Managing Texas Pavements

Basic Concepts and Data Interpretation for TxDOT's Pavement Management Information System (PMIS)

Texas Department of Transportation
Construction Division, Materials and Pavements Section
July 2003

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SH 207 near Claude
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Executive Overview

Customer demands for quality pavements are higher today than ever before. Pavements are carrying higher traffic and heavier loads as Texas and the nation compete in an ever-expanding global economy. And yet, while pavements are becoming so much more important, the funds to build them and maintain them are becoming more restricted.

As a public agency, TxDOT must balance these apparently opposite demands. But how can TxDOT provide the high quality pavements that Texans have learned to expect without continually raising fuel taxes to dangerously high levels?

This book explains how TxDOT can use Pavement Management System (PMS) concepts to meet these increasingly complex demands. It explains how to use the automated Pavement Management Information System (PMIS) to monitor pavement condition, estimate pavement needs, anticipate future conditions and needs, and develop efficient work programs to meet those needs.

Finally, it describes ways to incorporate pavement work history and cross-section information into the pavement management process to improve materials, design, construction, and maintenance practices for building longer-lasting pavements.

Together, PMS and PMIS can help TxDOT improve overall pavement condition within existing funds by providing longer-lasting treatments at the right place and at the right time.

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Chapter 1

Pavement Problems… Pavement Solutions

Texas pavements are caught in a crossfire of conflicting demands. Customer demands for quality pavements are higher today than ever before. Pavements are carrying higher traffic and heavier loads as Texas and the nation compete in an ever-expanding global economy.

And yet, while pavements are becoming so much more important, other forms of transportation (such as public transit, air, rail, and water) are also becoming more important. The funds to provide and preserve transportation are becoming increasingly limited. At the same time, the personnel to provide and preserve transportation are declining in number and in overall experience

As a public agency, TxDOT must somehow meet these increasing pavement demands in the face of decreasing pavement resources. But how? How can TxDOT provide the high quality pavements that Texans depend on without continually raising fuel taxes to excessively high levels?

This book will explain how TxDOT employees can use Pavement Management System (PMS) concepts to meet these increasingly complex demands. It will also explain how to use the automated Pavement Management Information System (PMIS) to manage pavements at all levels of TxDOT. Finally, it will describe ways to incorporate pavement work history and cross-section information into the pavement management process to improve materials, design, construction, and maintenance practices for building longer-lasting pavements.

Together, PMS and PMIS can help TxDOT provide the highest quality and longest-lasting pavements for the lowest possible cost.

Typical Pavement Questions

TxDOT pavement managers face a new set of problems every day. But actually, many of these new problems are old ones in disguise. To get an idea of some of these pavement problems, think for a moment about how you would answer the following questions:

- What is the current condition of pavements in your area? Are they getting better, getting worse, or staying the same? What do you think the condition will be next year?
- Do you get enough funding for pavements? How do you determine how much you need? How do you determine which projects to fix when funding is low? Do you try to spread out treatments over all of your candidate projects, or do you defer some projects to another year?
- What are the effects of inadequate funding? How do you measure these effects?
- How do you estimate and document pavement needs for the Administration? What documentation do you present? Who compiles this information? What would help you better document your needs?
- Can you easily retrieve information about any pavement in your District? What types of information would you like to be able to get? How do you explain the poor condition of a highway to the public or its elected officials?
- How much research or testing do you perform on a pavement scheduled for rehab? Do you know what the existing cross-section is for a candidate pavement? When was the pavement last surfaced, and what type of surface was it?
- How long are seal coats and thin overlays lasting in your area?
- How do you evaluate the effectiveness of a new material, specification, or pavement design?

These questions seem innocent. In fact, they often come up in casual conversation, as if they could be answered in a few minutes. But in reality, answering any one of these questions can be very difficult and tedious. However, TxDOT must be able to quickly and confidently answer these questions if we are to meet increasing pavement demands in the face of decreasing pavement resources.

Now that we have all of these pavement problems, what do we do about them? In the past, we have done the best we could — which was usually very good. The experience and engineering judgement of TxDOT employees produced an unparalleled network of high-quality pavements.

But now, we can no longer build new mileage just for the sake of building new mileage. We must maintain, rehabilitate, and preserve the mileage we have. We must link our highways with air, rail, water, and other forms of transportation. We must work with greater sensitivity to the environment. And we must do all of this with restricted funds and without the help of thousands of very experienced employees who have recently retired. This does not mean that the old methods for managing pavements are now bad. It just means that they need to be refined to meet today's higher demands.

Pavement management provides these refinements.

Chapter 2

What is Pavement Management?

Pavement Management is "a method of finding cost-effective strategies for providing, evaluating, and maintaining pavements in a serviceable condition." Put in more general terms, pavement management is a method for solving all of the pavement problems listed on page 2.

Two other similar terms are worth defining here:

- A **Pavement Management System (or PMS)** is "a set of tools or methods that can assist decision-makers in finding cost-effective strategies for providing, evaluating, and maintaining pavements in a serviceable condition." (FHWA, 1989) This may seem the same as the definition for "pavement management." The main difference is that "pavement management" can be quite informal, while a "pavement management system" tends to be much more formalized (for example; with written policies, procedures, and documentation).

- The **Pavement Management Information System (or PMIS)** is "an automated system for storing, retrieving, analyzing, and reporting information to help with pavement-related decision-making processes." PMIS is not a system for giving all of the answers, but a set of tools to compare alternatives — pavement managers must still make the final decisions. PMIS is automated, so that you can quickly retrieve and analyze pavement information.

This book will occasionally refer to TxDOT's "pavement management system," as if there were a single computer program, manual, or procedure that is used statewide. In reality, TxDOT's "pavement management system" is a system for managing pavements, and it is made up of the following items, all working closely together:

- District Pavement Engineers to oversee all field activities related to pavements.
- District PMIS Coordinators to oversee PMIS-related activities in the field, and to support the District Pavement Engineers.
- District Pavement Data Collection Coordinators to oversee pavement evaluation and equipment activities in the field, and to support the District Pavement Engineers.
- Pavement evaluation equipment to measure rutting, ride quality, structural strength, skid resistance, layer thicknesses, and in-place material properties. This includes equipment such as the Profiler/Rutbar, Falling Weight Deflectometer (FWD), Skid truck, Multi-Function Vehicle (MFV), Ground-Penetrating Radar, and Seismic Pavement Analyzer (SPA). It also includes accelerated pavement testing done by the Texas Mobile Load Simulator (TxMLS).
- Equipment operators to collect the data and to keep the equipment maintained and calibrated.
- Pavement Management Information System (PMIS) to store, analyze, report, and summarize data at various levels of detail.
- Pavement Design programs such as FPS-19 for flexible (asphalt) pavements and DARWin 2.0 for rigid (concrete) pavements, and design support programs such as Modulus 5.0.
- Construction Division, Materials and Pavements Section to support District materials and pavement personnel and to support pavement management activities statewide.

Why is it Important?

TxDOT spends more than one billion dollars each year on pavements. And yet, with all of this money, we only have enough to meet about half of our pavement needs.

Pavement management systems are often used to improve road conditions by increasing fuel taxes. But there is much more to a good pavement management system than just increasing taxes. Used effectively, a pavement management system can help stretch existing funds and improve pavement conditions within existing funding by applying longer-lasting treatments at the right place and at the right time. This will improve the quality, efficiency, and effectiveness of transportation in Texas. It will also improve TxDOT's ability to serve as a good steward of the taxpayers' money.

In the end, a pavement management system can make TxDOT's request for tax increases less frequent, but more successful. Citizens and elected officials are more willing to accept higher taxes if they know that the extra funds will be put to good use. In such a case, additional funds for transportation will be seen as an investment in the future of Texas, instead of just a waste of hard-earned money.

But most importantly, a pavement management system will give us the tools to answer pavement questions quickly and confidently. We will become even more responsive to the public, to elected officials, and to ourselves. We will be able to explore alternatives that we never could have explored before. We will be able to plan for the future with much greater confidence. We will be able to anticipate and solve problems instead of just reacting to them.

All of these things, and many more, will help us provide higher-quality, longer-lasting pavements just when they are needed the most.

Levels of Pavement Management: Network, Program, and Project

Pavement management occurs throughout TxDOT, from the highest levels down to the lowest levels. It also occurs across the agency, as well (as the questions on page 2 suggest). Today's pavement management tools can help solve problems in design, construction, maintenance, and in the lab. They can help Administrators establish goals, plan ahead, and budget for changing conditions; and they can help practitioners diagnose and solve pavement problems in the field.

Different pavement managers will have different information needs. Figure 1 shows how the pavement management system must give general and detailed information to pavement managers.

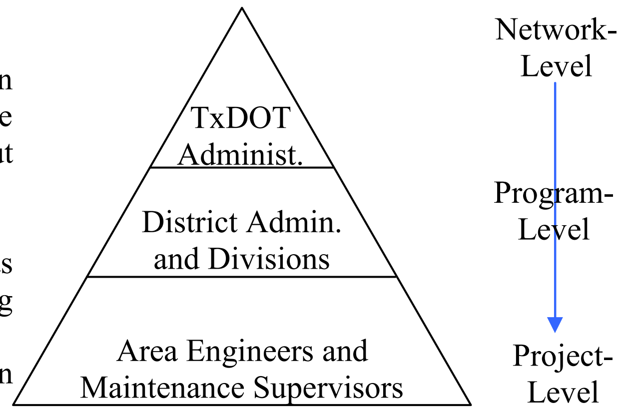

Figure 1 - Information Needs, by Level.

TxDOT Administration, the Transportation Commission, the State Legislature, and the FHWA needs general information about pavements. For example:

- What is the current condition of Texas pavements? Are we getting better, getting worse, or staying the same?
- How much money do we need to maintain the current level of pavement condition? How much more money do we need to improve pavement condition?
- Are our funding allocation formulas giving each District the ability to do the best possible pavement work?
- What will the impacts of future changes in funding, traffic, or policy be on pavement condition?

This type of work, which looks at all roads or large groups of roads, is called **Network-level Pavement Management**. For example, is the condition of the Interstate system getting better or worse? Network-level pavement management is good for:

- planning
- budgeting
- estimating pavement needs
- impact analysis
- setting goals or objectives
- measuring performance
- identifying trends.

Any pavement manager can use network-level information: it's not just for executives. In fact, it can be very good practice for Area Engineers and Maintenance Supervisors to run network-level PMIS reports, because when they look at the overall condition of pavements they will be able to keep minor problems from becoming major problems.

District Administration and Divisions are caught in the middle. Sometimes they need general information to see how pavements are doing overall (for example, to allocate funds to each Area Office), but other times they need detailed information about a specific pavement section (for example, to diagnose the cause of a premature failure). Pavement managers at this level deal directly with TxDOT Administration and with the Area Engineers and Maintenance Supervisors.

This type of work, which looks at several roads or several groups of roads, is sometimes called **Program-level Pavement Management**. For example, which roads should we seal coat this year? Program-level pavement management is good for:

- developing lists of candidate projects to meet specific pavement objectives
- analyzing the impact of changing projects or treatments on overall condition
- maintaining a list of backlog projects available for design on short notice.

Area Engineers and Maintenance Supervisors need detailed pavement information. They are uusally forgotten in pavement management discussions, but they are the ones who can benefit the most from a reliable pavement management system. After all, they are the ones who actually build the longer-lasting pavements.

This type of work, which focuses on one road, or one part of one road, is called **Project-level Pavement Management**. For example, what pavement design (layer types and thicknesses) should be placed on this US highway rehab project, and how long will that design last? Project-level pavement management is good for:

- diagnosing the cause(s) of a premature failure
- gathering data for pavement design
- designing pavements
- evaluating new materials, specifications, or construction techniques
- evaluating effectiveness of design, materials, construction, or maintenance
- measuring impact of heavy traffic loads, heavy rainfall, or freezing temperatures
- research.

