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PAVEMENT MANAGEMENT:

WHERE DO WE GO FROM HERE?

Prepared under the guidance of:

The Pavement Management Steering Committee

Texas State Department of Highways
and Public Transportation

Chairman: Mr. B. Neeley

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PREFACE

"The Amarillo District wants a Pavement Management System for the following three reasons; firstly, to illustrate network conditions and identify potential projects; secondly, to develop strategies for maintaining the entire system within a fixed budget and thirdly, to assist in creating a multi-year plan of optimum designs to be available when program calls are made. If a system were available to allow the Department to do its job 1% more effectively then each District should be willing to spend on average $400,000 per year to build and maintain such a system."

Bill Lancaster, District Engineer
January 21, 1988

"The new Federal guidelines on pavement design rehabilitation and management are nothing more than an extension of the approach that we have been advocating in Texas for the past 20 years. If we adopt and implement the design and rehabilitation requirements I estimate that this will add 0.3% to the cost of each design. However, the saving will be of the order of 15-30% per project in terms of improved pavement life."

Jim Brown, Pavement Design Engineer
March 14th, 1988

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Executive Summary

This executive summary report has been extracted from a recently completed study of the Pavement Management needs of the Texas SDHPT. In that study, interviews were conducted with the SDHPT Administration, Division Heads, senior engineers and the staff of six Districts, and a questionnaire was completed by all 24 Districts. The major findings of that study are:

1) All levels within the Department are supportive of the continuing development of PMS and that now is an excellent time to allocate resources to continue this effort.
2) The PMS must become a District-oriented system meeting their programming, management and design needs.
3) The PMS is viewed as a management tool at all levels within the organization. At the administrative level, it will assist in identifying the total statewide funds required for each work category, permit the setting of goals and monitoring performance in achieving them and finally, provide a consistent, defensible basis for making funding requests to the legislature. At the District level, its use will be in highlighting deficient highway segments, estimating overall District needs and providing optimum design procedures.
4) It is important to continue to use the allocation formulae to allocate funds to the Districts. There is not sufficient experience with PMS to be able to use it for funds allocation, and it is important not to reward poor management with allocations based upon needs. Systematic needs estimates made at the administrative level can be used to review and correct the allocation formulas to achieve optimum funding levels for each work category.
5) The Department has the technical capabilities "in-house" to implement a system which meets both Departmental and Federal requirements.

In the next section of this report, detailed recommendations are

presented. These are followed by a PMS Implementation Time Chart and estimates of additional resources.

Study Recommendations

The major recommendations of the study include the following;

(1) The formation of a PMS Support Group, shown in Figure 1, with all of the expertise needed to assist the Districts with implementation. This group can be assembled by combining several existing groups within the Austin Divisions.

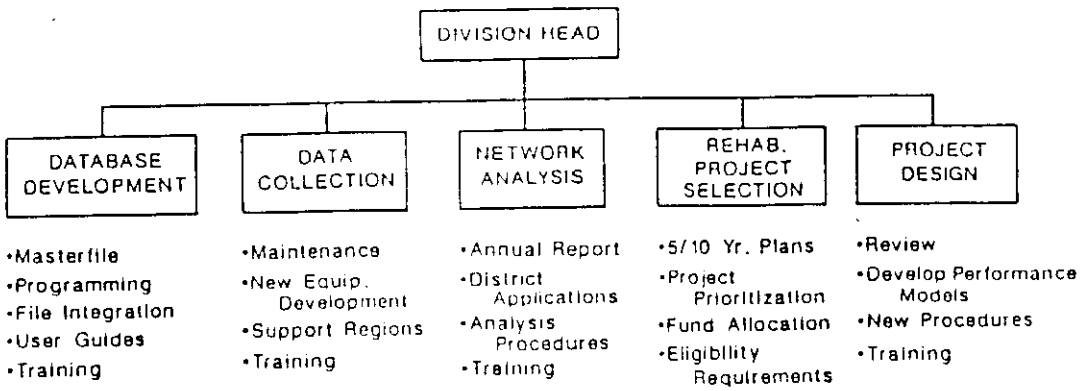


Figure 1 Proposed PMS Support Group

Organizationally, several options are available, including:

a) Create a new Division.

b) Create a pavement Division by incorporating all the PMS functions into an existing Division.

c) Divide the responsibility between network and project level PMS. Leave the project level responsibility with the Design Division (D-8). Combine the network level activities into a single group.

d) Create the staff position of Departmental Pavement Manager reporting to the Engineer-Director. The operating Division would remain as they are and their activities would be coordinated by the Pavement Manager.

(2) Expansion and clarification of the duties of the District Pavement Manager. He should be responsible for both network and project level activities within a District. A single group within each District such

as the one shown in Figure 2 should coordinate all PMS activities.

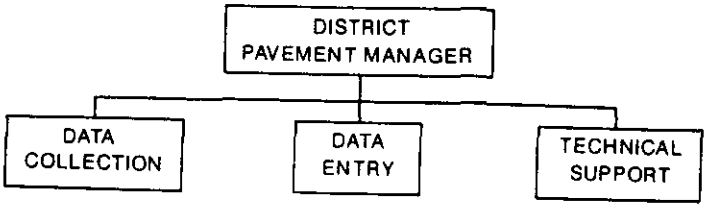


Figure 2 Proposed District PMS Group

(3) The appointment of an "PMS Champion", to be directly responsible for the development effort.

(4) The appointment of the SDHPT Executive Committee (Mr. Blaschke and the four Deputy Directors) to oversee the development effort.

(5) The development of output reports specified as high priorities by District personnel. These include a graphics output to locate substandard sections, a maintenance and rehabilitation needs estimate, project prioritization routines and network summary sheets which contain all the pavement information needed to support project selection and evaluation.

(6) A redesign of the existing PES Master File. Major new features will include the ability to store information by road bed, the addition of new data elements such as pavement layer information and the development of links to other systems, particularly Accident, Bridges and Maintenance Costs.

(7) Interfacing the existing PES (representing Districts and Division PMS needs) with HPMS (Planning/Legislative needs) to eliminate duplication of effort. The proposed PMS Master File must support both PES and HPMS analytical packages.

(8) The one time collection of a limited amount of pavement layer information not available within the existing computerized systems. It is the PMS Support Group's responsibility to identify the data items required and to develop simple procedures to store and update the PMS Master file with this information.

(9) The development of 4 new Life Cycle Cost Analysis procedures for new

pavement design and rehabilitation design of both rigid and flexible pavements.

(10) The development and implementation of New Pavement Design Reports and Rehabilitation Design Reports as requested by D-8 (Pavement Design).

(11) The appointment of a multi-disciplinary team to investigate major pavement failures, document the causes of failure, and propose an appropriate rehabilitation strategy. Members of this team will be drawn as required from the PMS Support Group, D-9 Materials and Test and the Universities.

(12) The development of pavement deterioration models for both flexible and rigid pavements for use at the network and project level. These models are essential for projecting future needs and optimizing designs. Initially they can be built on data currently available within the existing research data bases, from expert opinions and other existing sources. Procedures need to be identified by which improved models can be developed as part of the PMS activities.

