance, and information systems. Asset management should not be viewed, however, as yet another new program, requiring another new bureaucracy. Rather, asset management is a "way of doing business," not a separate business line or function:

- Clear linkages exist among goals, policies, plans, investment strategies, operating procedures, and delivery approaches.
- A proactive rather than reactive approach is taken, seeking constant improvement to ensuring the best use of available resources for improved performance.
- Strong top-down and bottom-up communication ensure that strategic decisions are well informed by tactical information, and that tactical decisions are aligned with strategic direction.
- Interdisciplinary decisions are coordinated across different agency divisions.
- Clearly defined organizational roles and responsibilities provide accountability for decisions and resulting system performance.

Benefits & Outcomes

The benefits of asset management may be seen in many different ways, depending upon an agency's transportation system, management philosophy, and current resources and priorities. Following are some possible outcomes when an agency takes action to improve asset management practices:

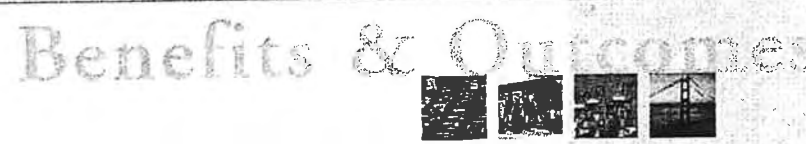
- Lower long-term costs for infrastructure preservation.
- Improved performance and service to customers.
- Improved cost-effectiveness and use of available resources.
- A focus on performance and outcomes.
- Improved credibility and accountability for decisions.

Achieving these benefits requires a willingness to evaluate current business practices and to take steps to improve where needed. Successful business process improvement will require:

- Strong executive leadership.
- Buy-in by managers and staff at all organizational levels.
- A multi-disciplinary perspective within the agency.
- A sustained and consistent commitment through implementation.

What "Quick Gains" Can Asset Management Provide?

- A snapshot of current infrastructure condition and performance – its status, what has been accomplished, areas of need.
- A framework for understanding investment needs – whether for structural repair, congestion mitigation, preservation of asset value, safety, operational improvements, environmental protection (e.g., at what locations and relative values?)
- A direct way to tie public perceptions of agency performance to your agency's methods of identifying and selecting projects and prioritizing services.
- Something better than anecdotal stories – facts, figures, and systematic methods by which to justify needed investments or additional resources.
- A "key to competition" – helping your agency to compete for scarce program funding, helping your staff to compete with other potential service providers in the quality and cost-effectiveness of their actions, and helping your organizational units to "sharpen their thinking" in looking for new ways to solve problems and delivering quality services cost-effectively.



Asset Management Self-Assessment

The Asset Management Self-Assessment exercise will help you characterize your agencies asset management practices and identify specific opportunities for improvement. This exercise is extremely useful to help organize thinking, develop a consensus among top-level managers as to where your agency's strengths and needs for improvement lie, and structure an agenda for asset management planning. The asset management self-assessment exercise has the following objectives:

- Develop a consensus among managers within your agency regarding the status of asset management.
- Assist your agency to identify asset management strengths, weaknesses, constraints, and opportunities for improvement.
- Develop priorities and recognize critical areas that need immediate attention.
- Provide a foundation for implementing your agency's asset management improvement strategy.

This exercise is a quick diagnostic tool that yields an overall impression, not a precise analytic measure, of where your agency is now regarding asset management practice. The statements in each survey form are designed to probe basic functions and capabilities that contribute to good asset management regardless of the particular characteristics and situation of your agency. They should prompt you to reflect on current business practices with a broad view:

"Even if we are constrained to do business or report information in a certain way, is there a better approach that satisfies asset management principles more closely?"

The self-assessment results will reflect your agency's individual institutional, organizational, financial, and IT environments. Involving top managers in this exercise will provide needed context for interpretation of the results. Because the results are specific to your agency's management environment and financial, organizational, institutional, and technological situations, they do not provide a meaningful basis for comparisons with peer agencies. The value of self-assessment is to help you move beyond possible preconceptions of where you are in asset management, and to provide a broad perspective from which you can plan asset management improvements more comprehensively.

The self-assessment survey lists a series of statements organized around the four key areas of asset management:

- Policy Guidance
- Planning and Programming
- Program Delivery
- Information and Analysis

Each statement covers a key aspect of asset management practice and is stated in a declarative form (e.g., "Our agency conducts life-cycle cost analyses for project alternatives."). Respondents are asked to rate the extent to which they agree with each statement, using a scale of 1 to 4. A "4" indicates strong agreement with the statement, whereas a "1" indicates strong disagreement.

Self-Assessment

A. Policy Guidance

How Does Policy Guidance Benefit from Improved Asset Management Practice?