All three levels of pavement management — network-, program-, and project-level — work together to support pavement activities throughout the organization. For example, someone in Maintenance may run a PMIS report and notice that all of the District's new thin overlays are rutting within two years. The Design Engineer might look at the report and find an error in thickness calculations. The Lab Engineer might find a stability problem, either because of poor materials or because of lenient specifications. The Construction Engineer might find that field inspectors have been complaining about the hot-mix being too rich. Or it might have been none of these things at all: the problem might have been caused by higher-than-expected truck traffic.

In any event, the pavement management system provides a single location where pavement managers can find general and detailed pavement information. The system doesn't have all of the information, and it doesn't have all of the answers, but it serves as a good place to begin looking for solutions to pavement problems.

Pavement Management at Work...

With all of the general concepts out of the way, how can pavement management be used to solve real-world pavement problems? The following paragraphs describe just a few of many possible examples.

Determine Adequacy of Pavement Funding

Pavement management can be used to estimate total funding needed for pavements. This estimate can be compared to the total funds spent to quickly determine the adequacy of pavement funding. For example, if TxDOT needs $2.0 billion for pavements and is currently spending only $700 million, then the adequacy of pavement funding is 35 percent of total needs.

This ratio of current-to-needed funding can be tracked over time and compared to changes in pavement condition.

A more elaborate way to determine funding adequacy would be to look at how many projects could not be funded in the current year ("backlog") or how many treatments had to be reduced in thickness or length because of limited funding ("stopgap treatments").

Fine-Tune Placement of Preventive Maintenance Treatments

In some cases, preventive maintenance is used to treat surface distress on a pavement that has extensive, underlying structural problems. When the treatment fails after only a few years in service, the treatment is blamed, when in reality it was the placement of the treatment that caused the premature failure. There is extensive pressure to treat as many miles of pavement as possible each year, but in some situations that approach causes more problems than it solves.

In other cases, preventive maintenance extends the life of pavement sections already in good condition. The rehabilitation money saved by such action can then be used to improve the structural condition of other projects.

Pavement management can be used to distinguish between these cases. It can be used to place a preventive maintenance treatment where it will do the most good, and keep it away from an area where it will only fail prematurely.

Evaluate Performance of New Treatments, Materials, and Designs

TxDOT has actively pursued development and use of new treatments, materials, and designs in an attempt to improve overall pavement condition. In all of these situations, the basic question has been the same: what is the best way to describe, monitor, and evaluate the performance of a new pavement practice?

One example is microsurfacing, which has shown promise as a preventive maintenance treatment for use in the repair of asphalt pavement rutting and cracking. How can TxDOT determine which projects are best suited for microsurfacing? Can it be used on high-traffic pavements?

How long does it protect against rutting? Does it improve ride quality; and if so, how much and for how long? These questions are very important. If we misapply microsurfacing (because of our lack of experience) and conclude that it is not effective, then we will unknowingly discard a valuable treatment. However, we must also be able to identify those circumstances where it is definitely not effective.

The controversy over Coarse-Matrix High-Binder (CMHB) pavement is another example. TxDOT developed CMHB as a way to prevent asphalt rutting. There were high expectations for its performance and many sections were built, but some of them still rutted. As a result, use of CMHB was discouraged on future projects. Once again, pavement management can be (and could have been) used to monitor these new sections, and to improve the CMHB mix design (where necessary). TxDOT could then have learned how to apply CMHB treatments where they had the best chance of being effective.

Superpave binder, mix, and design procedures, developed as part of the national Long-Term Pavement Performance (LTPP) program, give us another opportunity to use pavement management data to guide and support our use of new pavement practices. New "heavy-duty" asphalt mixes such as stone-mastic asphalt (SMA) and porous friction courses (PFC), and even the newer "super-thick" concrete pavements are also being used in the continuing effort to get more pavement life out of existing funds.

In all of these cases, pavement management can help us get the best performance out of these new treatments.

Determine Best Use of Recycled Pavement Materials

National interest in using various types of waste materials in pavement construction continues to increase, as a means of reducing demands on local landfills. TxDOT has been looking for ways to use these "new" materials while preserving high-quality pavement performance.

Pavement management can be used to determine if any of these materials are prone to rutting, cracking, poor ride quality, or other problems. The data can also be used to determine if these materials are suitable only for certain locations, climatic regions, or traffic levels. Thus, in one sense, we will be able to do the impossible: satisfy environmental and pavement requirements, without sacrificing either of them.

These are just a few of the many examples of how pavement management can be used to improve the overall condition of Texas pavements.

Chapter 3

PMIS: An Overview

As mentioned earlier, the Pavement Management Information System (PMIS) is an automated system for storing, retrieving, analyzing, and reporting information to help with pavement-related decision-making processes. PMIS contains most of the automated parts of TxDOT's pavement management system.

A few parts of the PMIS definition are worth describing in more detail:

- ***Storing*** means a step beyond just data collection. The data must be validated and then stored before PMIS can put it to use.
- ***Retrieving*** means that PMIS must provide ways for users to look at the data they spent so much time and money to collect (and store).
- ***Analyzing*** means that PMIS must do more than spit out the stored data. Analysis converts the data into information that decision-makers can use. Without this analysis feature, PMIS would be just a pavement management data system.
- ***Reporting*** means that PMIS must organize the information in a way that can be quickly and correctly understood, in summarized and detailed form.

What Is It?

PMIS is a tool to help you manage pavements more effectively within existing funds. With PMIS you can:

- Evaluate current pavement conditions (surface and sub-surface)
- Monitor trends in conditions over time
- Estimate pavement needs (lane miles and funding for preventive maintenance and rehab)
- Analyze the impacts of limited funding on current and future conditions
- Fine-tune treatments by evaluating what works where and when.

Although PMIS focuses primarily on network- and program-level pavement management, it also contains information to support project-level pavement design and engineering. As mentioned in the definition, PMIS helps with pavement-related decisions — it cannot make those decisions.

Where Is It?

PMIS runs on the TxDOT mainframe computer. Data is submitted from TxDOT offices statewide and stored in the central PMIS database in Austin. Reports are requested using the mainframe CICS environment and are printed using the mainframe ROSCOE text editor (which is also used to edit and store PMIS data).

After storage, users can immediately run PMIS reports to list, summarize, and analyze the data. There is no additional waiting time needed for data verification/approval because that has already been done by the PMIS storage programs.

Copies of the PMIS data can also be downloaded to TxDOT workstations for use in microcomputer programs such as word processors, spreadsheets, databases, presentation graphics, and geographic information systems. This download feature means that PMIS combines the security, universal access, and extra-large storage space of a mainframe system with the flexibility and ease-of-use of a microcomputer system.

What's In It?

PMIS contains extensive information about TxDOT-maintained pavements, dating back to September, 1983 (Fiscal Year 1984). Included in PMIS are:

- Pavement Evaluation and Other Data
- Scores
- Reports
- Analysis Procedures.

Each of these items are described in more detail in later chapters of this book.

A Brief Historical Note: PMIS and the Pavement Evaluation System (PES).

There was a predecessor to PMIS: the Pavement Evaluation System (PES). TxDOT developed PES in September, 1982, primarily to answer legislative questions about statewide pavement condition and to justify statewide funding requests. Districts collected distress and ride quality data for PES each year. Collection of skid resistance data was optional. Deflection data was first collected in September, 1986.

PMIS replaced PES in September, 1992 (Fiscal Year 1993). The old PES data (from Fiscal Years 1984-1992) was converted, and is now available in PMIS. The first year of PES data (September, 1982 — Fiscal Year 1983) only covered a very small (5 percent) sample of Texas pavements and used different rating procedures, thus it was not converted into PMIS.

Pavement Types in PMIS

PMIS covers all of the major types of pavement used in Texas. These pavement types are shown in the table below:

Table 1 - PMIS Pavement Types (Broad and Detail).

Pavement Type		Description
Broad	Detail	
CRCP	1	Continuously-Reinforced Concrete Pavement
JCP	2	Jointed Concrete Pavement, reinforced
	3	Jointed Concrete Pavement, unreinforced ("plain")
ACP	4	Thick Asphalt Concrete Pavement (greater than 5.5" thick)
	5	Intermediate Asphalt Concrete Pavement (2.5-5.5" thick)
	6	Thin Asphalt Concrete Pavement (less than 2.5" thick)
	7	Composite Pavement (heavily-stabilized asphalt-surfaced pavement)
	8	Overlaid or Widened Old Concrete Pavement
	9	Overlaid or Widened Old Flexible Pavement
	10	Thin-surfaced Flexible Base Pavement (surface treatment or seal coat)

Notes: Pavement Type 5 is the default value for all PMIS Data Collection Sections. If a pavement section has not been rated, or if it is new, it will have a Pavement Type value of 5 (even for concrete pavements).

The "Broad" Pavement Type is used to select "general" pavement performance prediction curves and to distinguish between asphalt-surface (sometimes termed "flexible") pavement and portland cement concrete surface (sometimes called "rigid") pavement. The Detail Pavement Type is used in the pavement distress rating, utility value, and score calculations.

It is very important that the Pavement Type values be correct because they affect the Condition Score, the SSI Score, the Needs Estimate, and predictions of future pavement condition/needs.

Pavement Type is only an approximation of the pavement structure. Detailed layer and cross-section data is needed to support project-level pavement design and engineering studies. However, this type of information can be supplied and used with PMIS, as will be discussed in Chapter 9.

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Chapter 4

PMIS Pavement Evaluation and Other Data

PMIS contains pavement evaluation and other data for use in managing Texas pavements.

Pavement Evaluation Data

PMIS contains five types of pavement evaluation data:

- **Visual Distress** data measure surface defects such as rutting, cracking, and patching. Specially-trained pavement raters collect this data every Fall. In urban areas, where rating would be very dangerous, the Pavements Section collects distress data using its Multi-Function Vehicle (MFV). On flexible pavements, rutting is measured electronically by special sensors mounted on the front bumper of a Profiler/Rutbar vehicle.
- **Ride Quality** data measure pavement roughness. Specially-trained operators collect this data using the Profiler/Rutbar vehicle. The Profiler/Rutbar measures the pavement surface directly, for use in computing Serviceability Index (SI) and International Roughness Index (IRI). The pavement profiles could also be used to compute roughness indices for specific vehicle types (e.g., a roughness index for trucks).
- **Rutting** data measures the depth and percentage of rutting in each wheelpath. Specially-trained operators collect this data using the Profiler/Rutbar vehicle (at the same that it measures ride quality). For asphalt pavements, PMIS summarizes the rut measurements into Shallow Rutting and Deep Rutting ratings. Pavement raters no longer have to visually rate Rutting as they did in the past (before fiscal year 1996).
- **Deflection** data measure overall pavement structural strength. PMIS deflection data can help the pavement manager identify weak base/surface and subgrade layers for more detailed coring and lab testing, and for use in pavement design programs. Specially-trained operators collect this data using the Falling Weight Deflectometer (FWD).
- **Skid** data measure pavement surface friction (“skid resistance”). It is tempting to equate surface friction with crash potential, however crashes occur because of many reasons other than just surface friction. PMIS skid data, by itself, does not measure a pavement’s overall safety. Specially-trained operators collect this data using the TxDOT Skid truck.

  In the Future: The Profiler/Rutbar vehicle will be converted into a TxDOT Modular Vehicle (TMV) which will be able to measure pavement distress (using a digital line scan camera, measure ride quality using two wheelpath lasers, and measure rutting using a scanning laser). The TMV will also be equipped with one or two wheelpath lasers to measure pavement surface texture, as a supplement to the existing PMIS Skid tests.

Visual Distress Data

PMIS contains distress ratings for asphalt and concrete pavements. These ratings describe surface rutting, cracking, spalling, potholes, patching, and other pavement defects.

For ACP, PMIS contains ten distress types, as shown below:

Table 2 - ACP Distress Types and Rating Methods.