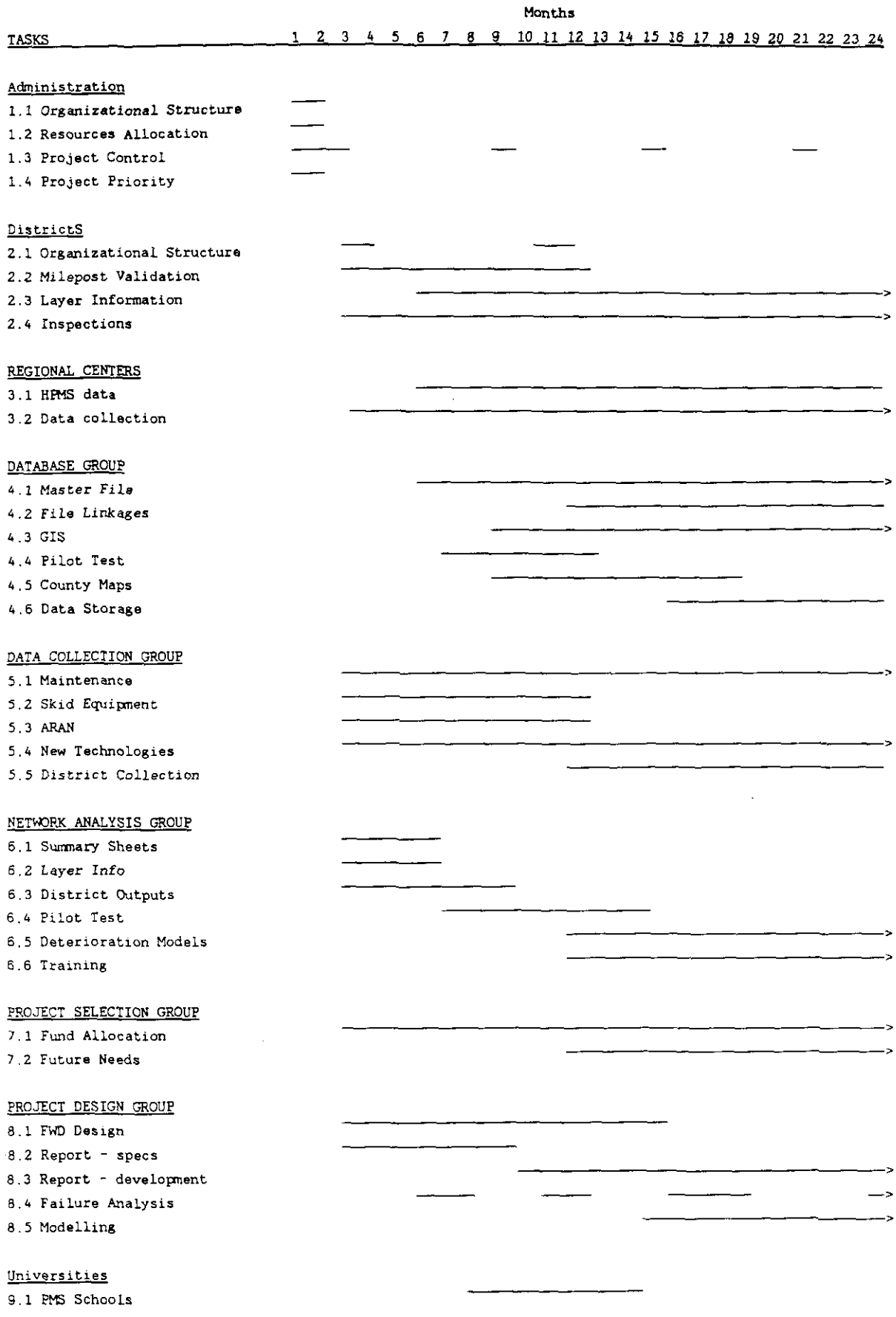
(13) The immediate initiation of a pilot study not to exceed 9 months. A recommended study area would be the Interstate 35 route in District 14.

(14) Training of key District staff in Pavement Management principles.

PMS Implementation Time Chart

The implementation period for this effort is four years, at the end of which the Department will have in place a PMS that meets both District and Federal requirements. Furthermore, the development should be performed "in-house" with the two Universities providing support. The time chart shown in Figure 3 covers actions to be undertaken in the first two years of the implementation period. The major tasks of each group in the development effort and their time sequence are identified. Details of each of these tasks are presented in the detailed study report, which follows this executive summary.

FIGURE 3 PMS IMPLEMENTATION TIME CHART



Resource Requirements

This section identifies the resources (manpower and equipment) necessary to implement the proposed Pavement Management System.

Staffing Levels

1) The staffing level of the Austin-based PMS support group to handle current and anticipated PMS efforts is shown below:

	Recommended Level	Current Level
1. Section Head	1	0
2. Database Development	6	2
3. Data Collection	18	14
4. Network Analysis	8	7
5. Project Selection	3	2
6. Project Design	8	6
	44	31

The majority of the required staff are existing employees and can be assigned to this development effort. The only new group is the database development group which can be made up of employees from D-10 and D-19. The data base to be developed will support the Pavement Management effort only, not the proposed Department-wide information system. The start-up staffing requirement in this area is estimated at 6; this should drop to 3 once the system is implemented. The Project Selection group is responsible for developing the Project Development Plan and maintaining the current fund allocation system. It will not be significantly impacted during the first two years of the effort.

2) The ultimate recommended staffing level for the average District PMS group is shown below:

1. Pavement Manager	1
2. Data Collection	2
3. Data Entry	1
4. Technical Support	2
	6

This group will be larger in the urban Districts and smaller in rural Districts, but an average staffing level of 6 is thought to be appropriate. It is not required immediately, but should be in place by year 3 of the effort when the new pavement design procedures become available.

3) The staffing level of the Regional Centers is shown below:

	Recommended Level	Current Level
Data Collection	5	3

The regional centers are responsible for the operation of sophisticated data collection units. To provide quality data, it is necessary to staff the centers with full-time operators who can be given the necessary training.

Equipment Requirements

The regional centers will be adequate for years 1 and 2 of this implementation effort. However, in years 3 and 4, efforts should be made to move the equipment to the District level. The anticipated equipment requirements are:

Ride Equipment	1 per District
Deflection Equipment	1 every two Districts
Skid Equipment	1 every two Districts

Specialized equipment, such as profilometers and videologgers, will still be managed by the regional centers. The following new equipment will be required in year 3 of the development effort:

Ride Meters - 6	(estimated cost @ $20,000 per unit)
Skid Trailers - 6	(estimated cost @ $120,000 per unit)
Videologging - 4	(estimated cost @ $290,000 per unit)

Research and Development Cost

The two Universities can greatly assist the development effort through the existing HPR research program. The PMS Support Group should identify and specify needs which can be addressed. However, additional outside development costs will be required in the following two areas:

$600,000 - New Pavement Design Procedure Development and Implementation
$500,000 - Geographic Information System and Database Development

Totals

The incremental system development costs are estimated as follows:

One-Time Equipment and Development Costs

Equipment Purchase	$2,400,000
Development Costs	$1,300,000
Total	**$3,700,000**

These costs include a 20% contingency estimate. They can be spread over the four year development effort, with the majority of the equipment being required in years 3 and 4.