		Strongly Disagree			Strongly Agree
Policy Guidance Benefiting From Good Asset Management Practice					
A1.	Policy guidance supports preservation of existing infrastructure assets.	1	2	3	4
A2.	Policy guidance encourages resource allocation and project selection based on cost-effectiveness or benefit-cost analysis.	1	2	3	4
A3.	Policies support a long-term, life-cycle approach to evaluating investment benefits and costs.	1	2	3	4
A4.	Policy guidance considers customer perceptions and expectations.	1	2	3	4
A5.	Our customers contribute to the process that formulates policy goals and objectives.	1	2	3	4
Strong Framework For Performanced-Based Resource Allocation					
A6.	Policy guidance on resource allocation allows our agency sufficient flexibility to pursue a performance-based approach.	1	2	3	4
A7.	Our agency has a business plan or strategic plan with comprehensive, well-defined goals and objectives to guide resource allocation.	1	2	3	4
A8.	Our agency's goals and objectives are linked to specific performance measures and evaluation criteria for resource allocation.	1	2	3	4
Proactive Role in Policy Formulation					
A9.	Our agency estimates the resources needed to accomplish particular objectives as part of policy development.	1	2	3	4
A10.	Our agency regularly communicates to customers and other stakeholders our accomplishments in meeting policy objectives.	1	2	3	4
A11.	Our agency works with political leaders and other stakeholders to present funding options and consequences as part of our budget proposal.	1	2	3	4

Policy Guidance

B. Planning & Programming

Do Resource Allocation Decisions Reflect Good Practice in Asset Management?

	Strongly Disagree			Strongly Agree
Consideration of Alternatives in Planning and Programming				
B1. Our agency's long-range plan includes an evaluation of capital, operational, and modal alternatives to meet system deficiencies.	1	2	3	4
B2. Capital versus maintenance expenditure tradeoffs are explicitly considered in the preservation of assets like pavements and bridges.	1	2	3	4
B3. Capital versus operations tradeoffs are explicitly considered in seeking to improve traffic movement.	1	2	3	4
Performance-Based Planning and a Clear Linkage Among Policy, Planning, and Programming				
B4. Our agency's long-range plan is consistent with currently established policy goals and objectives.	1	2	3	4
B5. Our agency's long-range plan includes strategies that are consistent with plausible projections of future revenues.	1	2	3	4
B6. Our agency's long-range plan provides clear and specific guidance for the capital program development process.	1	2	3	4
B7. Our agency periodically updates its planning and programming methods to keep abreast of current policy guidance and critical performance criteria.	1	2	3	4
Performance-Based Programming Process				
B8. Criteria used to set program priorities, select projects, and allocate resources are consistent with stated policy objectives and defined performance measures.	1	2	3	4
B9. Our agency's programs are consistent with realistic projections of future revenues.	1	2	3	4
B10. Our agency's programs are based on realistic estimates of costs, benefits, and impacts on system performance.	1	2	3	4
B11. Project selection is based primarily on an objective assessment of relative merits and the ability to meet performance targets.	1	2	3	4
B12. The preservation program budget is based upon analyses of least-life-cycle-cost rather than exclusive reliance on worst-first strategies.	1	2	3	4
B13. A maintenance quality assurance study has been implemented to define levels of service for highway/transportation system maintenance.	1	2	3	4

Planning & Programming

C. Program Delivery

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

	Strongly Disagree			Strongly Agree
Consideration of Alternative Project Delivery Mechanisms				
C1. Our agency periodically evaluates the use of alternative delivery options such as maintenance outsourcing, intergovernmental agreements, design-build, design-build-maintain, and similar options.	1	2	3	4
C2. Our agency has an incentive program for recognizing or rewarding outstanding performance in improving upon schedule, quality, and cost objectives.	1	2	3	4
Effective Program Management				
C3. Our agency solicits input from all affected parties to ensure that project scope is consistent with objectives of the project.	1	2	3	4
C4. Our agency uses well-defined program delivery measures to track adherence to project scope, schedule, and budget.	1	2	3	4
C5. Our agency has a well-established and functioning process to approve project changes and program adjustments.	1	2	3	4
C6. When adding projects or changing project schedules, our agency considers effects on the delivery of other projects in the program.	1	2	3	4
C7. Projects with significant changes to scope, schedule, or cost are reprioritized to ensure that they are still competitive in cost and performance.	1	2	3	4
C8. Agency executives and program managers are regularly kept informed of program delivery status.	1	2	3	4
C9. External stakeholders and policy-makers feel that they are sufficiently updated on program delivery status.	1	2	3	4
Cost Tracking and Estimates				
C10. Our agency maintains and uses information on the full unit costs of construction activities.	1	2	3	4
C11. Our agency maintains and uses information on the full unit costs of maintenance activities.	1	2	3	4

Program Delivery

D. Information & Analysis

Do Information Resources Effectively Support Asset Management Policies and Decisions?