ACP Distress Type	Rating Method
Shallow (¼-½" depth) Rutting	percent of wheelpath length (0 to 100)
Deep (½-1" depth) Rutting	percent of wheelpath length (0 to 100)
Patching	percent of lane area (0 to 100)
Failures	total number (0 to 99)
Block Cracking	percent of lane area (0 to 100)
Alligator Cracking	percent of wheelpath length (0 to 100)
Longitudinal Cracking	length per 100' station (0 to 999)
Transverse Cracking	number per 100' station (0 to 99)
Raveling (optional)	none, low, medium, or high
Flushing (optional)	none, low, medium, or high

Note: Rutting definitions were changed in FY 2001. In previous years (FY 1985-2000), Shallow Rutting was ½-1 inch and Deep Rutting was 1-3 inches. Shallow Rutting and Deep Rutting are measured electronically using the Profiler/Rutbar vehicle. All other flexible pavement distress types are rated visually by certified pavement raters.

For CRCP, PMIS contains five pavement distress types, as shown below:

Table 3 - CRCP Distress Types and Rating Methods.

CRCP Distress Type	Rating Method
Spalled Cracks	total number (0 to 999)
Punchouts	total number (0 to 999)
Asphalt Patches	total number (0 to 999)
Concrete Patches	total number (0 to 999)
Average Crack Spacing	spacing (1 to 75), to the nearest foot

Note: All CRCP distress types are rated visually by certified pavement raters.

For JCP, PMIS contains six distress types, as shown below:

Table 4 - JCP Distress Types and Rating Methods.

JCP Distress Type	Rating Method
Failed Joints and Cracks	Total number (0 to 999)
Corner Breaks	Total number (0 to 999)
Failures	Total number (0 to 999)
Shattered (Failed) Slabs	Total number (0 to 999)
Slabs With Longitudinal Cracks	Total number (0 to 999)
Concrete Patches	Total number (0 to 999)
Apparent Joint Spacing	Spacing (15 to 75), to the nearest foot

Note: All JCP distress types are rated visually by certified pavement raters.

For more information about PMIS distress ratings, please get a copy of the latest PMIS Rater's Manual, available from the Materials and Pavements Section of the Construction Division. Distress rating data is also shown on the Distress Data Report in PMIS.

Ride Quality and Rutting Data

Ride Quality and Rutting data are measured from the actual pavement surface by a TxDOT Profiler/Rutbar vehicle, shown in Figure 2 below. This vehicle has two lasers and five ultrasonic sensors in an assembly mounted on the front bumper. The two lasers (one over each wheelpath) measure pavement profile for ride quality, and the five ultrasonic sensors (one over each wheelpath, one on each end, and one in the middle) measure rutting.

The measurements are summarized at 0.1-mile intervals and stored in PMIS as International Roughness Index (IRI, inches per mile, for left wheelpath and right wheelpath), Serviceability Index (SI), Shallow Rutting percentage, Deep Rutting percentage, and average rut depth (in inches, for left wheelpath and right wheelpath).

PMIS averages the SI values over the length of each Data Collection Section (usually 0.5 mile) to calculate the PMIS Ride Score.

Ride Quality and Rutting data can be collected and stored down to 0.001-mile intervals (5.28 feet), if needed, for project-level studies or designs.

To see raw Ride Quality data (IRI and SI), run the Ride Quality Data report in PMIS. To see Rutting data, run the Automated Rutting Data report in PMIS.

Figure 2 - TxDOT Profiler/Rutbar Vehicle.

Deflection Data

Deflection data is measured at least once in every Data Collection Section by the Falling Weight Deflectometer (FWD), shown in Figure 3 below. The raw data shows a deflection measurement (in mils, or thousandths of an inch) for each of the seven FWD geophones. The geophones are spaced at 1-foot intervals, from directly underneath the load plate (geophone W1) to six feet away from the load plate (geophone W7). FWD data can help isolate base/surface or subgrade problems.

PMIS uses the FWD geophone readings to calculate the SSI Score.

Deflection data can be stored in PMIS down to 0.001-mile intervals (5.28 feet), if needed, for a Data Collection Section to support pavement design or other detailed engineering analyses.

To see raw Deflection data, run the Deflection Data report in PMIS. You can use the "normalized" option to set all geophone readings to 9,000 pounds for direct comparison of FWD test sites. You can also use the "raw" option to show the actual geophone readings and load for backcalculation of layer strength ("modulus").

Figure 3 - Falling Weight Deflectometer (FWD).

Skid (Surface Friction) Data

Skid data is measured at least once in every Data Collection Section by the TxDOT Skid Truck, shown in Figure 4 below. The skid tests are performed according to ASTM methods.

PMIS uses the lowest SN value in a Data Collection Section to calculate the PMIS Skid Score.

Skid data can be stored in PMIS down to 0.001-mile intervals (5.28 feet), if needed, for project-level studies or designs, but that is really only a theoretical capability because the skid test itself covers approximately 75 feet.

To see raw Skid data, run the Skid Resistance (SN) Data report in PMIS.

Figure 4 - TxDOT Skid Truck.

Other Data in PMIS

PMIS contains other types of data which are taken from TxDOT's Texas Reference Marker (TRM) system and Maintenance Management Information System (MMIS). Examples of these types of "other" PMIS data are:

- **Location**
  - Responsible District (that is, the district actually responsible for maintenance)
  - County
  - Maintenance Section
  - Highway
  - Beginning Reference Marker and Displacement
  - Ending Reference Marker and Displacement
  - Roadbed (for divided highways).

- **Traffic Data**
  - Current ADT (vehicles per day, by roadbed)
  - ADT growth rate
  - Cumulative ADT since original surface date
  - Cumulative ADT since last overlay date
  - 20-year projected 18-k ESAL (thousands of repetitions, by roadbed)
  - Cumulative 18-k ESAL since original surface date
  - Cumulative 18-k ESAL since last overlay date
  - Percent trucks
  - Average ten heaviest wheel loads (hundreds of pounds).

- **Climate Data**
  - Average rainfall, by County
  - Average number of freeze-thaw cycles, by County.

- **Roadway Characteristics Data**
  - Roadbed pavement type
  - Number of lanes
  - Roadbed width (travel lanes and paved shoulders)
  - Original surface (date and type)
  - Last overlay (date and type)
  - Last seal coat (date and type)
  - Left shoulder (type and width)
  - Right shoulder (type and width)
  - Speed limit (miles per hour)
  - Functional classification
  - National Highway System (yes or no).

- **Maintenance Data**
  - Total pavement-related maintenance expenditures (for each of last 10 fiscal years).

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Chapter 5

PMIS Scores

PMIS contains five scores which describe the quality of Texas pavements. These are:

- Distress Score
- Ride Score
- Condition Score
- SSI (Structural Strength Index) Score
- Skid Score.

These Scores use utility factors to adjust the ratings and data into a uniform scale for comparison purposes. For more information about utility factors, please refer to Chapter 8.

PMIS also contains International Roughness Index (IRI) values for each wheelpath.

Distress Score

Distress Score describes the amount of visible surface deterioration (pavement distress). The values range from 1 (most distress) to 100 (least distress). Table 5 lists the five classes of Distress Score used in PMIS.

Table 5 - Distress Score Classes.

Distress Score	Class	Description
90-100	"A"	Very Good
80-89	"B"	Good
70-79	"C"	Fair
60-69	"D"	Poor
1-59	"F"	Very Poor

Note: A Distress Score below 80 indicates that the pavement section has problems caused either by multiple distresses or by a single "severe" distress.

Ride Score

Ride Score describes a pavement's roughness. Ride Score ranges from 0.1 (roughest) to 5.0 (smoothest). Table 6 lists the five classes of Ride Score used in PMIS.

Table 6 - Ride Score Classes.

Ride Score	Class	Description
4.0-5.0	"A"	Very Good
3.0-3.9	"B"	Good
2.0-2.9	"C"	Fair
1.0-1.9	"D"	Poor
0.1-0.9	"F"	Very Poor

Note: A Ride Score below 3.0 indicates a rough ride to the average person.

Condition Score

Condition Score describes a pavement's overall condition in terms of distress and ride quality (SI values). Condition Score values range from 1 (worst condition) to 100 (best condition). Table 7 lists the five classes of Condition Score used in PMIS.

Table 7 - Condition Score Classes.

Condition Score	Class	Description
90-100	"A"	Very Good
70-89	"B"	Good
50-69	"C"	Fair
35-49	"D"	Poor
1-34	"F"	Very Poor

Note: Condition Score is **not** weighted by regional factors such as climate and material properties, but it is affected by Average Daily Traffic (ADT) and Speed Limit.

SSI (Structural Strength Index) Score

SSI (Structural Strength Index) Score describes a pavement's overall structural strength, based on deflection data (from the Falling Weight Deflectometer), truck traffic data (18-k ESAL), pavement cross-section, and climatic data (average County rainfall and average County freeze/thaw cycles). SSI values range from 1 (Very Weak) to 100 (Very Strong). Table 8 lists the five classes of SSI Score used in PMIS.

Table 8 - SSI Score Classes.

SSI Score	Class	Description
90-100	"A"	Very Strong
80-89	"B"	Strong
70-79	"C"	Fair
60-69	"D"	Weak
1-59	"F"	Very Weak

Note: An SSI Score below 70 indicates that the pavement section is "structurally deficient."

Skid Score

The PMIS Skid Score measures a pavement's surface friction (skid resistance), from 1 to 99. The Skid Score does not indicate the stopping characteristic of any one vehicle, driver, or climatic condition, but it is useful to engineers in evaluating surface friction properties of aggregate types, asphalt mix designs, and pavement construction methods. Although higher Skid Scores are preferrable to lower Skid Scores, it is not possible to select a single value which can be considered adequate for all sites and traffic situations.

International Roughness Index (IRI)

The International Roughness Index (IRI) describes the amount of roughness within a given length of pavement (inches per mile) – higher values mean more roughness. IRI is a standard measure of roughness used by transportation agencies around the world, and it is used in FHWA's Highway Performance Monitoring System (HPMS) to describe the condition of the nation's transportation system to the U.S. Congress. IRI is also used as a performance measure in TxDOT's new ride quality ("smoothness") specification.

IRI values in PMIS range from 1 (smoothest) to 950 (roughest). Table 9 lists the five classes of IRI used in PMIS.

Table 9 - International Roughness Index (IRI) Classes.

IRI (inches per mile)	Class	Description
1 – 59	"A"	Very Good
60 – 119	"B"	Good
120 – 170	"C"	Fair
171 – 220	"D"	Poor
221 – 950	"F"	Very Poor

Note: These are not the same as the Ride Score ranges shown earlier (in other words, 1-59 IRI is not the same as 4.0-5.0 Ride Score).

Chapter 6
PMIS Reports

PMIS contains many reports to help list, summarize, and analyze data. The reports are organized in the same five categories shown on the PMIS Main Menu:

Item 1: Standard Reports
Item 2: Data Transactions (On-line) Reports
Item 3: Management Sections Reports
Item 4: Network Analysis Reports
Item 5: Administration Reports.

The Administration reports are for routine tasks performed in maintaining and administering PMIS, and are not described in this book.

PMIS also supports downloading of data for use in GIS maps and ad-hoc reports, as will be described at the end of this chapter.

Item 1: Standard Reports

PMIS contains three types of standard reports. These standard reports list data and provide some basic summaries, with little additional analysis. They are good for getting a first-look at what's in PMIS. These report types are:

- Class 1 Reports — Section Lists and Data
- Class 2 Reports — Administrative Summaries
- Other Standard Reports.

The "Class 1" reports list PMIS sections and whatever data has been stored for them. The lists of sections can include inventory data along with the PMIS pavement evaluation data. These reports can list pavement evaluation data for each Data Collection Section, or they can also list "raw" data for more-detailed needs.

"Class 1" also includes the frequently-used Ratings and Scores reports, which list all available PMIS data (ratings <u>and</u> scores) for each Data Collection Section, for one year or multiple years. Ratings and Scores reports also allow "critical values" searches on the PMIS database (for example, list all sections with Ride Score less than 3.0).