PAVEMENT MANAGEMENT: WHERE DO WE GO FROM HERE

STUDY REPORT

WHERE ARE WE NOW

In this section of the report some of the basic Pavement Management definitions will be presented together with a brief description of the status of the PMS tools currently available within the Department. Within a PMS, two levels are frequently identified, these are the network and project levels. At the network level the concerns are the overall network condition, trends in condition, estimating overall funding requirements and selecting potential projects. The selected projects are analyzed in detail at the project level where the optimum maintenance or rehabilitation strategies are identified. Currently within the SDHPT, the Pavement Evaluation System (PES) has been used to supply network level information, and efforts are now underway to use the Federal Highway Performance Monitoring System (HPMS) for strategic planning purposes. At the project level, the Flexible and Rigid Pavement Design Systems (FPS and RPS) have been in existence for more than a decade. Linking the network and project levels is the Project Development Plan (PDP) which determines priorities for added capacity projects and provides formula-based funding needs estimates for District maintenance and rehabilitation activities. In the remainder of this section, the benefits of an effective PMS, identified by each management level within the SDHPT, are presented in summary form. This will be followed by a status report of each operational system within the Department's current PMS.

1.1 BENEFITS OF PAVEMENT MANAGEMENT

The development of an effective PMS will be a costly effort. Is it worth it? What new capabilities will this system give the Department? In this section an attempt will be made to summarize these benefits at each of the operating levels,

Benefits of PMS at the District Level

(1) Automatic location of all deficient highway segments for input to Project Development Plan.

(2) Procedures to estimate one year and multi-year maintenance and rehabilitation needs.

(3) Defensible techniques for prioritizing projects.

(4) Easy access to information for evaluating the cost effectiveness of historic decisions.

(5) Techniques for determining the cause of pavement failures so that optimum rehabilitation designs can be selected.

Benefits of PMS at the Division Level

(1) Statewide information on cost effectiveness of designs and maintenance strategies.

(2) A basis for the development of pavement performance models.

(3) The ability to answer ad-hoc queries from the general public, commission and legislature.

(4) Development of Life Cycle Costing Analysis procedures to optimize rehabilitation fund allocation.

Benefits of PMS at the Administrative Level

(1) To provide defensible statewide estimates of needs to the legislature and evaluate the consequences of variations in funding.

(2) To permit the Department to set goals and evaluate performance in meeting those goals.

(3) To provide information to determine the optimum funding level for each work category in the PDP.

(4) Network and Project level PMS techniques that satisfy federal requirements.

1.2 PAVEMENT EVALUATION SYSTEM

The original aim of PES was (a) to identify overall network rehabilitation funding requirements and (b) to monitor trends in statewide pavement condition. The system was implemented in the early 1980s, and samples of the highway network have been evaluated each year. This evaluation consists of a visual distress survey and roughness evaluation of the pavement. In addition to these, recent efforts have been aimed at performing a structural evaluation. The information generated by PES has been used largely at the Austin level and typical results from the system are shown in Figure 1.

Figure 1 shows the condition trends for one District from 1983 until 1987. This District has done a good job of improving the overall condition of its network. The percentage of pavements in the excellent category has increased from 47% to 70%, while the very poor pavements have almost been

eliminated. Reports of trends in overall state condition and estimates of rehabilitation requirements for the Farm to Market system have also been prepared.

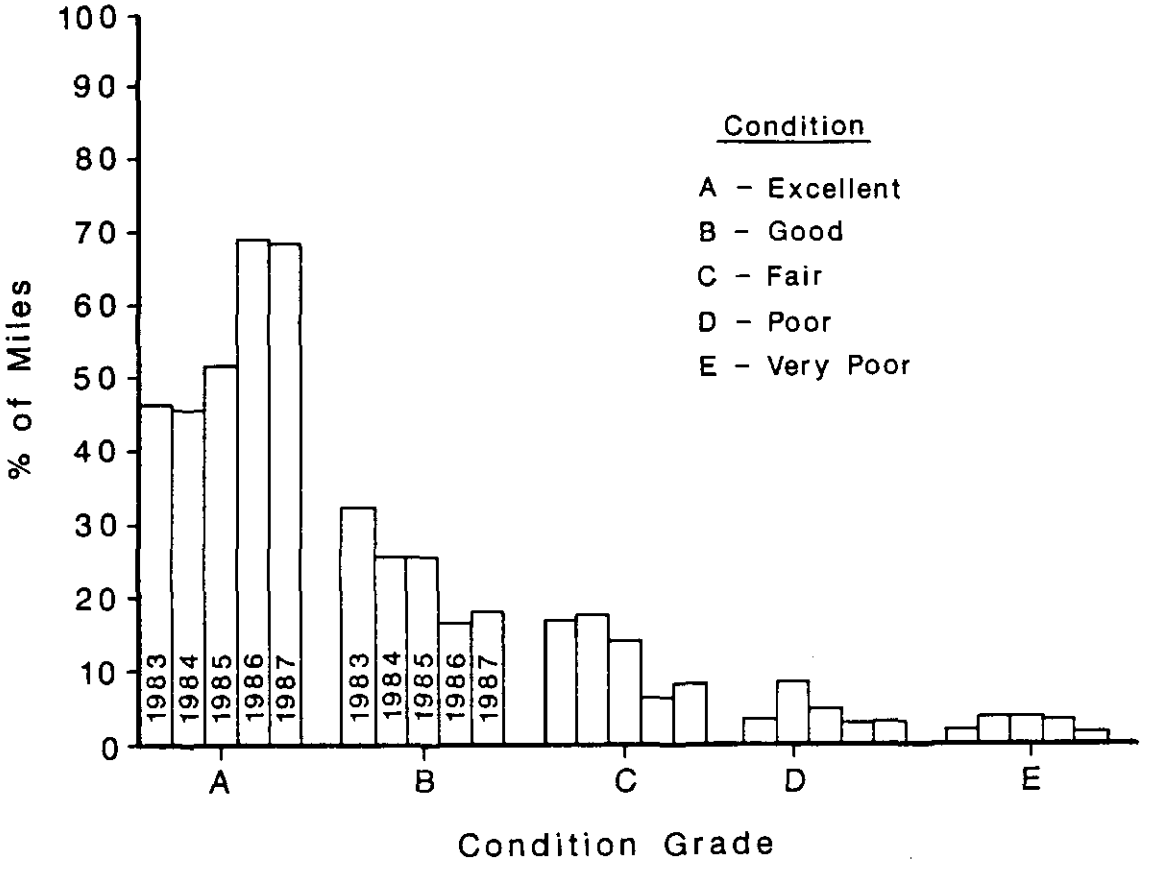


Figure 1. Pavement Condition Trends 1983-1987

A recent addition to the PES system has been the development of a microcomputer analysis system for each District. Packages supplied with the system include procedures for locating deficient highway segments, making estimates of maintenance and rehabilitation (M&R) workloads and performing project prioritization. The prioritization routine ranks projects in terms of "maintenance effectiveness" and was designed to assist Districts in defining the optimum combination of projects within a fixed budget level. The system is easy to use and has been installed for review purposes in District 4, 10, 11, 12, 14, 20 and 23.

The Districts view PES as a good tool in allowing them to select projects. However, its usefulness is limited when only a sample of pavements

are surveyed. Several Districts have been voluntarily completing 100% PES surveys and these Districts view the system as beneficial in their program development efforts.

The strengths of the PES system include;

(1) Trained raters are in-place in each District

(2) The data processing system is in place

(3) It provides Good analysis of pavement condition

(4) District analysis packages are available

The weaknesses of the PES system include;

(1) Not all highways are rated

(2) The pavement inventory data is poor.

(3) No skid or safety evaluations are performed

(4) Limited access to historical data.