	Strongly Disagree			Strongly Agree
Effective and Efficient Data Collection				
D1. Our agency has a complete and up-to-date inventory of our major assets.	1	2	3	4
D2. Our agency regularly collects information on the condition of our assets.	1	2	3	4
D3. Our agency regularly collects information on the performance of our assets (e.g., serviceability, ride quality, capacity, operations, and safety improvements).	1	2	3	4
D4. Our agency regularly collects customer perceptions of asset condition and performance.	1	2	3	4
D5. Our agency continually seeks to improve the efficiency of data collection (e.g., through sampling techniques, use of automated equipment, other methods appropriate to our transportation system).	1	2	3	4
Information Integration and Access				
D6. Agency managers and staff at different levels can quickly and conveniently obtain information they need about asset characteristics, location, usage, condition, or performance.	1	2	3	4
D7. Our agency has established standards for geographic referencing that allow us to bring together information for different asset classes.	1	2	3	4
D8. Our agency can easily produce map displays showing needs/deficiencies for different asset classes and planned/programmed projects.	1	2	3	4
D9. Our agency has established data standards to promote consistent treatment of existing asset-related data and guide development. of future applications.	1	2	3	4
Use of Decision Support Tools				
D10. Information on actual work accomplishments and costs is used to improve the cost-projection capabilities of our asset management systems.	1	2	3	4
D11. Information on changes in asset condition over time is used to improve forecasts of asset life and deterioration in our asset management systems.	1	2	3	4
Our agency uses asset management decision-support tools to:				
D12. Calculate and report actual system performance.	1	2	3	4
D13. Identify system deficiencies or needs.	1	2	3	4
D14. Rank candidate projects for the capital program.	1	2	3	4
D15. Forecast future system performance given a proposed program of projects.	1	2	3	4
D16. Forecast future system performance under different mixes of investment levels by program category.	1	2	3	4
System Monitoring and Feedback				
D17. Our agency monitors actual system performance and compares these values to targets projected for its capital preservation program.	1	2	3	4
D18. Our agency monitors actual system performance and compares these values to targets projected for its capital improvement program.	1	2	3	4
D19. Our agency monitors actual system performance and compares these values to targets projected for its maintenance and operations program.	1	2	3	4
D20. We periodically distribute reports of performance measures relevant to customer/stakeholder satisfaction with transportation system and services.	1	2	3	4

Scoring Guidelines (optional)

A. Policy Goals and Objectives

Policy Guidance Benefiting From Good Asset Management
(A1+A2+A3+A4+A5)/5 = ____

Strong Framework for Performance-Based Resource Allocation
(A6+A7+A8)/3 = ____

Proactive role in Policy Formulation
(A9+A10+A11)/3 = ____

B. Planning and Programming

Consideration of Alternatives in Planning and Programming
(B1+B2+B3)/3 = ____

Performance-Based Planning and Clear Linkage Among Policy, Planning, and Programming
(B4+B5+B6+B7)/4 = ____

Performance-Based Programming Process
(B8+B9+B10+B11+B12+B13)/6 = ____

C. Program Delivery

Consideration of Alternative Project Delivery Mechanisms
(C1 + C2)/2 = ____

Effective Program Management
(C3+C4+C5+C6+C7+C8+C9)/7 = ____

Cost Tracking and Estimating
(C10+C11)/2 = ____

D. Information and Analysis

Effective and Efficient Data Collection
(D1+D2+D3+D4+D5)/5 = ____

Information Integration and Access
(D6+D7+D8+D9)/4 = ____

Use of Decision Support Tools
(D10+D11+D12+D13+D14+D15+D16)/7 = ____

System Monitoring and Feedback
(D17+D18+D19+D20)/4 = ____

- The scores for each of the sections of the self-assessment can be used as part of the discussion for developing future strategies and directions for asset management.
- The percentage of statements in each area receiving a 3 or 4 can be used to further discuss how well the agency is doing with various aspects of asset management.
- These scores are rough indicators of how you see your agency's performance of each function or capability described in the statements.

APPLYING THE RESULTS

To learn how to translate the results of the self-assessment exercise into a plan for improving asset management at your agency, consult the NCHRP's Transportation Asset Management Guide. This Guide will help you further analyze your agency's strengths and weaknesses, build consensus on priority areas, develop a comprehensive asset management strategy, and identify specific actions for moving forward.

Scoring Guidelines

Sponsorship

This work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program, which is administered by the Transportation Research Board of the National Academies.

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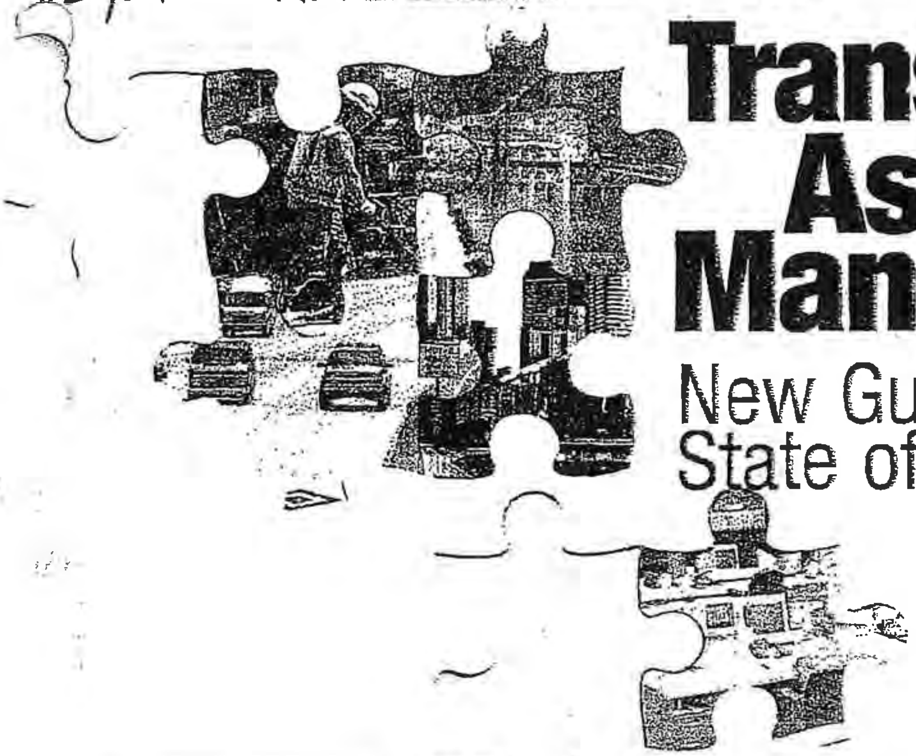