There are 19 Class 1 reports, as shown below:

Class 1 Reports – Section Lists and Data	
Data Collection Reports	
Pavement Sections to be Rated	Lists PMIS beginning and ending limits for each section, and indicates what type of data (if any) is required
Status of Data Collection Survey	Lists PMIS sections and indicates which types of data (if any) have been stored
Unrated Pavement Sections	Lists sections where particular types of PMIS data have not yet been stored
Summary Status of Data Collection Survey	Summarizes lane miles (total and percentage) which do and do not have data stored, by PMIS data type
Modified Section Length and Pavement Type	Lists sections where Section Length or Pavement Type have been changed
Raw Data Reports	
Distress Data	Lists distress ratings and calculated Distress Score (if possible)
IRI / Ride Data	Lists 0.1-mile IRI data (by wheelpath), SI values, and summary statistics (high, low, average, and standard deviation)
Deflection Data	Lists deflections for each geophone (normalized to 9000 pounds or not) for each deflection test
Skid Resistance (SN) Data	Lists skid numbers (SN) and calculated Skid Scores for each skid test
Automated Rutting Data	Lists 0.1-mile rut percentages and average depths (by wheelpath)
Ratings and Scores Reports	
Single-Year Ratings and Scores (Ride Version)	Lists distress ratings and scores for all PMIS sections (shows Ride Score instead of IRI)
Single-Year Ratings and Scores (IRI Version)	Lists distress ratings and scores for all PMIS sections (shows IRI instead of Ride Score)
Single-Year Ratings and Scores, by Increasing Condition Score (Ride Version)	Lists worst sections first, based on Condition Score (shows Ride Score instead of IRI)
Single-Year Ratings and Scores, by Increasing Condition Score (IRI Version)	Lists worst sections first, based on Condition Score (shows IRI instead of Ride Score)
Critical Values Ratings and Scores (Ride Version)	Lists sections meeting specific criteria (for example, Ride Score less than 3.0)
Critical Values Ratings and Scores (IRI Version)	Lists sections meeting specific criteria (for example, IRI greater than 120 inches/mile)
Multi-Year Ratings and Scores (Ride Version)	Lists ratings and scores over time (shows Ride Score instead of IRI)
Multi-Year Ratings and Scores (IRI Version)	Lists ratings and scores over time (shows IRI instead of Ride Score)
Construction and Work History Reports	
Construction and Work History Report	Lists sections under construction, or with specific dates or types of surfacing

The Class 2 Administrative Summaries reports provide executive-level ("network-level") descriptions of pavement condition. Results from the reports are excellent for displaying in tables, charts, graphs, or maps.

There are six of these reports:

Class 2 Reports — Administrative Summaries	
Average PMIS Scores Reports	Computes averages of PMIS Scores (Distress, Ride, Condition, IRI Left Wheelpath, and IRI Right Wheelpath)
Maintenance Level of Service Reports	Shows percentage of miles (flexible pavement only) in each of the five pre-defined maintenance level of service categories for Rutting, Failures, Alligator Cracking, Ride Quality, and Combined
Score Classes Reports	Shows percentage of miles in each of the five pre-defined class categories (A, B, C, D, and F) for the PMIS Scores (Distress, Ride, Condition, IRI Left Wheelpath, IRI Right Wheelpath, and Skid), as used in the *Condition of Texas Pavements* PMIS Annual Report
PMIS Scores by Control Sections	Calculates PMIS Scores (Distress, Ride, Condition, Skid, and SSI) by Control-Section
PMIS Mileage Summary Reports	Shows the total centerline, roadbed, and lane miles in PMIS
PMIS Overall Scores Reports	Shows 'overall' (as opposed to 'average') Distress, Ride, and Condition Scores

There are four other PMIS standard reports that do not fit easily into the categories already described. These reports primarily support data collection.

Other PMIS Standard Reports	
Create Section List File	Creates a small file of PMIS section limits that can be downloaded and used in data collection equipment
Create Automated Rating Form	Creates paper forms with PMIS section limits already filled-in, which can be used for distress rating in the field Please Note: forms will show any ratings that have already been stored
Visual Data Action Report	Lists sections and distress data stored by a particular person (based on mainframe sign-on key) at a particular time
Deleted Raw Data Action Report	Lists sections where raw data has been deleted

Item 2: Data Transactions (On-line) Reports

Although this feature is mainly used to store, browse, and delete PMIS data in an interactive, on-line environment, it does have three reports.

Data Transactions (On-line)	
Visual Data – Store, Browse, and Delete	
Visual Data (On-line) Action Report	Lists sections and distress data stored by a particular person at a particular time
Other Raw Data – Browse and Delete	
Deleted Raw Data Action Report (duplicate)	Lists sections where raw data has been deleted
Construction and Work History Data	
Construction and Work History Report (duplicate)	Lists sections under construction, or with specific dates or types of surfacing

Item 3: Management Sections Reports

PMIS Management Sections lets the pavement manager combine PMIS Data Collection Section into "candidate projects." This feature is especially helpful when running the Network Analysis reports to develop proposed lists of sections ("projects") to be treated within existing funds. This feature directly supports "program-level" pavement management, as described in Chapter 1.

There are four Management Section reports:

Management Sections	
Print Management Sections	Shows the beginning and ending limits of each Management Section in PMIS
Check Validity of Management Sections	Lists Management Sections which will fail analysis because of invalid limits (which must be altered before the section can be analyzed)
Alter Management Sections (PMIS Coordinators only)	Lets the district PMIS Coordinator create, modify, or delete Management Sections
Reset District Management Sections (PMIS Coordinators only)	Lets the district PMIS Coordinator undo **all** changes and go back to the PMIS default Management Section limits

Chapter 8 has more information about PMIS Management Sections.

Item 4: Network Analysis Reports

Network Analysis is where PMIS estimates pavement needs and tries to help pavement managers respond to the realities of limited funding.

There are 14 Network Analysis reports, as shown below:

Network Analysis	
Needs Estimate (select up to three of the following reports)	
Executive Summary	Summarizes lane mile and funding needs (PM/LRhb, MRhb/HRhb, and Total) for entire district, by county, and by maintenance section Summaries are based on functional classification, not highway system
Highway System Summary	Summarizes lane mile and funding needs for each treatment type (and total), by PMIS Highway System (IH, US, SH, FM, BR, and PR)
Broad Pavement Type Summary	Summarizes lane mile and funding needs for each treatment type (and total), by Broad Pavement Type (ACP, CRCP, and JCP)
Detail Pavement Type Summary	Summarizes lane mile and funding needs for each treatment type (and total), by Detail Pavement Type (1-10)
List All Sections	Lists all PMIS sections, along with estimated treatment type and cost (if any)
List Sections by Treatment	Lists all PMIS sections that can be analyzed, for any particular type of treatment (for example, PM sections only, or MRhb and HRhb sections)
Projected Pavement Condition	
Projected Pavement Condition Report	Estimates future pavement condition (distress ratings, ride quality, treatment, and cost) for 1-10 years based on current PMIS data and prediction models
Optimization and Impact Analysis (select up to three of the following reports)	
Optimization List Sections Which Can be Treated	Lists all PMIS sections and shows which sections can receive which treatments within a user-specified funding amount (budget)
District Optimization, by Highway System	Summarizes optimization results (lane miles and funding) for a district, by PMIS Highway System
District Impact, by Highway System	Summarizes impacts of limited funding for a district, by PMIS Highway System
Statewide Optimization, by District	Summarizes optimization results (lane miles and funding) for the entire state, by district
Statewide Optimization, by Highway System	Summarizes optimization results (lane miles and funding) for the entire state, by PMIS Highway System
Statewide Impact, by District	Summarizes impacts of limited funding for the entire state, by district
Statewide Impact, by Highway System	Summarizes impacts of limited funding for the entire state, by PMIS Highway System

There are four other Network Analysis reports that do not fit easily into the categories already described. These reports are:

Network Analysis (continued)	
Analysis File Maintenance	
Current Analysis File Status Report	Summarizes the amount of data in the SAS Analysis Work File, and when it was last created
Other Network Analysis Reports	
PMIS Usage Reports – Year to Date	Shows how many people have used PMIS in the current fiscal year, and which reports have been run
Modify Treatment Costs	Lets a PMIS user change the default costs (dollars per lane mile) for one or more of the PMIS treatment types (PM, LRhb, MRhb, and HRhb)
List Sections Which Cannot be Analyzed	Lists sections which cannot be analyzed, and identifies the data problem(s) that need to be corrected

GIS Maps and Ad-Hoc Reports – PMIS MapZapper

As mentioned earlier, PMIS data can be download from the mainframe database for use on local workstations. The Pavements Section has developed a program, the PMIS MapZapper, that downloads PMIS data into a Microsoft AccessXP database for use in developing geographic information system (GIS) maps of PMIS data (for example, a district map of Distress Scores). The AccessXP database can also be used to develop non-standard ("ad-hoc") reports and summaries.

For more information about this program, please contact the Materials and Pavements Section of the Construction Division.

Chapter 7

PMIS Analysis Procedures

PMIS contains three analysis procedures to help pavement managers with network-, program-, and project-level pavement management decisions. These analysis procedures are:

- Needs Estimate
- Projected Pavement Condition
- Optimization and Impact Analysis.

Needs Estimate

Pavement managers are often asked to locate deficient, problem, or substandard pavement sections and to estimate how much money is needed to repair them. PMIS includes a Needs Estimate program to answer such questions.

The PMIS Needs Estimate program looks at each pavement section and checks the distress ratings and ride quality data against the following pre-defined broad treatment types:

- Preventive Maintenance (PM)
- Light Rehabilitation (LRhb)
- Medium Rehabilitation (MRhb)
- Heavy Rehabilitation/Reconstruction (HRhb).

PMIS multiplies the pavement's area by a typical Statewide cost to estimate the cost of each treatment. The sum of these costs is the District's total estimated pavement needs.

District users can modify the PMIS treatment costs for their particular district to more accurately reflect local project costs.

Figure 5 shows an example of results from the PMIS Needs Estimate. In this example, 19 percent of statewide pavement funding needs in fiscal year 2003 are for Preventive Maintenance (PM) treatments.

Treatment types in the Needs Estimate are general categories only — they are not meant to specify actual pavement designs. The treatment costs are also general in nature and are not meant to be used as actual project costs.

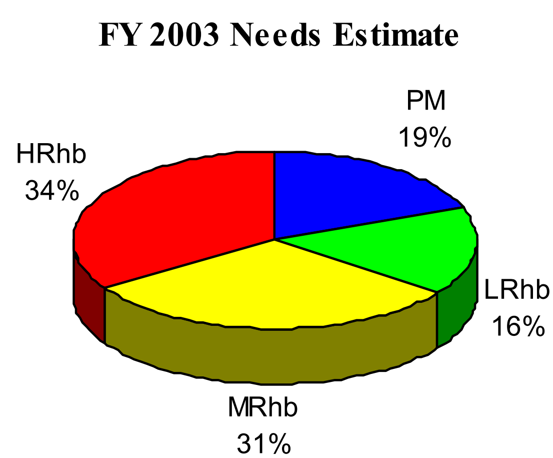

Figure 5 - PMIS Needs Estimate.

Examples of typical pavement treatments and costs used in the Needs Estimate are shown in Table 10 below:

Table 10 - Typical Treatments and Costs Used in Needs Estimate.

Pavement Type	Typical Treatment and Cost (dollars per lane mile)			
	PM	LRhb	MRhb	HRhb
1 (CRCP)	None	CPR $60,000	Patch and ACP Overlay $125,000	Concrete Overlay $400,000
2 (JRCP)	Joint Seal $6,000	CPR $60,000	Patch and ACP Overlay $125,000	Concrete Overlay $400,000
3 (JPCP)	Joint Seal $6,000	CPR $60,000	Patch and ACP Overlay $125,000	Concrete Overlay $400,000
4 (Thick HMAC)	Crack/Surface Seal $10,000	Thin ACP Overlay $35,000	Thick ACP Overlay $75,000	Remove Surface, Replace/Rework Base $180,000
5 (Med. HMAC)	Crack/Surface Seal $10,000	Thin ACP Overlay $35,000	Thick ACP Overlay $75,000	Remove Surface, Replace/Rework Base $180,000
6 (Thin HMAC)	Crack/Surface Seal $8,000	Thin ACP Overlay $35,000	Mill and ACP Overlay $60,000	Reconstruct $125,000
7 (Semi-Rigid)	Crack/Surface Seal $11,000	Thin ACP Overlay $40,000	Mill and ACP Overlay $62,000	Remove Surface, Repair Conc. Base $175,000
8 (Overlaid PCC)	Crack/Surface Seal $11,000	Thin ACP Overlay $40,000	Mill and ACP Overlay $62,000	Remove Surface, Repair Conc. Base $175,000
9 (Overlaid ACP)	Crack/Surface Seal $11,000	Thin ACP Overlay $40,000	Thick ACP Overlay $62,000	Remove Surface, Replace/Rework Base $175,000
10 (Surface Trmt.)	Surface Seal, No Patching $6,000	Surface Seal, Light/Med. Patching $11,000	Surface Seal, Heavy Patching $20,000	Rework Base and Surface Seal $62,000

Note: CPR is "Concrete Pavement Restoration."
HMAC is "Hot-Mix Asphalt Concrete."