1.3 THE HIGHWAY PERFORMANCE MONITORING SYSTEM

This system is to be used this year by the Planning and Policy Division to prepare the 20 year development plan. HPMS was developed by the Federal Highway Administration for reporting the condition of the nations' highways to Congress. Within the system, the highway system is subdivided into a number of unique links and limited inventory data is collected on each (known as Universe Records). From within these Universe Records a small sample (<15%) is selected for detailed inspection. A comprehensive data base is assembled for each of these sample records and each year a pavement condition evaluation and a list of capital improvements is input to HPMS. The system projects condition, capacity and traffic into the future for each section and estimates when a pavement widening, realignment or rehabilitation will be required. There are numerous analysis packages available within this system and several more are under development at FHWA, including an integrated bridge analysis package.

The strengths of the HPMS system are as follows;

(1) Considers Condition/Capacity/Geometric Deficiencies

(2) Allows for "what if" analysis

(3) FHWA developed and supported

(4) Excellent for capacity type analysis

The weaknesses of the HPMS system are as follows;

(1) Not tuned for Texas condition

(2) Poor for pavement condition analysis

(3) Uses only a sample

(4) Not linked to PES (duplicate data collection)

1.4 PROJECT DEVELOPMENT PLAN

The link between the network and project level pavement management system is the Project Development Plan (PDP). The current PDP is divided as follows;

(a) 10-year Project Development Plan

(b) 5-year Development Schedule

(c) 4-year Letting Schedule

(d) 1-year Letting Schedules

Within these plans the following construction categories are identified,

Category	Approx.Annual Funding ($ million) (1986)	Allocation Scheme
1. Interstate (New)	88	Statewide project Ranking
2. Interstate (Added Capacity)	290	Statewide Project Ranking
3. Primary (Added Capacity)	980	Statewide Project Ranking
4. Rehabilitation	300	50% Miles 50% VMT
5. Farm to Market	23	33% Pop., 33% Miles, 33% VMT
6. Urban System	55	% Pop.
7. Preventive Maintenance	140	TEBS Score (developed by D-5)
8. Bridge	55	% VMT
9. Miscellaneous	65	80% Pop., 20% Miles

Table 1. Construction Funding Categories within 1986 PDP

A District nominates projects for categories 1 through 3, and these are included in the 10 year plan and prioritized in terms of cost per vehicle mile or congestion relief index. Categories 1,2,3 and 6 are project specific, and priorities are assigned state wide. Categories 4,5,7,8 and 9 receive fixed allocations based on historic trends. The allocations to the Districts are based on formulae which include the factors shown in Table 1.

Excluded from Table 1 is the maintenance budget. This currently is approximately $450 million annually, and is allocated to the Districts based on a formula which includes environment, traffic and mileage factors. Project selection for categories 4,5,7,8, and 9 and for maintenance is the responsibility of the District staff, primarily the District Engineers. The current allocation process is viewed as equitable and the system is reported to provide sufficient flexibility to address major problems should they arise.

The major weakness of the existing system is that there is no link between the network level activities and the Pavement Rehabilitation Category of the Project Development Plan. For a Pavement Management System to be cost-effective it must be an integral part of the Project Development Plan. Below are listed several areas in which PMS information can be incorporated into the planning process,

(1) Provide objective analysis of the impact of budget level changes on the overall condition of the Texas Highway network.

(2) Provide the Administration with tools to determine the optimum funding level for each work category. The total funding level for Rehabilitation (category 4) was thought critical. It was suggested that Urban Districts are able to combine added capacity and pavement rehabilitation into a single project, giving them, in effect, additional rehabilitation funds.

(3) Generate project priority lists in each District from their PMS, using criteria and procedures of their choice. "First-cut" project lists should be available for each work category including added capacity, geometrics, rehabilitation, maintenance, safety or bridge replacement.

(4) Provide estimates in each District of their current and future rehabilitation (categories 4,5,7,8, and 9) and maintenance needs by analysis of data stored within a PMS.

1.5 PROJECT LEVEL DESIGN SYSTEMS

The Flexible (FPS) and Rigid Pavement Design Systems are used extensively throughout the Department largely for new pavement design. These systems contain many original features including deflection analysis, life cycle costing, user cost calculations and reliability concepts. Many of

these features have been incorporated into the new AASHTO Pavement Design Guide published in 1986. The Design Division (D-8PD) is currently reviewing its procedures in accordance to the recommendation of the AASHTO Guide. Particular attention is being paid to the following,

(1) Development of a new mechanistic-empirical design procedure to replace FPS
(2) Development of pavement rehabilitation design procedures for both flexible and rigid pavements which include life cycle costing techniques
(3) Training schools for District design staff

It is anticipated that major changes will be incorporated in the pavement design area in the next five years. These will permit the designer to make realistic estimates of anticipated performance based on pavement models which have been calibrated with historical performance data and field experience. Furthermore, tools will be available to optimize rehabilitation strategy selections. Further discussion on anticipated changes in the design systems is given in Section 2.3 of this report.

1.6 SUMMARY

To continue the development of an effective PMS for the Texas State Department of Highways and Public Transportation the next step is the formal linking of the 3 independent systems: the Network Level Pavement Evaluation System, the Project Development Plan and the Design Systems. The weak link in the chain is the link between the network evaluations and project development activities. Developing a strong link must be a top priority in any PMS development effort. Project prioritization of added capacity projects makes use of a congestion relief index. In order to be compatible with this, development efforts should be undertaken to develop "maintenance and rehabilitation effectiveness indices" for use by Districts in allocating their available resources.

The first step in developing the necessary linkages should be an organizational change to allow the existing groups to work more closely together and to be more effective in coordinating and supporting all PMS activities. A possible structure is discussed in Section 3.1.

2 WHERE DO WE WANT TO GO

In this section, the recommendations of the Administration and the Districts are presented. These were obtained by interviews and from a PMS questionnaire completed by each District office. The implications of the new Federal policy on pavements is also discussed.

2.1 ADMINISTRATION REQUIREMENTS

At the administrative level four major uses of the Pavement Management System were identified,

(1) To produce credible, defensible needs estimates for the legislature. One-time needs studies are not acceptable, what is required is an on-going management and evaluation program.
(2) To allow the Department to set goals and measure the progress towards meeting these goals.
(3) To provide the ability to evaluate the size of each program; for example, are adequate resources being made available for pavement rehabilitation?
(4) To provide a long-term outlook on strategy selection, and an evaluation of the cost effectiveness of treatments. For example, when are seal coats and thin overlays cost effective.

Although there was a desire to move towards a more rational fund allocation procedure, it was agreed that the current funding categories and formula-based allocation process are equitable. The current system has Commission approval, makes provisions for Districts with large numbers of rural roads and eliminates the concern about rewarding poor managers.

Other major issues that were identified at the administrative level were the following;

(1) The PMS must be District oriented, collecting only the level of detail required to meet their needs.
(2) The Austin Divisions should be able to summarize the District data to meet their requirements, eliminating duplicate data collection efforts (PES v. HPMS, for example)
(3) The control of the system's development and operation should be administered by an Austin Division, and this Division must be a

prime user of the PMS information to ensure control over information quality, timeliness and usefulness.

(4) The location of the PMS support group in the organization was viewed as the key problem. The PMS information generated cuts across all Division lines, and this combined with the decentralized organizational structure of the Department makes management of the development effort a crucial issue. In general, it was viewed as essential that its location should be high enough in the organization to assure that it can cut across lines to provide information and services to all other elements. The suggested organizational options are summarized below:

Option A Create a new Division and place all PMS (network and project) activities in that Division.