Transportation Asset Management

New Guide Advances State of the Practice

LANCE A. NEUMANN, MICHAEL J. MARKOW, AND LOUIS H. LAMBERT

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The recent completion of a National Cooperative Highway Research Program (NCHRP) Project, Asset Management Guidance for Transportation Agencies,[1] marks a milestone in transportation asset management. The *Transportation Asset Management Guide* will help agencies gain new insights into asset management and improve their practices.

The NCHRP project also produced a synthesis of U.S., international, and private-sector practice in asset management, the management framework for the guide, and a prioritized list of research to fill gaps in the knowledge and practice of asset management for transportation infrastructure. These products resulted from tasks outlined in the American Association of State Highway and Transportation Officials' (AASHTO) Strategic Plan for Transportation Asset Management, issued in December 2000.

AASHTO has adopted and will distribute the *Transportation Asset Management Guide*. The final draft is available on NCHRP's website.[2] In addition, the Federal Highway Administration, through the National Highway Institute, has developed a one-day course on transportation asset management for agency executives and senior managers.[3]

Following is a preview of the concepts, principles, and techniques described in the guide, with examples of the improvements that asset management can introduce in the ways an agency allocates resources and employs different types of investments.

Defining the Principles

Asset management has many interpretations—for example,

- A next-generation infrastructure management system,
- A way to bring private-sector thinking into public-sector decisions,
- An economics-based approach to investment planning and decision-making,
- A comprehensive program of facility maintenance or maintenance contracting,
- A management philosophy to secure the future life of transportation infrastructure, and
- A way of combining pavement, bridge, safety, and other maintenance management systems to yield more effective information.

All of these descriptions reflect elements of sound asset management, but none captures the concept fully. Asset management is a strategic approach to managing transportation infrastructure. It builds on several principles:

- Asset management is policy-driven. Decisions about managing infrastructure reflect the policy goals and objectives that define the condition of assets, the

[1] NCHRP Project 20-24(11).
[2] http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+20-24(11)
[3] www.nhi.fhwa.dot.gov/coursedesc.asp?coursenum=1130

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levels of performance, and the quality of services to meet customer needs and achieve economic, community, and environmental goals.

◆ **Asset management is performance-based.** Goals and objectives must have clear measures of performance. Targets established for performance measures will guide decisions in analyzing options, setting priorities, establishing budgets, and implementing programs, and must be technically and financially realistic.

◆ **Asset management examines options and tradeoffs at each level of decision making.** Resources are limited. Investment decisions in other areas and about other assets are interrelated and have an effect on transportation assets. Therefore decision makers should consider all options and evaluate the tradeoffs among alternatives.

◆ **Asset management takes the long-term view.** Analyses of program options should incorporate a long-term view of facility condition, performance, and cost. Analysis procedures rooted in engineering and economics are most effective in assessing the tradeoffs among different actions at different times in an asset's life cycle.

◆ **Asset management bases decisions on merit.** Choices among options during program development, project selection, and program and service delivery should be based on comparisons of costs and of the consequences of meeting performance targets. Objective, high-quality information must be applied at each step, using analytic methods and decision criteria consistent with policy goals and objectives and with the agency's business processes.

◆ **Asset management maintains clear accountability.** Performance measures are monitored and reported. This provides feedback on the effectiveness of transportation investments and services, as well as accountability to management for work accomplished and for the effectiveness of program and service delivery.

Applying the Principles

Applying these principles defines an agency's way of doing business, its procedures for decision making, and its applications of information technology. Asset management is not a separate function or system but a way of improving an agency's procedures for allocating and using available resources to achieve results cost-effectively.

Most agencies already employ aspects of good asset management practice; the principles in the guide therefore suggest ways for agencies to leverage strengths and improve the integration of data, information, and decision making. To be most effective, the asset management principles must be applied comprehensively to all of the agency's infrastructure expenditures, including preservation, operations, and system expansion—in capital construction as well as in maintenance and operations programs.

Asset management should be implemented in as many resource allocation and utilization processes as possible—for example, in policy development; long-range planning; project development; program development and priority setting; delivery of projects, programs, and services; and system monitoring and reporting. Agencies, however, may decide to focus at first on high-priority functions, to gain initial results quickly and affordably.

The *Transportation Asset Management Guide* covers asset management in these investment areas and in resource allocation and utilization. Nonetheless, an agency does not need to mount an all-encompassing effort to make headway in asset management. An agency can apply the concepts and principles quickly with current personnel and information technology—taking advantage of good asset management practices already in place.