If a section was not rated in the current fiscal year, PMIS will look back for ratings in previous years, and then project those ratings forward to the current year. Thus, PMIS will estimate needs for all pavements, even though the District may not rate all pavements in a given year.

Projected Pavement Condition

Sometimes the pavement manager is asked to predict the condition of a road several years in the future. If it's not possible to treat a particular section in the current year, what additional work will be required if the section is deferred for one or more years?

PMIS has a Projected Pavement Condition report to answer these questions. This report lists current PMIS distress ratings and Scores, and then "projects" those values into the future. The report also shows estimated treatments and costs, if any, for up to ten years in the future.

In some cases, the report will show when a road switches from "no treatment" to "Preventive Maintenance" or one of the "Rehab" treatments. Comparison of the costs from year to year can be used to describe the impacts of deferred maintenance (that is, the increased cost of waiting). It can also be used to give a very simple estimate of "remaining life" based on how many years it takes to reach a user-specified condition (for example, how many years before the Ride Score drops below 3.0).

Figure 6 shows an example of results from the PMIS Projected Pavement Condition report. In this example, ride quality on a section of US 83 declines from 4.2 to 2.3 in a ten-year period, while treatment costs increase to $7,000 in FY 2004, $40,000 in FY 2008, and $50,000 in FY 2009.

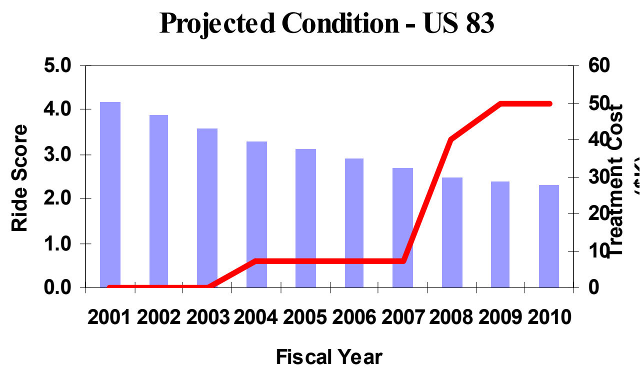

Figure 6 - Projected Pavement Condition.

Optimization and Impact Analysis

Estimating total pavement needs and future condition is important, but the real power of pavement management is in its ability to deal with the reality of limited funds. Most pavement management questions concern the problem of providing adequate pavements with inadequate funding. How can the pavement manager provide and maintain serviceable pavements if there's not enough money to fix all of the bad roads?

PMIS provides Optimization and Impact Analysis programs to help deal with limited funds, both current and expected. This program looks at the "needed" treatment (from the Needs Estimate) for each section and tries to select those sections which will give the most benefit for a specified budget.

Optimization and Impact Analysis works with any budget or allocation, including:

- actual budget
- expected budget
- desired (or "proposed") budget.

It also accepts values which change over time, such as:

- budget (percent increase or decrease)
- truck traffic (18-k ESAL percent increase or decrease)
- length of time between preventive maintenance seal coats (in years).

Thus, PMIS Optimization and Impact Analysis lets the pavement manager anticipate and effectively prepare for change. For example:

- What if funding stays constant for the next five years?
- What if funding increases by 5 percent for the next ten years?
- What if funding decreases by 5 percent for the first five years and then stays constant for the next five years?
- How much money is needed to keep pavements at their current condition?
- What if truck traffic (18-k ESAL) increases by 10 percent for each of the next four years?
- What if we try to seal coat our roads every seven years instead of every ten years?

PMIS compares the benefit to be gained by a section's Needs Estimate treatment to the cost of that treatment. Then, the Optimization program ranks the sections in order of decreasing benefit/cost ("effectiveness") and prints out the list of selected sections on a report. If multiple years were requested, PMIS treats its selected sections and then ages all pavements one year. PMIS then applies the next fiscal year's budget, computes the needed treatments, and ranks the sections again. This process continues until PMIS reaches the last requested analysis year.

Optimization can give the pavement manager an idea of how much work (and what type) can be done with a particular funding level. If multiple funding levels are used (for example, "minimum," "tolerable," and "desirable"), then the PMIS results can be used to show the expected benefits of increased funding.

Figure 7 shows an example of results from the PMIS Optimization program. In this example, three possible FY 2003 pavement programs for a county are considered. The results show that increasing the county funding from $1 million to $2 million would more than double the mileage that could be treated, and would also treat more than 70 miles of backlog pavement (from 476.8 to 406.4).

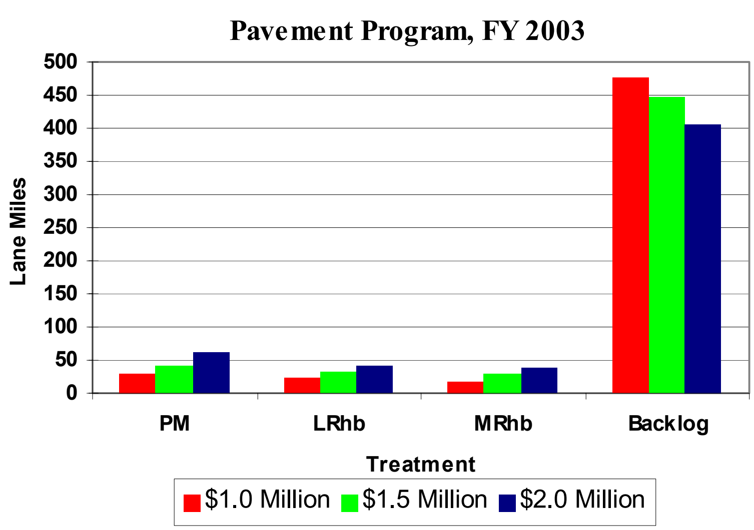

Figure 7 - Example of PMIS Optimization.

Impact Analysis measures the consequences of pavement decisions. It can help the pavement manager justify funding requests or policy changes by documenting the expected effects on current and future pavement condition.

PMIS Impact Analysis shows the effects of five different factors on current and future pavement condition. These factors are:

- budget
- Management Section limits
- Management Section treatments
- truck traffic (18-k ESAL)
- preventive maintenance seal coat policy.

The Impact Analysis program determines the effect of the five factors by estimating pavement condition at the following three points in time:

- current condition (before treatments)
- after Needs Estimate treatments (assumes unlimited funding)
- after Optimization treatments (assumes limited funding).

Impact Analysis reports are an option within the PMIS Optimization program. Thus, a pavement manager can run Optimization for a given scenario and see the impact of that scenario.

Figure 8 shows an example of a PMIS Impact Analysis. In this example, $1.5 million per year would maintain county pavements at their current condition for the next five years, while $1 million per year would worsen condition and $2 million per year would improve condition.

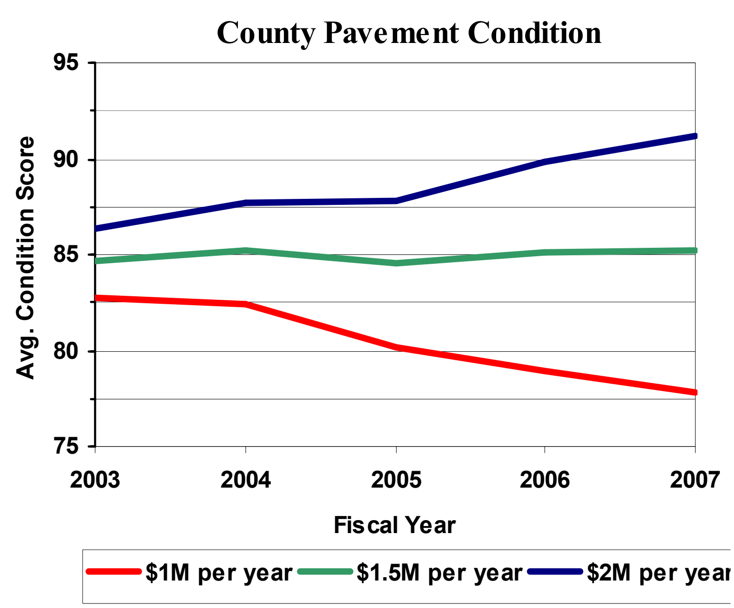

Figure 8 - Example of PMIS Impact Analysis.

Tracking Stopgap Mileage, Stopgap Cost, and Backlog

If PMIS does not have enough money to give a section its needed treatment, that section will receive a stopgap treatment.

♦ A ***Stopgap*** treatment simulates the cost of frequent repair maintenance that a road must get when there is not enough money to give it the treatment that it needs.

The cost of a stopgap treatment is not taken from the Optimization budget. It is totalled separately as additional maintenance funds needed. The ability to track stopgap mileage over time is an important PMIS feature.

The PMIS Impact Analysis reports provide only some of the possible measures of impact. There are three other important measures which can be taken from the Optimization program and used for Impact Analysis. These measures are:

- stopgap mileage, which is the total lane mileage receiving stopgap treatment
- stopgap cost, which is the estimated extra maintenance cost of doing repair maintenance on stopgap mileage
- backlog, which is the difference between the Needs Estimate cost (total pavement needs) and the Optimization budget.

Chapter 8

Some Technical Details...

Previous chapters have described PMIS data, Scores, and reports, without going into the technical details of how they work. This chapter will describe some of the technical details behind the following PMIS features:

- Utility Values
- PMIS Score Equations (Distress, Ride, Condition, SSI, and Skid)
- Needs Estimate Decision Trees
- Optimization "Effectiveness" and "Benefit"
- Management Sections
- Maintenance Levels of Service.

For more information about the techincal details of PMIS, please contact the Materials and Pavements Section of the Construction Division.

Utility Values

How do you combine distress ratings and ride quality measurements on different sections and get a consistent, reliable measure of each section's condition? Is an asphalt pavement with 25 percent Shallow Rutting in worse condition than a jointed concrete pavement with 38 Failed Joints and Cracks? Are five CRCP Punchouts worse than 10 percent Alligator Cracking and, if so, then by how much?

PMIS uses a system of utility values to determine the subjective value of the pavement at different levels of condition. "Utility" may be thought of as the value of the service provided by the pavement in use with a particular level of damage. Utility values range from 0.0 (least valuable) to 1.0 (most valuable). Value of service may be thought of in two ways:

- ***Structural Utility***, which considers the pavement section as a structure designed to carry traffic loads effectively.
- ***Functional Utility***, which considers the pavement section as a small link in a network which is designed to move traffic (people and goods) smoothly and efficiently.

It is important to understand that structural utility and functional utility are not always related. As an example, consider a flexible pavement with Alligator Cracking. A utility curve for this pavement would look something like the curve shown in Figure 9. As defined in PMIS, the pavement's Alligator Cracking can range from 0 to 100 percent of the total wheelpath length. With 0 percent Alligator Cracking, the pavement's Distress Score is 100 (highest possible value), assuming that there are no other distress types present. Structural utility is excellent because the pavement structure is strong — there are no cracks. Functional utility is also excellent because the pavement has no cracks to make the surface rough.