Option B Create a Pavements Division by incorporating all the major PMS functions into an existing Division. D-8 was thought to be the logical choice. The pavement group in D-18 and the data collection and automation group in D-10 would be incorporated, together with the data processing support from D-19. This new PMS group would be coordinated with the existing key users, Design (D-8PD) and Project Programming (D-8A).

Option C Divide the PMS responsibility between network and project level. Leave the project level responsibility with D-8. Combine the network level activities currently performed by D-18, D-10, D-19 into a single group. Locate this network level PMS group in an existing Division, alternatives of which could be D-18, D-10, or D-7. Make formal links between the network and project level groups.

Option D Create a position of Departmental Pavement Manager reporting to either the Engineer-Director or the Deputy Engineer Director. The Pavement Manager would have a very small group of Division representatives working for him. The operating Divisions would remain as they are and their activities would be coordinated by the Pavement Manager.

There are pros and cons for each alternative. It would be difficult to get approval for Option A, however Options B, C and D, or some combination thereof, are definitely feasible. One disadvantage of Option D is that the Division personnel will now

have two "bosses", which will lead to work prioritization problems.

(5) Each District already has a Pavement Manager. He needs to get additional training in Pavement Management Principles (Design, Maintenance, Investigative Analysis, Inspection and Management). Successful implementation will only occur with District involvement.

(6) Pilot testing of the system is essential.

(7) Develop a total Pavement Research Data Base to continue long-term pavement monitoring, coordinating closely with Strategic Highway Research Program (SHRP) activities.

2.2 DISTRICT REQUIREMENTS

During this study, six District offices were visited and a questionnaire was completed by all 24 Districts. The questionnaire is shown in Appendix A of this report. Question 1 dealt with identifying the Districts uses of PMS information . Question 2 dealt with the types of data to be collected and its frequency. The District responses to these questions are shown in Tables A2 and A3 of Appendix A. A summary of District replies to Question 1 is tabulated below in Table 2.

Table 2. District PMS Priorities

Rank	Average Score	Results of District Questionnaires
1	2.21	Plots of current pavement condition - maps highlighting substandard sections
2	1.88	One year rehabilitation needs
3	1.83	Identify accident black spots
4+	1.79	One-year maintenance needs
4+	1.79	Multi-year maintenance needs
6	1.75	Assist in analyzing the cause of premature pavement failures
7+	1.71	Permit a district to maintain a project backlog available for program calls
7+	1.71	Multi-year rehab estimates
9	1.67	Prioritize projects
10	1.62	Assist in placint or removing load zones
11+	1.5	Evaluate materials performance
11+	1.5	Evaluate design performance
13	1.38	Provide links to design systems for "first cut" design estimates
14	1.25	Identify consequences of different funding levels
15	1.21	Identify the impact of special users
16	1.12	Assist district in allocating funds by function
17	1.08	Make quantity estimates for routine maintenance
18	0.96	Make planning estimates, 20-year plans, including capacity/condition
19	0.83	Assist district in allocating funds to residencies
20	0.75	Evaluate performance of maintenance section

Other used identified but not ranked

(1) Remaining life of pavement
(2) Accumulative 18 kips to date
(3) Complete history of contruction/maintenance
(4) Evaluation of Geometric/Safety adequacy

Numerical Score

3 = Must Have 2 = Very Important 1 = Nice to Have 0 = Not Important

By far the most frequent use of PMS data was that of obtaining plots of current pavement conditions in the form of maps in which substandard sections are highlighted. Pavement deficiencies could take the form of capacity problems, geometrics, condition, accidents, inadequate structures; in other words, all of the categories required within the Project Development Plan. The questionnaire replies did show bias in that the preferences were influenced by the needs of the respondent, whether he was from maintenance, design, construction, or planning appeared to influence preferences. Despite this, it is thought that the rankings in Table 2 are a reasonable representation of the overall state requirements. These requirements must drive PMS development efforts.

During the interviews with District personnel, it was determined that one of the favored output formats was that of a road log. There are currently several successful applications in the Department including the Straight-Line Road Log Diagrams and the Skid-R logs. Maintenance and Design Engineers reported that these logs were invaluable during field surveys. One of the key recommendations of this study is that an integrated network summary sheet be developed for the state of Texas. Several states are in the process of developing such outputs which link together all the relevant information in a usable form. The logs under development by the South Dakota DOT are shown in Appendix B.

The replies from the data collection question are summarized in Table 3.

Table 3. Preferred Data Collection Activities

Item	Average Score[1] (0-3)	Average Frequency[2] (Years)
VISUAL DISTRESS	2.58	1.39
SKID	2.42	1.62
RIDE	2.38	1.56
ACCIDENT RATE	2.25	1.30
DEFLECTION[3]	2.21	2.47
MAINTENANCE COST	1.82	1.35
SHOULDER CONDITION	1.41	2.10
GEOMETRIC PROBLEMS	1.28	2.78[4]
CAPACITY PROBLEMS	1.21	2.25

1 3 = Must Have 2 = Very Important 1 = Nice to Have 0 = Not Important

2 Frequency at which tests should be taken in years. Calculated from averaging district responses.

3 Some districts though deflection testing should be limited to project evaluation level.

4 As changes occur was a frequent qualifier.

Also identified was the need to set the frequency of testing depending on traffic level and pavement deterioration rate.

Visual Distress ratings ranked as the most urgent District requirement. There was general agreement that the PES type rating was beneficial in identifying projects. The Districts thought visual surveys should be taken on either a one year or two year interval with the average interval being 1.39 years (i.e., more Districts voted for a one year testing interval). The Districts interviewed considered that a 100% sample was needed in the first two years of implementation to permit project selection and determine condition trends. Once in place, the annual sample would drop to less than 50% of the network. It is important to note that the top five items were ranked between "Very Important" and "Must Have."

Questions 3 and 4 of the questionnaire on the hopes and fears of PMS development provided as much information if not more than questions 1 and 2. A large number of good suggestions and comments were made and these are shown in Appendix A. It is appropriate to list some of the key comments that were made time and time again.

On the uses of PMS

> "We would like to have a more consistent method of selecting rehabilitation and preventative maintenance projects and then properly prioritizing them. At present, we rely on input from the resident engineers and maintenance foremen to determine which highways need to be included in these particular programs. Both selection and prioritization work fairly well within the area of one supervisor's responsibility, but we do not always get totally valid results on a District-wide basis. Some reliable method of comparing roadway conditions from different areas of the District is needed. A PMS program, properly used, could satisfy this need and help insure that we utilize our resources in the most cost-effective way."

On the fears of PMS

> "The District feels that having data such as condition ratings, roughness, skids and shoulder conditions available to assist in making comparative ratings would be beneficial. However, we do not feel that project selection and prioritization should be based on computerized ranking instead of determination by qualified experienced personnel with personal knowledge of historical performance."

On the Dos and Don'ts

Dos

1. Sample 100% of system.
2. Provide needed resources to regional data centers.
3. Determine optimum frequency for collecting data.
4. Include geometry data.
5. Include date of last surfaced in data.

6. Combine skid data.
7. Consider rating of pavement by maintenance foreman.
8. Write programs for easy access to data in sorted form
9. Keep simple.
10. Staff each District with a pavement manager to oversee PES.
11. Use as management tool to see effectiveness of construction and maintenance programs in District.

Don'ts

1. Make too complex.
2. Don't use to allocate monies to Districts.
3. Don't consider to be "Final Word," but a tool to help to manage resources."