Because state departments of transportation (DOTs) and other transportation agencies differ substantially in priorities, business practices, and available resources, the guide presents a broad treatment. By enabling agencies to understand the context of asset management, the guide helps agency managers to focus on the specific areas in which asset management improvements can have the strongest early payoff. A self-assessment exercise in the guide helps agencies determine strengths, identify areas for improvement, and develop an implementation strategy for priority areas.

Investment Categories

Some practical examples can show what asset management involves and how the principles can improve an agency's practices. Because agencies differ in program structure and in management culture, the examples relate to the types of investments common to all agencies. The descriptions are limited to three investment areas: preservation, operations, and system expansion. These investment areas encompass capital as well as maintenance and operations expenditures.

◆ **Preservation** extends the life of an asset or corrects a distress that impedes mobility, safety, serviceability, or engineering integrity. Preservation counters wear-and-tear, providing a cost-effective way to keep a facility functioning at its intended level. Corrective and preventive maintenance, repair, and rehabilitation are examples of preservation.

◆ **Operations** focus on real-time service and operating efficiency. Operations enable facilities to provide the maximum level of service before expansion becomes necessary. Examples include real-time traffic surveillance, intelligent transportation systems (ITS), real-time signal controllers, various strategies formerly grouped under transportation system management, safety improvements, ramp metering, incident response, road weather information systems, and traveler information systems.

◆ **Capacity expansion** affects a facility's level of service by adding physical capacity, by creating new capacity through a new facility, or by implementing long-term operating strategies. New construction, for example, may include new mainline facilities, interchanges, or intermodal facilities. Expansion also can be achieved through general-purpose or HOV lanes, climbing and passing lanes, bridge widening or construction of a parallel structure, and improvements on interchanges, intersections, and intermodal facilities. Long-term operating strategies could introduce reversible peak-hour lanes, adjustments to speed limits, and new signals and lane controls.

These investment categories provide a framework for the practical implications of transportation asset management. All agencies invest in these areas, but in different measures. Agencies with mature infrastructure in settled urban areas may emphasize preservation and operations improvements, while agencies in regions experiencing population and economic growth may have a relatively higher percentage of expenditures for capacity expansion.

Projects may comprise more than one investment type, creating interactions among preservation, operations, and capacity expansion. For example, preservation work in construction or maintenance work zones can cause traffic disruptions that require operations remedies. Capacity expansion may include installation of ITS or traffic monitoring hardware to serve operations needs. Operations equipment requires maintenance.

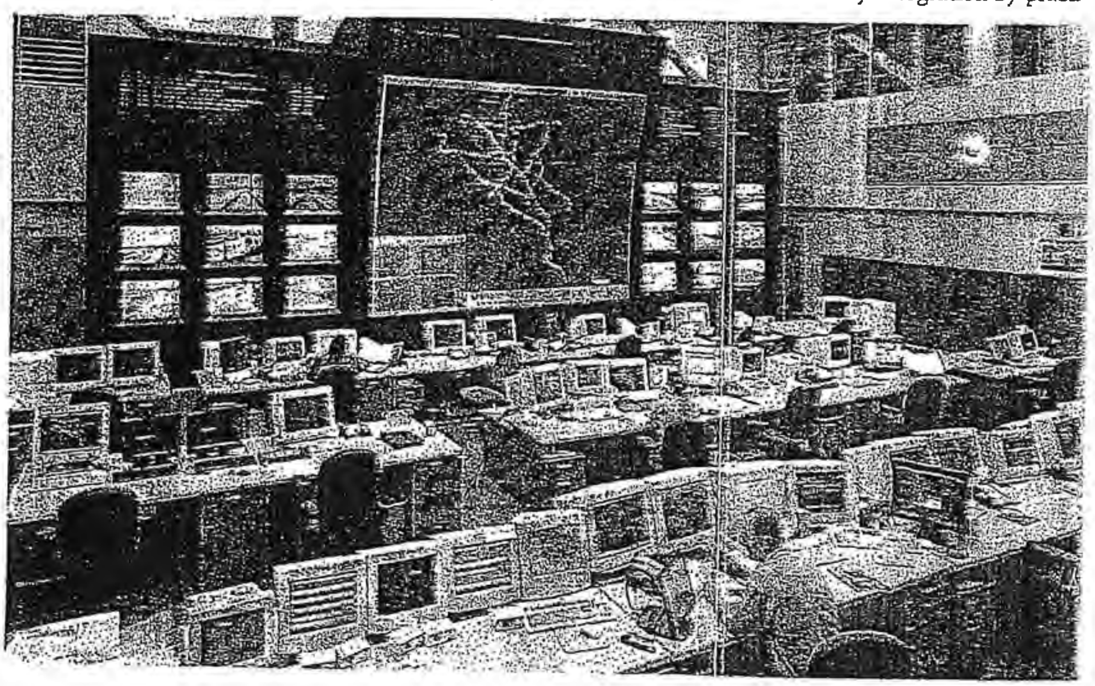
Breaking down an agency's infrastructure management into preservation, operations, and capacity expansion provides a straightforward way of organizing asset management techniques and of considering strategic tradeoffs among the categories of investment.