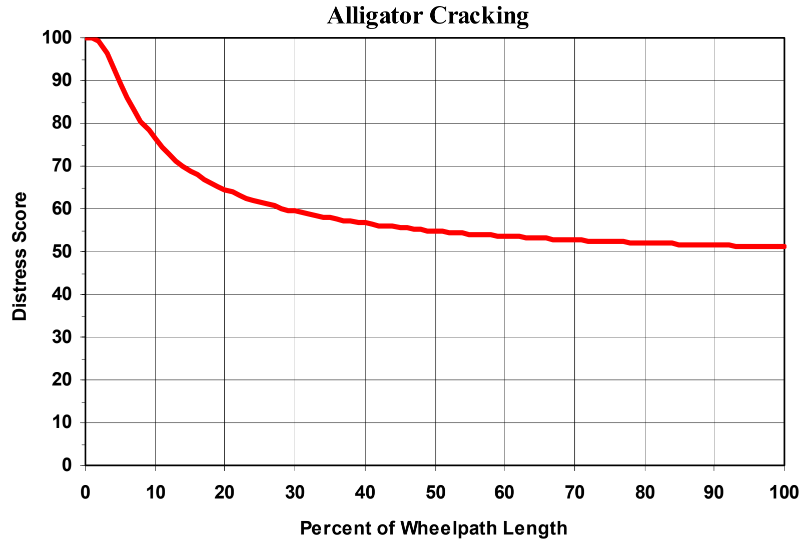

Figure 9 - Utility Curve for Alligator Cracking.

As the amount of Alligator Cracking increases, structural utility begins to drop. Functional utility also drops, though probably not as quickly — there are a few cracks, but not enough to make the road rough. As the Alligator Cracking approaches 100 percent, the pavement engineer would say that the structural utility is near zero. But the functional utility is not zero — maybe the road is somewhat rough from all the cracks, but it is still passable. Thus, the pavement's Distress Score — again assuming no other distress types are present — would fall to some value between 0 and 1 (51.08 in this example).

Looking at the pavement's Ride Score would give a different view of the utility curve. As mentioned before, PMIS Ride Score values range from 0.1 (roughest) to 5.0 (smoothest). At 5.0, the pavement's functional utility is certainly 1.0. But the structural utility might not necessarily be that high — a newly-resurfaced pavement tends to be very smooth, no matter how strong the underlying material is. As the Ride Score drops, structural and functional utility drop as well, until eventually the road gets so rough that people complain (this will occur well before the Ride Score drops to 0.1). At that point, the functional utility is zero, but the pavement structure could still be somewhat sound. Once again, the pavement's overall utility would fall somewhere between 0 and 1.

There is no exact rule that says structural utility is more important than functional utility. Thus, PMIS utility values consider both when describing the overall utility provided by a pavement section. Obviously, it's not possible to match every user's expectation of pavement quality every time, but the PMIS utility values allow TxDOT to compare pavements as fairly as possible.

Distress Score Equation

Distress Score multiplies the utility factors for all distress types. It describes the overall amount and severity of distress (e.g., rutting, cracking, patching, and potholes) on a pavement.

For CRCP (Pavement Type 1), the Distress Score equation is:

$$DS = 100 \times \left(U_{Spall} \times U_{Punch} \times U_{PCPat} \times U_{ACPat}\right) \qquad \textbf{Equation 1}$$

where DS = Distress Score
U_{Spall} = Utility value for Spalled Cracks
U_{Punch} = Utility value for Punchouts
U_{PCPat} = Utility value for Concrete Patches
U_{ACPat} = Utility value for Asphalt Patches.

For JCP (Pavement Types 2 and 3), the Distress Score equation is:

$$DS = 100 \times \left(U_{FLJ} \times U_{Fail} \times U_{SSlab} \times U_{LCrack} \times U_{PCPat}\right) \qquad \textbf{Equation 2}$$

where DS = Distress Score
U_{FLJ} = Utility value for Failed Joints and Cracks
U_{Fail} = Utility value for Failures
U_{SSlab} = Utility value for Shattered (Failed) Slabs
U_{LCrack} = Utility value for Slabs With Longitudinal Cracks
U_{PCPat} = Utility value for Concrete Patches.

For ACP (Pavement Types (4-10), the Distress Score equation is:

$$DS = 100 \times \left(U_{SRut} \times U_{DRut} \times U_{Patch} \times U_{Fail} \times U_{Block} \times U_{Alg} \times U_{LCrack} \times U_{TCrack}\right) \qquad \textbf{Equation 3}$$

where DS = Distress Score
U_{SRut} = Utility value for Shallow Rutting
U_{DRut} = Utility value for Deep Rutting
U_{Patch} = Utility value for Patching
U_{Fail} = Utility value for Failures
U_{Block} = Utility value for Block Cracking
U_{Alg} = Utility value for Alligator Cracking
U_{LCrack} = Utility value for Longitudinal Cracking
U_{TCrack} = Utility value for Transverse Cracking.

Note: Raveling and Flushing are optional distress types. They have no utility factors in PMIS are thus not used in the Distress Score equation.

Distress Score values range from 1 (most distress) to 100 (least distress).

Ride Score Equation

The PMIS Ride Score is a measure of pavement roughness. It is the length-weighted arithmetic mean ("average") of all SI values in a Data Collection Section, as shown below:

$$RS = \frac{\sum_{i=1}^{n} d_i SI_i}{\sum_{i=1}^{n} d_i}$$ **Equation 4**

where RS = Ride Score
n = number of SI values in the Data Collection Section
d = length of pavement, in miles, covered by the SI value
SI = Serviceability Index (from Profiler).

Ride Score values range from 0.1 (roughest) to 5.0 (smoothest).

Condition Score Equation

The PMIS Condition Score is a measure of overall condition in terms of distress and ride quality.

$$CS = DS \times U_{Ride}$$ **Equation 5**

where CS = Condition Score
DS = Distress Score
U_{Ride} = Utility value for Ride Quality (based on SI value, ADT, and Speed Limit).

Condition Score is a function of pavement distress (Distress Score), Ride Score, ADT, and speed limit.

Condition Score values range from 1 (worst condition) to 100 (best condition).

SSI (Structural Strength Index) Score Equation

The PMIS SSI ("Structural Strength Index") Score is a measure of overall structural strength, by Pavement Type, based on pavement deflections obtained from Falling Weight Deflectometer tests. SSI Score also includes adjustments for rainfall and truck traffic, as shown in the equation below:

$$SSI = 100 \times U_{FWD}^{[1/(RF \times TF)]} \qquad \textbf{Equation 6}$$

where SSI= SSI Score
U_{FWD}= Utility value for the FWD deflections
RF = Rainfall factor
TF = Traffic factor.

SSI Score values range from 1 (weakest) to 100 (strongest).

Skid Score Equation

Skid Score is the lowest of the raw skid numbers (SN values) collected on a PMIS Data Collection Section.

Skid Score values range from 1 (least surface friction) to 100 (most surface friction).

Needs Estimate Treatment Factors and Decision Trees

The PMIS Needs Estimate uses six factors to estimate the treatment for a particular section:

1. Pavement type
2. Distress ratings
3. Ride Score
4. Average Daily Traffic (ADT) per lane
5. Functional class
6. Average County rainfall (in inches per year)

The Needs Estimate can also use "time since last surface (in years)," if date of last surface (seal coat, overlay, or original surface) has been entered for a PMIS data collection section (as described in Chapter 9).

PMIS uses a series of "decision tree" (if-then) statements to estimate the treatment, if any, for each section. For example, one decision tree statement for asphalt pavements is:

ACP005 RECONST

TYPE OF TREATMENT: Heavy Rehabilitation or Reconstruction (HRhb).

CAUSE: ADT per lane greater than 5,000 **and**
Ride Score less than 2.5.

This is an "HRhb" treatment on an asphalt pavement, triggered by ADT per lane (greater than 5,000) and Ride Score (less than 2.5). The "ACP005" is a "Reason Code" that shows up on the Needs Estimate report to indicate the cause of the treatment.

Optimization "Effectiveness" and "Benefit"

The PMIS Optimization program takes limited funding and tries to treat those sections that give the greatest "effectiveness" (benefit divided by annualized cost). It calculates the effectiveness of each section with its Needs Estimate treatment (if any), and then sorts the sections with the largest "effectiveness" first. PMIS then "spends" the available funding and stops whenever it runs out of money.

PMIS defines the "benefit" of a treatment in terms of:

- How much it improves the section's current distress and ride quality
- How long those improvements last ("effective life").

This approach somewhat balances high-cost Heavy Rehab treatments (which last a long time) against low-cost Preventive Maintenance treatments (which don't last as long). In practice, though, Preventive Maintenance treatments tend to be favored in the PMIS Optimization program, especially when funding is low compared to needs.

Management Sections

PMIS summarizes its data into Data Collection Sections (which are usually 0.5-mile in length), but a District's candidate projects never exactly match these sections. This mismatch is a serious problem when the District tries to use PMIS Optimization and Impact Analysis to get the most benefit out of restricted funds.

PMIS thus allows each District to define "Management Sections" to more closely match their list of candidate projects.

♦ A ***Management Section*** is a section of pavement, of similar structure, that will be treated in a uniform manner.

PMIS initially defines Management Sections by Control-Section. But the District PMIS Coordinator, working with other District employees, is free to redefine these Management Sections.

There are some basic rules for defining Management Sections, but for the most part, all that is needed is the highway, and the beginning and ending Reference Marker limits.

PMIS combines all of the 0.5-mile Data Collection Sections and computes new ratings and scores for each Management Section. These combined ratings and scores then go into whatever PMIS analysis program (Needs Estimate, Optimization, or Impact Analysis) requests them.

Maintenance Levels of Service

PMIS also describes the level of service provided by Texas pavements. TxDOT defined these levels of service in 1992 to monitor the relative effectiveness of maintenance. There are four possible levels of service:

- Desirable (best)
- Acceptable
- Tolerable
- Intolerable (worst).

Levels of service for pavements are defined for:

- Rutting
- Failures
- Alligator Cracking
- Ride Quality.

There are many other levels of service defined for roadside maintenance activities.

It should be noted that levels of service are defined based on traffic. This means that the same PMIS rating or score can give different levels of service if the traffic changes. For example, a Ride Score of 3.0 is considered to be Desirable for low-traffic roads, Acceptable for medium-traffic roads, and Tolerable for high-traffic roads. Thus, levels of service should only be thought of as descriptions, not as actual PMIS ratings or scores.

There is a fifth level of service — "Combined" — that describes the overall level of service that a pavement section provides. This is defined as the worst of the Rutting, Alligator Cracking, and Ride Quality levels of service. In the example above, the pavement section's Combined level of service would be Tolerable because of the ride quality.

For example, consider a high-traffic pavement section which provides a Desirable level of service for Alligator Cracking, an Acceptable level of service for Rutting, and a Tolerable level of service for Ride Quality. The Combined level of service for such a section would be Tolerable, because of its ride quality.

Table 11 shows the maintenance levels of service definitions, by traffic category, for Rutting, Alligator Cracking, and Ride Quality.

Table 11 - Level of Service Definitions for Pavement Maintenance.

PMIS Distress Type	Traffic Category (ADT)	LEVEL OF SERVICE			
		"Desirable"	"Acceptable"	"Tolerable"	"Intolerable"
Rutting	Low (0-500)	0% shallow & 0% deep	1-50% shallow & 0% deep	51-100% shallow & 0% deep **OR** 0-50% shallow & 1-25% deep	51-100% shallow & 1-25% deep **OR** 26-100% deep
	Medium (501-10,000)	0% shallow & 0% deep	1-50% shallow & 0% deep	51-100% shallow & 0% deep **OR** 0-50% shallow & 1-25% deep	51-100% shallow & 1-25% deep **OR** 26-100% deep
	High (over 10,000)	0% shallow & 0% deep	1-25% shallow & 0% deep	26-50% shallow & 0% deep	51-100% shallow & 0% deep **OR** >1-100% deep
Alligator Cracking	All Traffic	0%	1-10%	11-50%	51-100%
Ride Quality	Low (0-500)	2.6-5.0	2.1-2.5	1.6-2.0	0.1-1.5
	Medium (501-10,000)	3.1-5.0	2.6-3.0	2.1-2.5	0.1-2.0
	High (over 10,000)	3.6-5.0	3.1-3.5	2.6-3.0	0.1-2.5

Reference: *TxDOT Administrative Circular 5-92* (February 13, 1992)

Note: Levels of service are defined for asphalt pavements only.
Failures level of service was defined after approval of Administrative Circular 5-92.
Failures are defined as "Desirable" or "Intolerable").