On Cost-Effectiveness

"Do not get into project-specific data which would be needed for only design purposes on an actual project. For example, it does not appear to be practical to maintain deflection data on the entire highway system. This data should be collected on an "as-needed" and "when-needed" basis. Please keep in mind that if PMS is to be successful, all of the data must be current. The cost of maintaining an excessively elaborate system could become prohibitive."

On the Future

"Ultimately expand data gathering capabilities from the region concept to each individual District."

On Staffing

"Provide FTE's for the five regional centers so that they can properly staff for data collection."

On Information Availability

"Make the information readily available on one system or by one means. There is information available that is too difficult to retrieve. Programs have to be developed to access so many files that personnel are not able to accomplish the task.

On Information Accessibility

"Make on-demand reports that can be selected by county, highway, pavement score, year of last surface, etc."

To summarize the findings of the District interviews the following conclusions are presented:

(1) The Districts interviewed (Districts 4, 10, 11, 12, 14, and 20) all thought that an effective system would allow them to make better use of their funds. From the questionnaire responses, all of the Districts thought a PMS would be beneficial.

(2) To be of use to the District, a 100% condition survey, at least in the first two years of operation, was viewed as essential.

(3) The Districts should be responsible for updating inventory items, such as the date of the last surface, base type, etc.

(4) Various reports are required such as maps highlighting deficiencies, estimates of M&R needs, and others. Some of these are available within PES, and others need to be developed.

(5) The data stored should be available in one system. Network summary sheets should be developed for field personnel which list all relevant pavement information in a usable, easily understood format. Reference should be made to Appendix B where the format used by the South Dakota DOT is presented.

(6) Simple access to the data should be available so that the Districts can tailor reports to their needs.

(7) A single system will not meet the needs of each District. Priorities vary from District to District and the PMS must be adaptable to such differences. Several Districts view the system as solely a method of identifying deficient segments of pavement, while others view it as a system that will eventually (under their control) be used to assist with budgeting, project prioritization and planning.

(8) Districts need to centralize data collection and analysis procedures at the District level. A full-time supervising engineer with appropriate support staff should be appointed. This supervisor needs to be trained in Pavement Management Principles.

2.3 FHWA PAVEMENT POLICY

In February, 1988 the FHWA published its Pavement Policy which "set forth a policy to select, design and manage Federal-aid highway pavements in a cost-effective manner and identify pavement work eligible for Federal-aid funding." This is an extensive policy statement with far-reaching recommendations at both the network and project level. Their goal is that the policy should be implemented within a reasonable length of time, not to exceed four years. The following is a summary of discussions with D-18 and D-8 personnel on how this policy impacts current operations.

Implications on Network Level Activities

The policy calls for an inventory to be built which should include as a minimum the following:

(1) Location Reference
(2) Pavement Layer Information (including maintenance and rehabilitation action)
(3) Pavement Condition (current and historic)
(4) Traffic Estimates (historic and future)

This data bank is to be used for the following:

(1) Generate a current and projected network needs estimate
(2) Analyze project alternatives and strategies over time in terms of cost-effectiveness
(3) Develop pavement performance models
(4) Establish criteria for design, construction, maintenance and rehabilitation.

The current Pavement Evaluation System (PES) meets a limited number of these requirements, however, it is deficient primarily in the area of pavement layer information. The existing files are out of date and of little use to the Department's PMS effort. A large one time effort is required to determine which layer data items are required, which can be extracted from existing files and which need to be input by District forces. Simple procedures need to be developed so that the Districts can update the inventory. In general, it is thought that it would not be cost-effective to store large volumes of historic data. A recommended approach would be to identify an acceptable minimum requirement (for example, date and type of last surfacing and date, thickness and type of base), then develop procedures by which the system can be updated with current and future work by District personnel.

Implications on Project Level Activities

The FHWA policy is viewed as very good and basically an extension of the principles that D-8 has been promoting for the past 20 years. The SDHPT actions to meet these requirements are classified as (A) Development (B) Documentation (C) Training (D) Application and (E) Continuing Research. Each of these is discussed below.

(A) Development

New Life Cycle Cost Analysis (LCCA) procedures are required for optimizing pavement designs in the following four areas: 1) New Flexible Pavements, 2) Flexible Pavement Rehabilitation, 3) New Rigid Pavements, and 4) Rigid Pavement Rehabilitation. It is anticipated that the Rehabilitation models will initially be developed primarily from SDHPT "experience," supplemented by field performance data.

(B) Documentation

This will take the form of Pavement Design Manuals and computer program documentation.

(C) Training

Trial usage of new procedures on regional team basis and modification where appropriate. Once the initial versions are adopted, train the 24 Pavement Design Engineers in their usage.

(D) Applications

A typical District has four new pavement designs and 13 rehabilitation designs each year. The new federal policy implies that the following reports will have to be produced.

1. New Pavement Design Reports, including
   - (a) Pavement Type Selection Analysis
   - (b) Pavement X-Section Analysis
   - (c) Life Cycle Cost Analysis
   - (d) Subgrade Characterization
   - (e) Traffic Analysis
2. Rehabilitation Design Reports, including
   - (a) Existing Pavement Study that includes a history of maintenance, condition, accidents, also coring and lab test results.
   - (b) Structural Distress Analysis which identifies the cause of distress and estimates remaining life.
   - (c) List of Feasible Alternatives
   - (d) Life Cycle Cost Analysis

(E) Continuing Research

This includes collecting performance data and performing analysis on in-service pavements. Development of LCCA techniques and training programs.

There are some resource requirements to meet these objectives. Each District will need a full-time pavement design engineer and two technicians. Each project will take between one and two weeks of design engineer's time. Resources will also be required to develop LCCA procedures.

To meet these requirements it is estimated that the total additional engineering cost will be 0.3% of the cost of a typical project. The estimated savings are estimated to be in the order of 15 to 30% obtained by extended pavement lives.

3 HOW ARE WE GOING TO GET THERE

In this section of the report, a series of recommendations will be given on how the Department should proceed with PMS development and implementation. The Department faces both technical and organizational problems. The technical problems include how to collect, store, analyze and report pavement information in a timely manner to support District operations. The organizational problems involve defining which organizational structure is most appropriate for implementing this system. As shown in Figure 2, it is thought that the major problem is organizational. The Department has tremendous technical capability and should be able to implement such a system with minimum external assistance. However, who should control this development effort and how can a system which cuts across every organizational line be successfully managed?

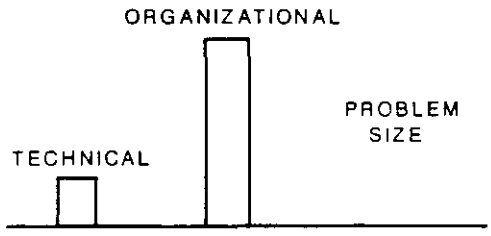


Figure 2 Problem Size

3.1 RECOMMENDATIONS ON ORGANIZATIONAL STRUCTURE

The current PMS system structure is shown in Figure 3.