Preservation

Asset management has historical roots in preservation. During the significant capacity expansion under the Interstate program in the second half of the 20th century, the need to manage the maintenance, repair, and rehabilitation of the highway inventory increased, as pavements, bridge elements, and other key features of the earliest Interstate-era highways began to approach the end of their design lives.

As more and more portions of the network aged, competition increased for preservation resources. The need for knowledge and tools to preserve the system as cost-effectively as possible stimulated research programs and the development of computerized decision-support systems for pavement, bridge, and maintenance management.

In this way, preservation had a head start in the field of highway management, propelled by its importance and visibility for transportation agencies and motorists, as well as the early recognition by practi-



Transportation management centers regulate travel on streets and freeways and maximize levels of service.

Crack sealing preserves pavement.

tioners that system preservation required ongoing management. Nonetheless, the *Transportation Asset Management Guide* emphasizes that the other areas of investment—that is, operations and capacity expansion—also must be considered within a comprehensive, balanced approach.

The guide encourages continuing improvements in preservation in areas such as the following:

✦ Application of management systems and other analytic tools. Pavement and bridge management systems are applied routinely to assess condition, identify projects, and track performance. However, use in higher-level management tasks—such as testing scenarios, developing programs and budgets, analyzing program tradeoffs, and supporting executive decisions—should be expanded.

✦ Preventive maintenance strategies. Capital and routine preventive maintenance offer economic benefits but are politically difficult to sell. Analytical methods and research documenting the benefits, moreover, are not as advanced as those for design and rehabilitation. Better information is needed on the long-term benefits of preventive maintenance strategies.

✦ Continued development of new materials and practices. Preservation benefits from better materials and remedial practices. New technology should provide cost-effective options for extending the service lives of assets.

✦ More comprehensive analysis of strategies for road occupancy. Work zone management is a major issue, involving the safety of workers and motorists, and is key in planning major rehabilitation projects. Economic analyses of the effects of work zone configurations and scheduling will become common practice as preservation activities increase, traffic volumes grow, and urbanized areas spread.

✦ Continued enhancement of analytic and decision support tools. Development and enhancement of decision-support tools for preservation have been ongoing. The focus will be on information for executives, integration with other applications, incorporation of customer-oriented performance measures and criteria, and analyses of program-level tradeoffs.

✦ Maintenance quality assurance programs. Maintenance quality assurance takes a performance-based approach, applying customer-oriented definitions of levels of service to budgeting decisions. Maintenance quality assurance embodies the principles of good asset management.

Operations

Operations always have been a component of highway management and are a logical extension of the asset management concept. Responsibility for operations, however, has been fragmented within and across agency jurisdictions. As a result, operations have not been integrated effectively into an overall system management strategy.

But just as preservation was recognized as critical to sustaining the service life of infrastructure cost-effectively, operations have been gaining recognition for a strategic role in maximizing the system's ability to move passenger and freight traffic. Operations have become a key element of good system management.

An effective operations strategy relies on a range of equipment and software that must perform reliably throughout the network. The physical assets supporting operations must be integrated into agency preservation programs for inspection, periodic maintenance, and repair.

The general principles of asset management apply to operations as much as to preservation, but with a different focus:

✦ The goals and objectives must reflect system service and reliability in real time;

Ground-penetrating radar instrument locates and inspects utilities, part of maintenance quality assurance.

◆ The focus is on immediate response to situations and real-time results, not on a program of projects; and

◆ Performance measures and monitoring must track real-time service delivery.

The principles of asset management therefore imply the following for operations:

◆ **More integrated decision making.** Decision making in operations must coordinate with decision making in other areas of asset management, to support a unified set of system performance measures. Coordination is necessary, for example, in allocating resources to balance investments in physical assets with those in operating programs; in maintaining and preserving operations assets, as well as other physical infrastructure; in long-range planning, project development, and design; in analyses of program tradeoffs; and in dealing with other agencies and jurisdictions that influence operations policies and practices.

◆ **Interjurisdictional considerations.** The so-called trip perspective looks at the entire transportation system without regard to jurisdictional boundaries and operating responsibilities. Many traffic management centers and incident response programs follow this principle.

◆ **Comprehensive asset inventories, condition databases, and analytic techniques.** An agency's overall preservation strategy should include the operations hardware. This requires database and analytic capabilities for the operations equipment on a par with those for other infrastructure assets. Moreover, other capabilities can be applied to operations—for example, maintenance management and bridge management systems that include such assets as traffic management devices, ITS systems, sign bridges, and tunnel facilities.