Chapter 9

Pavement Work History and Cross-Section Information

Previous chapters have described PMIS data, Scores, reports, analysis procedures, and technical details. Although these items are valuable for describing current and future pavement conditions and needs, they do not fill in the complete pavement management picture. One of the most valuable features of a pavement management system is its ability to help evaluate and improve pavement practices. To do this, the system must have information about when pavements were built and how they were built. This information can be summarized as "work history" and "cross-section."

PMIS can store and report pavement work history and cross-section information such as:

- **Date Information:** Month and year of original surface, last overlay, or last seal coat.
- **Material Type Information:** Type (and sometimes thickness) of the original surface, last overlay, or last seal coat.

This information includes recycled and non-recycled pavements, along with bonded and unbonded concrete overlays. It includes many of the most commonly-used original surface and overlay types, as shown in Table 12 below:

Table 12 – PMIS Original Surface and Overlay Types.

Original Surface and Overlay Types	
CRCP	Fog Seal
JCP, Reinforced	Slurry Seal
JCP, Plain	Rubberized Chip Seal
Hot-Mix (thick)	Microsurfacing
Hot-Mix (medium)	Plant-Mix Seal
Hot-Mix (thin)	Limestone Rock Asphalt
Hot-Mix (unknown thickness)	Whitetopping (thin)
Composite (asphalt over CRCP)	Whitetopping (ultra-thin)
Composite (asphalt over JCP)	Whitetopping (other)
Surface Treatment (1-course)	Aggregate Surface
Surface Treatment (2-course)	Brick or Block Surface
Surface Treatment (other)	

It also includes many different hot-mix and seal coat types, as shown in Table 13 below:

Table 13 – PMIS Hot-Mix and Seal Coat Types.

Hot-Mix Types	Seal Coat Types
Other	Fog Seal
Type C hot-mix	One-Course Surface Treatment (1-CST)
Type D hot-mix	Two-Course Surface Treatment (2-CST)
Superpave (1/2-inch topsize)	Slurry Seal
Superpave (3/4-inch topsize)	Rubberized Chip Seal
Superpave (other topsize)	Microsurfacing
CMHB (coarse matrix, high binder)	Plant Mix Seal
SMA (stone mastic asphalt)	Surface Treatment
(PFC) Porous Friction Course	

How Is Work History and Cross-Section Information Used in PMIS?

At this time, work history and cross-section information are optional and are used mainly for reporting (they are analyzed in PMIS Needs Estimate, but only for selection of time-based preventive maintenance resurfacing). However, the date of last surface (original surface, overlay, or seal coat) is shown on several PMIS reports, including the Multi-Year Ratings and Scores report, Construction and Work History report, and the Needs Estimate report. This date of last surface information, combined with surface distress, ride quality, and other PMIS data, can be used to evaluate the performance of any pavement section.

Work history information is retained in PMIS from year to year until it is changed. This is very important because it means that PMIS keeps track of a particular treatment or type of material on a pavement section until it is replaced. This is how PMIS can help monitor the effectiveness of particular sections, materials, or treatment types.

For example, a May 2003 seal coat entered on a PMIS section in FY 2003, will show up as "05/2003" in FY 2004, FY 2005, FY 2006, and so on. The Construction and Work History report can then be used to search for seal coat sections older than a user-specified value, to help with developing an age-based preventive maintenance work program. The Multi-Year Ratings and Scores report can also be used to show increasing amounts of distress and roughness on the "05/2003" seal coat as it ages.

The Needs Estimate program also has a feature to trigger Preventive Maintenance treatments on sections which have not been surfaced within a user-specified number of years but are still otherwise in good condition (that is, do not need a heavier treatment). This feature works only for those PMIS data collection sections that have date of last surface (seal coat, overlay, or original surface) entered.

Using Work History Information to Evaluate Pavement Performance

Reliable work history information is the key to evaluating the performance of specific pavement sections, materials, or treatment types. It is also the answer to questions about how long seal coats last or how long thin overlays last, or whether thick overlays last any longer than thin overlays. As suggested earlier in Tables 12 and 13, there are many different types of pavement materials now being used — work history information is the key to evaluating the performance of all of these new (or old) materials.

From a "pavement management" perspective, work history and cross-section information is also the key to evaluating and improving PMIS analysis models, especially those that predict future pavement condition. For example (as shown in Figure 10), if the PMIS models suggest that new overlays will have adequate Shallow Rutting for five years but actual pavements are showing increases in Shallow Rutting 2-3 years earlier, then the PMIS models need to be changed to match the observed field conditions.

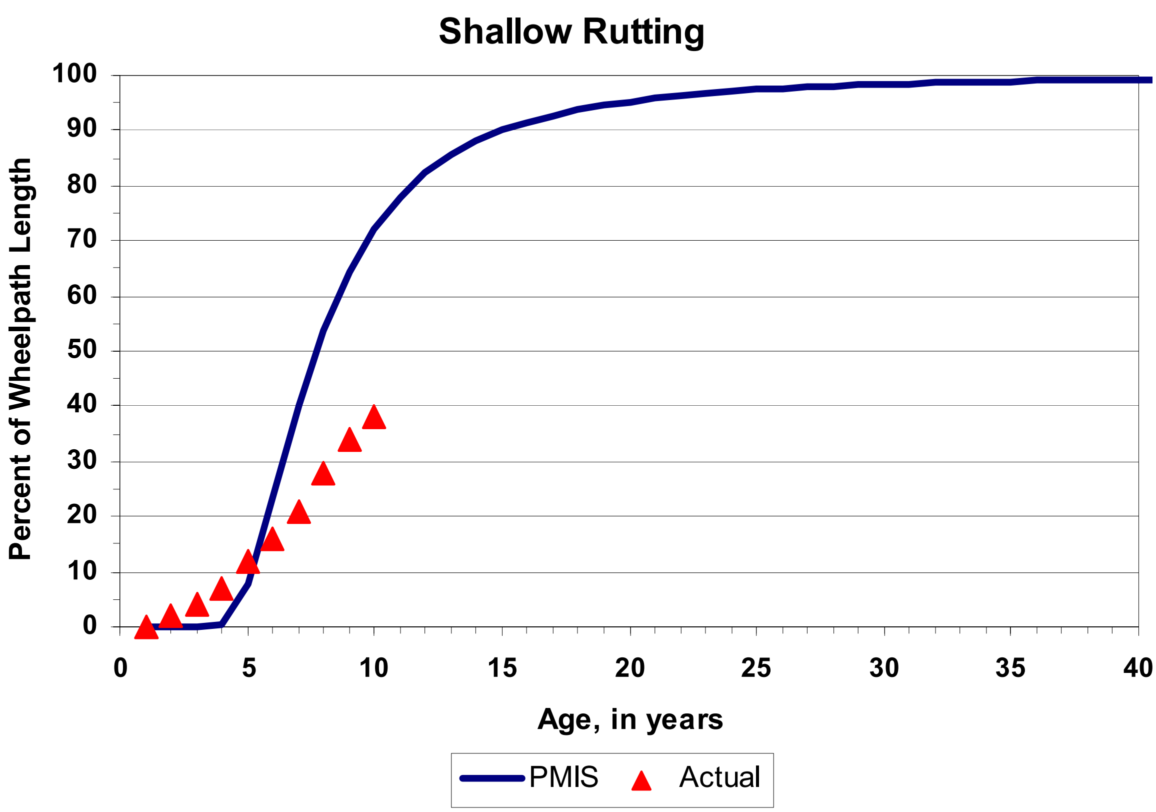

Figure 10 - Comparing PMIS and Actual Rutting.

Getting Work History and Cross-Section Information Into PMIS

The simplest approach for getting work history and cross-section information into PMIS is to start entering the information for construction projects as they are completed. This will quickly cover the major highways, which are usually the ones that are most important to monitor anyway. It will also reduce data entry and validation to a more manageable month-by-month effort which can be easily verified.

Test results taken from ongoing research, forensic, and rehabilitation design studies can be used in PMIS, as they become available. Ground-penetrating radar equipment has also shown promise for measuring surface layer thickness at highway speeds, either for site-specific projects or for long stretches of "network-level" testing.

In many cases, especially for lower-volume pavements, reliable work history and cross-section information can be obtained from asking experienced personnel. This approach can cover large amounts of mileage in a matter of days and thus free up limited personnel for more-detailed study of specific pavement sections, if necessary. Once obtained, this information can be updated whenever the sections are resurfaced.

For PMIS purposes, a complete history of the pavement is not necessary. If a pavement section has been reconstructed, information before the reconstruction is not needed because the pavement structure in question no longer exists. The "date of original surface" in PMIS is the date of the initial construction or subsequent reconstruction. Thus for some pavements — those that have been recently widened, realigned, or rebuilt — the "complete work history" in PMIS might only cover the last few years.

Chapter 10
The Future of Pavement Management…

Work on pavement management is a continuous process. TxDOT's pavement management system and PMIS must be calibrated against field conditions, to give the most reliable results possible. Additional capabilities must also be added to support users at all levels, to deliver the vision of longer-lasting pavements within existing funding. This work will occur primarily in the following areas:

- Incorporation of Pavement Work History and Cross-section Data Into PMIS
- Creation of Microcomputer Programs to Access and Analyze PMIS Data
- "Cradle to Grave" Pavement Management
- Use of Dynamic Segmentation and Geographic Information System (GIS) Concepts, Including PMIS MapZapper
- Evaluating Use of Local Materials in Pavement Construction
- Development of Performance-Based or Warranty Specifications
- Development and Evaluation of "As-designed/As-built" Tests.

Incorporation of Pavement Work History and Cross-Section Data Into PMIS

As described in Chapter 9, incorporation of work history and cross-section data into PMIS is essential for TxDOT to improve pavement design, construction, and maintenance practices — to keep doing what works and to stop doing what doesn't work. There is also a pressing need to evaluate the effectiveness of preventive maintenance surface treatments and thin overlays in improving long-term pavement condition, especially as compared to more expensive structural rehabilitation treatments. With the advent of the North American Free Trade Agreement (NAFTA), transportation users are also becoming very concerned about the structural load-carrying capacity of our pavement network.

TxDOT will not be able to reliably answer any of these questions unless it has a comprehensive pavement work history and cross-section database — and the best place for that data is with the extensive pavement evaluation data already available in PMIS.

Creation of Microcomputer Programs to Access and Analyze PMIS Data

Advances in microcomputer technology have made it possible for District users to load the full contents of PMIS directly onto their local workstation, with reports and analysis procedures available from within a point-and-click graphical user interface. Word processing, spreadsheet, graphics, and database programs have also evolved to the point where users can develop professional-looking pavement condition reports for specific areas of the State. It is also possible to link PMIS data with maps and digital video data to create a fully graphical pavement management system. The challenge will be to expand the power of PMIS while retaining the ease-of-use, flexibility, value, and usability necessary to support pavement managers.

"Cradle to Grave" Pavement Management

The benefits of pavement management can ultimately occur only in the field — out on the road. Thus, pavement management data and tools (such as PMIS) must be directly related to pavement design and construction practices so TxDOT can monitor and manage pavements literally "from cradle to grave."

Some of this is already happening. Falling Weight Deflectometer data has been incorporated into the flexible pavement design process. Pavement evaluation equipment has been refined to provide near-continuous measurements of pavement characteristics (for construction specifications and for post-construction monitoring). And soon it will be possible to measure all PMIS pavement distresses, instead of having to send raters out onto the road.

The final goal is to define a series of characteristics (for example, layer modulus) that directly influence pavement condition and performance, and to have those characteristics stored in PMIS. That way, PMIS will be able to support pavement design, construction, maintenance, rehabilitation, and (eventually) reconstruction.

Use of Dynamic Segmentation and Geographic Information System (GIS) Concepts, Including PMIS MapZapper

The availability of GIS software at TxDOT makes it possible to put PMIS information on maps (for example, a district map of Distress Scores, or a county map of pavement needs) using the PMIS MapZapper program developed by the Construction Division, Materials and Pavement Section. But this is only the beginning of GIS applications in pavement management. For example, GIS software can "intersect" PMIS and soil data to directly correlate the effects of subgrade type on pavement deflection data or rutting. These correlations can then be used to improve PMIS Distress Score equations, performance prediction models, or Needs Estimate treatments.