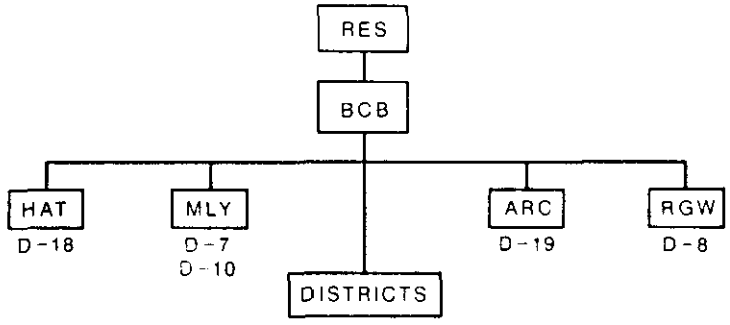


Figure 3 Current PMS Organizational Structure

The key user groups are in the Districts, D-8, D-7, and D-18M. The key support groups are in D-18P, D-10, and D-19. It is the first and foremost recommendation of this study that a PMS development and implementation support group be centralized in a single Division in Austin. The location of this

group must be the responsibility of the Engineer, Director and Executive Committee (Mr. Blaschke and the four Deputy Directors). It is proposed that the support group should have the range of skills shown in Figure 4.

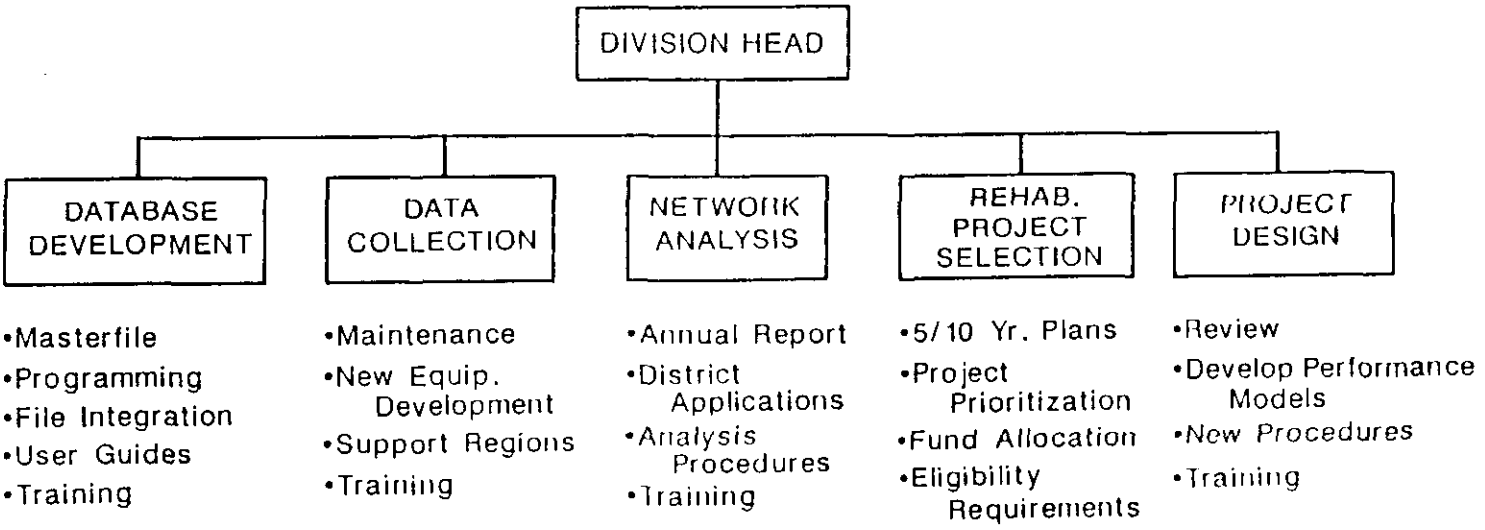


Figure 4 Proposed PMS Support Group

The project Design and Project Selection groups are already in existence in D-8. The data collection group is currently in D-10. The D-18P group has the responsibility for network analysis. The database development group should combine the groups currently located in D-19 and D-10 (Automation). It is anticipated that an immediate requirement will be the development of an extended PMS Master File. It is recommended that the existing PES Master File be expanded meet the additional District data requirements, particularly those of generating network summary sheets. A concentrated effort in the initial phase of this project will be required in the database design area. Once implemented, this effort will be less intense, however the other sections can be viewed as permanent. The senior staff to man this support group are already in Austin.

A similar organizational review should be made of District operations. It is proposed that each District appoint a full-time pavement manager. This person will have a staff as shown in Figure 5.

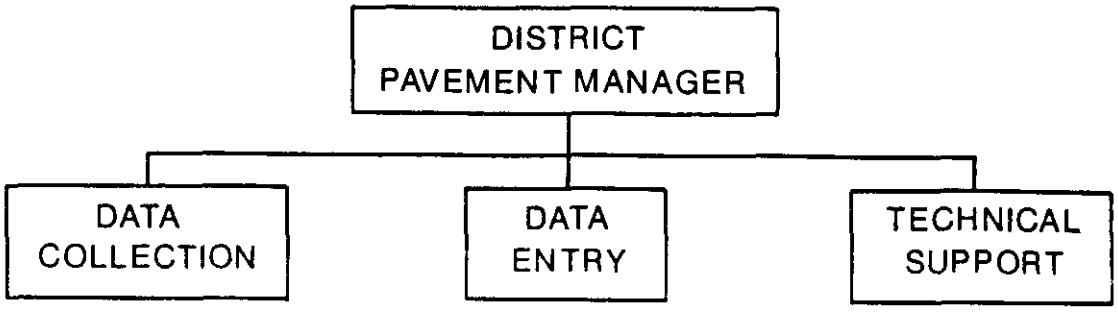


Figure 5 Proposed District PMS Group

The Pavement Manager will be a key individual who will be responsible for both network and project level activities, including supervising inspections, evaluating District needs, performing pavement failure analysis and assisting pavement design. Intensive training programs will need to be established to equip this manager in the principles of Pavement Management. The data collection group should be staffed with two FTE's to handle all inspections (Pavement and Bridges). Additional data collection support may be required at other peak times. The technical support group will be responsible for preparing the failure analysis and pavement design reports. On average, it is estimated that the required staffing level in each District will be six FTE's. The urban Districts may require more staff. This group will not be required immediately, but it should be in place by year 3 of the developmental effort.

The regional centers will continue to collect specialized data such as deflection and ARAN surveys. In order to provide the level of data collection needed, it is important that the Districts containing regional centers be allowed flexibility in hiring temporary staff during peak periods.

3.2 MANAGEMENT OF PMS DEVELOPMENT

The Department should appoint a single person as "the PMS champion." Such an appointment will give the effort the visibility needed for implementation. This person would be given overall responsibility for the development effort. His duties would be to coordinate the support group and District activities, develop a long term development plan with milestones and resource requirements and make regular presentations to the Executive Committee on progress, problems and future plans. Once underway, control of the development effort should be

the responsibility of the most senior levels within the Department. The champion should be a highway engineer with good communication and technical skills.

3.3 TECHNICAL CHALLENGES

The first task of the "PMS champion" should be to address the following technical challenges:

(1) What detailed outputs are required from this system? This report recommends the design of network summary sheets (similar to those shown in Appendix B), outputs to address each of the top District requirements shown in Table 2 and simple procedures by which the Districts can prioritize projects for input into the Project Development Plan.

(2) What type and frequency of field data gathering is required? The District recommendations are given in Table 3.

(3) What inventory items should be collected and how can this effort be minimized?

(4) What data storage technique should be used to provide the required reporting capabilities? The pilot test work in District 21 has indicated that the existing PES Master File can be redesigned to give the Department the data storage and reporting capabilities required.

(5) How can other data files (accidents, bridges, maintenance cost, traffic and others) be integrated with the PMS master file? The move towards a milepost based referencing system should make this relatively simple.

(6) What support from the two Universities is required in this development effort? The PMS needs should be one of the driving forces of the continuing research programs; the PMS support group should clearly specify research projects that are required, with details of deliverables and a time frame.