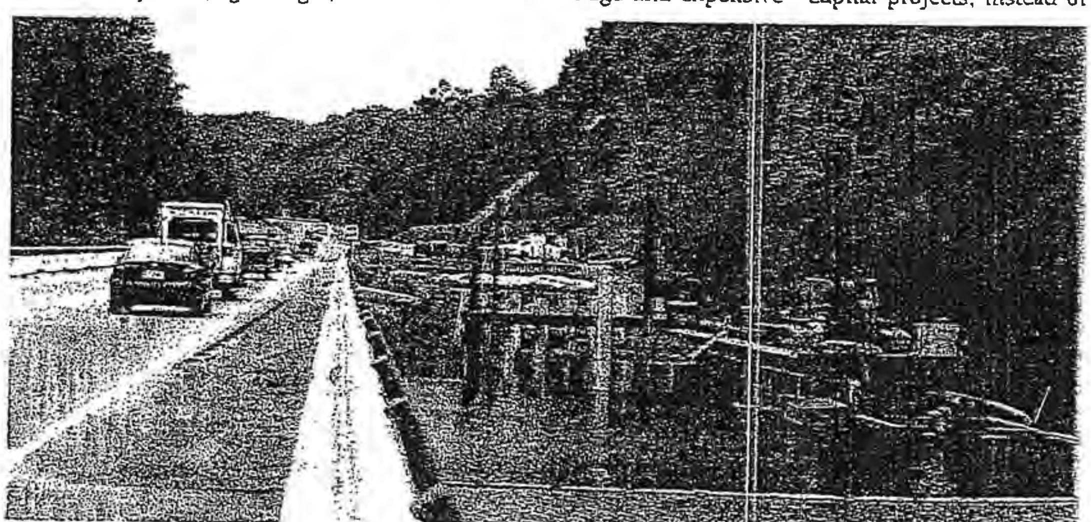
◆ **Methods to analyze operations strategies.** Analytic tools comparable to those used in preservation, for example, are needed to integrate operations fully into an agency's decision making about resource allocation and utilization. Developing such systems will require thinking "outside of the box," to analyze performance over time and in real time. Research is needed to understand performance from the perspective of reliability, response time, and the critical threshold values of motorists, as well as from the traditional viewpoints of physical condition and frequency of repairs.

◆ **Greater outreach and education.** Transportation agencies and operators may not recognize the relationship between operations and asset management. Clearly defining this relationship and communicating it through training, outreach, research, and deployment will help in advancing the state of the practice in system management and agency coordination.

◆ **Communication of the benefits of operations investments.** New analytic tools can improve an agency's ability to demonstrate the benefits of investing in operations, but demonstrating the actual benefits of systems that are already deployed also is valuable. Field tests and rigorous evaluations are critical in addressing agency skepticism about ITS, and particularly in communicating the advantages of strategies that improve system reliability and that benefit freight transportation.

Capacity Expansion

In contrast with operations, capacity expansion focuses on project development and program composition through a process that can extend for several years. In contrast with preservation, capacity expansion works through discrete—sometimes large and expensive—capital projects, instead of



Bridge widening (*above*, on VA-199) is an aspect of capacity expansion.

addressing continuing, systemwide needs.

In addition, the substantial federal matching formula for Interstate construction through the Highway Trust Fund has provided a direct and dependable funding mechanism for capacity expansion projects. The major expansion in U.S. highway capacity through the end of the 20th century, therefore, may be regarded as a massive, successful public works effort—but the expansion usually is not thought of in the context of asset management practice.

That has now changed—capacity expansion is part of resource-allocation decision making. Needs for funding have shifted toward preservation and, increasingly, toward operations.

Asset management for allocating and utilizing resources applies as much to capacity expansion projects as to preservation and operations. Translating asset management for more effective decision making in capacity expansion entails improvements in several functions and capabilities:

- **Performance-based planning.** A performance-based approach to long-range planning focuses on the outcomes of possible investments and the degree to which the outcomes support stated policies. Capacity expansion projects can affect a diverse customer base.
- **Updated performance measures.** Performance measures for new capacity projects must reflect more than level of service in evaluating operational or multimodal alternatives for expanding transportation capacity. Measures should enable analyses of the tradeoffs among capacity expansion and other types of investments and should reflect the interests of passenger and freight customers.
- **Procedures to analyze multimodal and intermodal investments and tradeoffs.** Different analytic methods and data requirements apply when assessing projects in different modes or evaluating the effects on passenger versus freight transportation. Methods for comparing cost and performance impacts across modes are under development but must be deployed and tested in agency settings. Data and analytic issues in freight transportation must be addressed.
- **Accelerated scheduling.** Capacity expansion projects often require several years from conception to completion, increasing costs and delaying benefits. Ways to accelerate this schedule while maintaining the necessary steps in planning, design, right-of-way, and construction include different ways of conceiving projects—for example, as corridor-based or multimodal—as well as streamlining or fast-tracking preconstruction activities and establishing contract incentives for rapid completion of construction.
- **Bidding and contracting mechanisms.** Agencies are applying contracting mechanisms such as design-build on projects with demanding schedules or to supplement agency expertise, as well as alternate bidding to base awards on lowest life-cycle cost. In awarding a paving contract for a new freeway, for example, Michigan DOT examined bids for concrete versus asphalt pavement and saved several million dollars in construction costs.

Agency Self-Assessment

Asset management takes a comprehensive view of resource allocation and utilization. Most agencies, however, will want to focus on particular priorities. To help identify the most promising areas for focus, the *Transportation Asset Management Guide* includes a self-assessment exercise.

Through the self-assessment, executives and senior managers can characterize agency practices, highlight the gains accomplished or under way, and identify opportunities for improvement. The exercise requires responses to a series of statements, organized under the four functional areas of asset management: policy development, planning and programming, program delivery, and information and analysis. Completing the form takes approximately 30 minutes.