To perform such analyses, the GIS software must be able to "dynamically segment" the PMIS data to intersect with the other types of spatial data. This means that the PMIS data must be stored in raw form, with exact location, as opposed to being summarized by "static" Data Collection Sections.

Evaluating Use of Local Materials in Pavement Construction

The use of local materials in pavement construction has become controversial in recent years. Use of local materials reduces overall project cost (which frees up limited funds for use on other projects), but in some cases it also reduces pavement performance.

PMIS can provide information which can help determine when local materials are providing adequate performance. It can also help in evaluating the effectiveness of additives or other treatments used to improve the performance of local materials. It can provide this information on a reliable and impartial basis so that the interests of TxDOT, material suppliers, highway contractors, and the public are considered without bias or prejudice.

Development of Performance-Based or Warranty Specifications

There has been continued interest in developing specifications and tests based on how the pavement performs ("performance-based"), instead of how it was built ("method-based"). TxDOT's new ride quality ("smoothness") specification is an example of this type of performance-based specification.

Closely related to this is the issue of "warranty" specifications. For example, a specification for Interstate highways might require that the pavement retain "Very Smooth" ride quality for the first five years of its life, and then retain "Smooth" ride quality for the rest of its design life.

The central issue in both of these specifications is the performance measure itself. For example, what is the actual measure of ride quality? Is it something like SI and IRI used in PMIS, or is it something more subjective — more "seat of the pants?" And what is the definition of "Very Smooth" ride quality? What is "Smooth" ride quality? More importantly, is ride quality even a meaningful measure of how well the pavement is performing?

PMIS provides many measures which might be used to develop a performance-based or warranty specification. It also can be used to monitor newly-built pavements for agreement with the expected performance.

Development and Evaluation of "As-designed/As-built" Tests

Advances in technology are allowing development of new tests which measure the actual physical properties used in pavement design ("as-designed/as-built"). For example, there are now reliable tests to measure a pavement layer's resilient modulus, for comparison with the original design.

This effort goes hand-in-hand with performance-based and warranty specifications. Expected performance is based on the original design, but actual performance depends on how the pavement was built. If there is disagreement between the "as-designed" and the "as-built" properties, then there will certainly be disagreement between the expected and the actual performance. Thus, there will be no reliable way to evaluate the quality of the performance-based specification or the warranty.

Again, PMIS provides information which can be used to monitor and evaluate the ability of "as-designed/as-built" tests to improve pavement performance.

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Chapter 11

For More Information...

We hope that this book has explained how you can use pavement management system concepts and PMIS to solve pavement problems. The Materials and Pavements Section of the Construction Division is ready to help you manage your pavements as effectively as possible within existing funds. This help includes:

- Analyzing and evaluating pavement designs
- Scheduling project-level pavement testing
- Interpreting pavement test results
- Identifying the cause of premature pavement failures (“forensic studies”)
- Accelerated pavement testing studies using the TxMLS
- Analysis for load-zoning of roads and bridges
- Interpreting PMIS data and report results
- Running non-standard reports using PMIS data
- Producing maps of PMIS data
- Answering other questions about pavement management or PMIS

If you should have questions about any aspect of pavement management, please contact us:

- by phone, at (512) 465-3676
- by fax, at (512) 465-3059 or
- by E-mail.

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Appendix One

Frequently Asked Questions

How much mileage must be rated in PMIS each year?

Almost all of it (more than 88,000 roadbed miles). The sample for distress and ride data increased to 100 percent of the State-maintained mileage in FY 2001. Deflection data is optional (but strongly recommended) for PMIS. Skid data increased to an approximately 25 percent statewide sample in FY 1999.

Table 14 summarizes the PMIS sample sizes used for pavement data collection, as of FY 2003.

Table 14 - PMIS Sample Sizes for Pavement Data Collection, as of FY 2003.

PMIS Highway System	Sample Size for…			
	Distress Data	Ride Data	Deflection Data	Skid Data
IH	100%	100%	optional	50%
US	100%	100%	optional	25%
SH	100%	100%	optional	25%
FM	100%	100%	optional	25%

Note: PMIS Highway System is a "superset" of highways with similar designations. For example, PMIS Highway System "FM" contains Farm-to-Market (FM), Ranch Road (RR), Ranch-to-Market (RM), FM Spur, RM Spur, and RR Spur designations.

What is a PMIS "Data Collection Section?"

A PMIS Data Collection Section is an arbitrarily-defined section of highway, usually 0.5-mile in length. PMIS stores inventory data, distress ratings, and Scores, by Data Collection Section. Data Collection Sections typically range from 0.1-mile to 1.0-mile in length.

PMIS Data Collection Sections do not match existing Control-Section or Control-Section-Job limits, and they can change from year to year.

Why do we have to collect pavement evaluation data for PMIS in the Fall, right after the summer seal coat program has covered up all the distress?

Fall was chosen for pavement evaluation for three reasons:

1) To let potential pavement raters remain available for construction and maintenance projects throughout the summer;
2) To avoid the day-to-day changes in pavement condition that occur in Winter and Spring;
3) To have current pavement condition data available for District use in time for the Spring requests for candidate projects.

If you want to document the deterioration of a specific pavement section in Winter or Spring, you can have certified pavement raters re-rate the section and store it as a Supplemental rating in PMIS. PMIS will accept two Supplemental ratings on a section each year, and those ratings will show up on reports, for comparison with the Annual rating done in the Fall.

What is the difference between an Annual and a Supplemental rating?

An Annual rating is the first rating on a PMIS Data Collection Section in the Fiscal Year. It should be done in the Fall, for ease of comparison to other PMIS sections. Annual ratings are the ones used in statewide descriptions of pavement condition such as the "Condition of Texas Pavements" PMIS annual report or legislative performance measures.

A Supplemental rating is the second or third rating on a PMIS Data Collection Section in the Fiscal Year. It can be done in the Fall, but it is usually done in Winter or Spring.

Designation of a rating as Annual or Supplemental has nothing to do with the section's being required for rating (sometimes known as "flagged" or "mandatory" sections).

Why do we have to collect PMIS data on frontage roads?

PMIS data on frontage roads is meant to give the Districts reliable information about the condition of these roads, whether they are eligible for Federal funding or not. Some frontage roads carry very little traffic (even on the Interstate), while others (especially in urban areas) carry very high amounts of traffic.

However, data collection on frontage roads can be very difficult, if not impossible, in some cases. If raters or equipment operators come upon a situation where they believe that data collection on a particular frontage road is excessively hazardous (to themselves or to the traveling public), then they should not collect the data on that frontage road.

This same guideline also applies to mainlanes. **Safety (of raters, operators, and the public) is more important than PMIS data!**

We rated all roads in the District this year: why don't they all show up in the Needs Estimate?

Roads that don't show up in the Needs Estimate are usually missing traffic (ADT or 18-k ESAL) data, especially on frontage roads.

It is also possible that the PMIS distress and ride quality data have been collected but not yet stored, especially in areas where another district collects the data. Please note that for flexible (ACP) pavements, Rutting data must also be stored, along the with the distress and ride quality data.

We stored distress data on a section: why doesn't it show up on the Ratings and Scores report?

Because the section is ACP (Pavement Type 4-10) and it does not have Rutting data stored. Rutting data is not stored at the same time as other ACP distress types, but it must be stored along with the other distress types before PMIS can calculate a Distress Score. A section must have at least one PMIS Score (Distress, Ride, Condition, SSI, or Skid) before it will show up on the Ratings and Scores report.

CRCP and JCP sections will show up because all of the distress types needed to calculate Distress Score are stored at the same time.

We just built (or divided) a new highway: why doesn't it show up in PMIS?

Highways must be in the Texas Reference Marker (TRM) system before they will show up in PMIS. If you make any changes to highways, be sure to have them validated and stored in TRM before August — then they will show up in PMIS for the new Fiscal Year.

Is the Average Daily Traffic (ADT) data in PMIS one-way or two-way?

ADT values are for the entire roadbed, whether it has one-way or two-way traffic. For undivided highways (one mainlane roadbed), ADT in PMIS is two-way, and the value is for both directions of travel. For divided highways (two mainlane roadbeds), ADT in PMIS is one-way, and the value is for one direction of travel.

Are the 18-k ESAL values in PMIS one-way or two-way?

18-k ESAL values are for the entire roadbed, whether it has one-way or two-way traffic. For undivided highways (one mainlane roadbed), 18-k ESAL in PMIS is two-way, and the value is for both directions of travel. For divided highways (two mainlane roadbeds), 18-k ESAL in PMIS is one-way, and the value is for one direction of travel.

Please note that PMIS 18-k ESALs are projections of the number of repetitions expected during the next 20 years – they are not single-year or cumulative values. The PMIS 18-k ESAL values are for general comparisons only and are not suitable by themselves for project-level pavement design.

This road has Deep Rutting: why is the Distress Score 100?

Deep Rutting values of 1-2 percent (1-3 percent for Pavement Types 7 and 8) have a utility factor greater than 0.9995. If there are no other distresses present, the utility factor will round up to a Distress Score of 100.

What makes this problem even more obvious is that the Needs Estimate will give the section a PM (Preventive Maintenance) treatment because of the Deep Rutting.

To list such sections, run a Critical Values Ratings and Scores report, using the following options: Distress Score from 100 to 100; Shallow Rutting from 1 to 100; Deep Rutting from 1 to 100. You can run this report on the mainframe or on the PMIS MapZapper.

Two CRCP sections have the exact same ratings: why are the Distress Scores different?

Because the sections are different length.

CRCP distress types are not rated by percentages. Thus, they must be converted, or else the utility factors will not make sense (a 0.1-mile section with 5 Punchouts will have the same Distress Score as a 0.5-mile section with 5 Punchouts). These conversions are based on section length (number per mile).

If two CRCP sections have the exact same ratings, the shorter section will have the lower Distress Score.

Two JCP sections have the exact same ratings: why are the Distress Scores different?

Because the sections are different length, or because they have different Apparent Joint Spacing values.

JCP distress types are not rated by percentages. Thus, they must be converted, or else the utility factors will not make sense (a 0.1-mile section with 5 Failed Slabs will have the same Distress Score as a 0.5-mile section with 5 Failed Slabs). These conversions are based on section length (number per mile) and Apparent Joint Spacing (percentage).

If two JCP sections have the exact same ratings, the shorter section will have the lower Distress Score.

An urban road and a rural road have the same Ride Score: why is the Condition Score lower on the urban road?

The effect of ride quality on the Condition Score depends on ADT and Speed Limit (high-traffic and high-speed sections need smoother ride). For Ride Scores of 3.5 and above, there will be no difference between urban and rural Condition Scores. When Ride Score drops below 3.5, there will be some differences between urban and rural sections, if the ADT and Speed Limit are high enough.

Why does the Needs Estimate show PM for a section with a Distress Score of 100?

Small values of certain distress types will produce a utility factor greater than 0.9995, which will give a Distress Score of 100 (if no other distress types are present). The Needs Estimate will still treat these distress types because the decision trees trigger some treatments for non-zero distress ratings (for example, PM if Deep Rutting is greater than zero).

Why does the Needs Estimate show PM for one section but LRhb for another section with a higher Distress Score?

The Needs Estimate does not base treatments on Distress Score or Condition Score. It uses the actual distress ratings, Ride Scores, ADT per lane, Functional Class, and average county rainfall. Thus, there will be some cases where heavier treatments will be shown on sections with better scores.

How do I get a copy of the PMIS MapZapper program?

Use your workstation's web browser to sign on to this website: **http://cst-649165-d/**. On the left side of the web page, under Section Branches, click PMIS. On the left side of the web page, then click PC Programs. On the left side of the web page, then click Map Zapper (whichever version number is shown). The browser will try to download a single executable file to your hard drive. When the file downloads, close the web browser, navigate to the folder where the file was stored, and unzip it.

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