The value of the exercise is in comparing the responses from the agency's executive office with those of managers for such units as planning, engineering, programming, maintenance, finance, operations, and information systems. Bringing together the different perspectives can help identify an agency's strengths and the areas that need improvement in asset management practice. Through this discussion, the agency can develop priorities for immediate and longer-term actions.

The self-assessment is a quick diagnostic tool that yields an overall snapshot of an agency's asset management practices. The information can be used in developing a more comprehensive asset management implementation plan, as described in the *Transportation Asset Management Guide*.

Implementing Programs

Several agencies have addressed asset management proactively, launching implementation programs and gaining organizational acceptance. The diversity of approaches, however, illustrates not only that asset management draws on a core set of principles, but that application should be customized to an agency's needs, priorities, and situations.

Some state agencies—such as the Colorado, Arizona, Pennsylvania, and Vermont DOTs—have developed plans to identify strengths and priorities for improvements in asset management and information technology. Other agencies have focused on innovations for asset management.

veral years. Montana DOT recently instituted a Programming Prioritization Process (or P3). Pennsylvania DOT summarizes performance information on a monthly report card, and Washington State DOT issues the quarterly *Gray Notebook* of performance measures and a monthly report card on construction projects.[4]

Asset management principles and techniques also are reflected in maintenance quality assurance programs and the associated levels of service. Several states have undertaken maintenance quality assurance programs, including Arizona, California, Colorado, Florida, Idaho, Iowa, Kansas, Maine, Maryland, North Carolina, Ohio, Texas, Utah, Vermont, and Washington State. A set of the performance measures commonly recognized for maintenance is in development, drawing from workshops, projects, and committee efforts sponsored by AASHTO, FHWA, and NCHRP.

National-Level Actions

Industry has supported asset management initiatives by individual agencies. At the national level, TRB, AASHTO, and FHWA have been active in supporting conferences, workshops, and TRB Annual Meeting sessions on asset management. The TRB and AASHTO task forces on asset management met jointly in summer 2002 to chart the implementation of asset management from a national perspective.

FHWA has sponsored development of a one-day training course on the *Transportation Asset Management Guide*, and AASHTO and FHWA collaborate in supporting "Transportation Asset Management Today," a community-of-practice website.[5] Other organizations, such as the American Public Works Association,[6] also have developed materials on asset management. The Midwestern Regional University Transportation Center provides several resources, including a website, research activities, and newsletters.[7]

Research is exploring advances in asset management practice that cut across the investment areas. The NCHRP project produced a prioritized list of research topics in the management, policy, analytic, technological, and academic aspects of asset management. AASHTO selected several of these topics, and studies already are under way through NCHRP.

The projects deal with analytic tools to support asset management, state DOT experience in implementing the Governmental Accounting Standards Board requirements in Statement 34, and identifying and setting targets for performance measures to support asset management. A project nominated for FY 2004 would investigate the effectiveness of asset management implementation. Other research efforts, such as the proposed Future Strategic Highway Research Program, complement the asset management research.

Where the Guide Goes

The *Transportation Asset Management Guide* can assist agencies in improving procedures and decisions about allocating and utilizing resources. The book is structured as follows:

◆ **Chapter 1: Introduction** defines transportation asset management and outlines past work by AASHTO, FHWA, NCHRP, and international agencies.

◆ **Chapter 2: Framework and Principles** explains concepts and tenets of asset management, defines a framework of benchmark practices, and indicates how to customize the management framework to an agency's particular needs.

◆ **Chapter 3: Self-Assessment** explains how to use the agency self-assessment test to identify strengths and areas for improvement, provides forms for the exercise, and illustrates how to evaluate results.

◆ **Chapter 4: Developing a Strategy** traces how to build a strategy to improve asset management.

◆ **Chapters 5 through 8** describe specific applications of asset management to key functions in resource allocation and utilization—policy goals and objectives, planning and programming, program delivery, and information and analysis, including performance monitoring.

◆ **Chapter 9: Implementation** presents initial steps to improve asset management and provides a long-term perspective for continuing improvements.

Questions To Consider

Asset management provides the framework for agencies to assess business practices for infrastructure management, to highlight accomplishments, and to identify opportunities for improvement. When exploring what this framework might do, agency decision makers should consider the following questions:

◆ How far has the agency progressed in defining and communicating its strategic direction to all stakeholders?

◆ Does the agency comprehensively consider all options in solving problems?

◆ Does the agency evaluate tradeoffs in cost and performance?

◆ Is the agency concerned about achieving long-term results cost-effectively?

◆ Does the agency place value on setting performance goals and on measuring results?

◆ What should the agency do to be in the strongest position to justify requests for resources?

◆ Even if significant advances in management practices have been implemented, are there better ways to do things?

Asset management addresses these questions by providing an improved way of doing business. The how-tos are presented in the first edition of the *Transportation Asset Management Guide*.

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[4] www.wsdot.wa.gov/accountability/GrayNotebook.pdf
[5] http://assetmanagement.transportation.org
[6] www.apwa.net/
[7] www.mrutc.org/assetmgmt/index.htm