(7) What can be learned from the PMS development efforts underway in other states like Minnesota, Washington, Pennsylvania and others?

The sequence of activities is critical. In any systems design effort, it is essential to clearly identify the outputs required before inputs and storage media can be addressed.

3.4 TRAINING

Training of District and Division personnel in pavement management principles is a key requirement. The two Universities should be encouraged to develop suitable training programs to cover all network and project level activities. These could take the form of an integrated, one year masters Degree Program where the student is expected to submit a research quality paper on implementing PMS techniques on returning to District duties, or an intensive four week crash course, followed by a PMS internship period and a PMS implementation report. Subjects to be covered should include materials, design, evaluation, maintenance and management.

3.5 ADDITIONAL RESOURCE REQUIREMENT

(a) Data Collection Equipment In the first two years of implementation no additional equipment purchases over those currently approved are required. However, additional equipment will be required in years 3 and 4 when it is recommended that 100% network samples of visual and ride be taken in both years. Also, skid data which is not currently collected at the network level was ranked very high on the Districts' needs list. Efforts should be taken to develop inexpensive skid equipment. These new equipment costs are estimated in Section 3.9.3 of this report.

In general, resources should be made available to the PMS support group to build "in-house" improved data collection equipment. Specialized equipment such as ARAN units are expensive to purchase and maintain. Other states such as Pennsylvania have found it more cost-effective to build their own network survey vehicles rather than purchase general purpose equipment.

(b) Mainframe Computers The master PMS inventory file will need to be maintained on the mainframe computer. Current computer resources are adequate.

(c) Microcomputer Most District offices have adequate microcomputers, minimal upgrades will be required to allow design programs and graphics packages to be installed.

3.6 PILOT TESTING

In an effort of this size, it is essential that the concepts be pilot tested prior to full-scale implementation. Pilot testing should be conducted within a short time frame not to exceed six months.

3.7 SUMMARY

The major recommendations of the study include the following;

(1) The formation of a PMS Support Group with all of the expertise needed to assist the Districts with the implementation of PMS. The group can be assembled by combining several existing groups within the Austin Divisions.

(2) The expansion and clarification of the duties of the District pavement manager. He should be responsible for both network and project level activities within a District.

(3) The appointment of a "PMS Champion", on the staff of the Engineer Director or his deputy, to be directly responsible for the development effort.

(4) The appointment of the SDHPT Executive Committee (Mr. Blaschke and the four Deputy Directors) to manage and control the development effort.

(5) The development of output reports specified as high priorities by District personnel. These include a graphics output to locate substandard sections, a maintenance and rehabilitation needs estimates, project prioritization routines and network summary sheets which contain all the required pavement information needed to support project selection and evaluation.

(6) The creation of a PMS Master File based on milepost and the development of links to other key files Accidents, Bridges, Maintenance costs, and others. The existing PES master file can be reconfigured to meet this need.

(7) Interfacing the existing PES (representing District and Division PMS needs) with HPMS (Planning/Legislative needs) to eliminate duplication of effort. The proposed PMS Master File must support both PES and HPMS analytical packages.

(8) The one time collection of a limited amount of pavement layer information not available within the existing computerized systems.

It is the PMS Support Group's responsibility to identify the data items required. Developing simple procedures to store and update the PMS Master file with this information.

(9) The Development of 4 new Life Cycle Cost Analysis procedures for new pavement design and rehabilitation design of both rigid and flexible pavements.

(10) The development and implementation of New Pavement Design Reports and Rehabilitation Design Reports as requested by D-8 (Pavement Design).

(11) The appointment of a multi-disciplinary team to investigate major pavement failures, document the causes of failure, and propose an appropriate rehabilitation strategy. Members of this team will be drawn as required from the PMS Support Group, D-9 Materials and Test and the Universities.

(12) The development of pavement deterioration models for both flexible and rigid pavements for use at the network and project level. These models are essential for projecting future needs and optimizing designs. Initially they can be built on data currently available within the existing research data bases, from expert opinions and other existing sources. Procedures need to be identified by which improved models can be developed as part of the PMS activities.

(13) The immediate initiation of a pilot study not to exceed 9 months. A recommended study area would be the Interstate 35 route in District 14.

(14) Training of key District staff in Pavement Management principles.

3.8 ACTION PLAN

The following action plan is tentative; it will be developed more fully by the PMS Support Group and the Steering Committee.

3.8.1 Assumptions

This action plan is based on the following assumptions,

(1) The implementation period will be four years.

(2) At the end of the four year period the Department will have in place a Pavement Management System that meets both District and Federal Requirements.

(3) The development will be performed "in-house" with the Department's personnel taking the lead and the two Universities providing support largely through research or interagency agreements.

(4) The Department has sufficient staff at the Austin level to perform the implementation if they can be dedicated full-time to this effort.

(5) The effort will get the energetic support of the top management levels within the Department. They will be actively involved in setting priorities, establishing goals, reviewing progress and facilitating communication.

The action plan presented in the next section covers activities that need to be undertaken in the first two years of the four year implementation period. The major tasks of each group in the development effort and their time sequence are identified. It is recommended that the action plan be reviewed at six monthly intervals by the Executive Committee. The updates to this action plan should be the responsibility of the "PMS Champion".

3.8.2 ACTION PLAN FOR YEARS 1 AND 2

ADMINISTRATION

Task 1.1 Review Organizational Structure (Months 1-2)

Review the recommendations of this report and select a structure which will support PMS development. The recommended support group is shown in Figure 4, although other options are possible as described in Section 2.1. The data collection, network analysis, project selection and project design groups are already in existence in D-10, D-18P and D-8. A database development group will need to be formed to assist development, currently this group is split between D-10 (Ben Barton) and D-19 (Joel Young).

Task 1.2 Approve Resource Allocation (Months 1-2)

Resource requirements are listed in Section 3.8.3. These should be reviewed and approved by the Administration.

Task 1.3 Project Control (Continuing)

Appoint (1) a "PMS Champion" to be responsible for the development effort and (2) the Executive Committee to be responsible for control of the effort.

Task 1.4 Project Priority (Months 1-2)

This PMS development should be considered a "fast-track" effort, the PMS support group should be provided with mechanisms to prioritize needed work requirements in either the automation process (SPECTRUM), equipment purchasing or research contracts (HPR process).

DISTRICTS

Task 2.1 Review Organizational Structure (Months 3-4)

Typically several groups within the District are responsible for inventory data collection, PES, Bridge, HPMS and others. These should be centralized under the District Pavement Manager. Organizational changes are not essential in year 1, however additional staff will be required in years 2 and 3 and by that time a District PMS group should be in place.

Task 2.2 Milepost Validation (Months 3-12)

Each District should review the existing mileposting system. For each highway a designated zero point should be documented and a DMI used to validate that milepost are at two mile intervals. The tolerance should be ± 50 foot. When exact post location is not possible the actual place position should be recorded.

It is the District Pavement Manager's responsibility to document the starting point of the highway and to certify that the posts are in place and accurate.

Task 2.3 Layer Information (Months 6-continuing)

The PMS support group will identify what additional layering information is required, what codes are to be used and how it is to be stored. The District Pavement Manager will be responsible for assembling this information on all major routes in this period (Interstate and U.S. Routes only in year 1 and 2). A tentative list of requirements for flexible pavement is (1) Type of Base (2) Data base constructed (3) Thickness of Base (4) Type of Subgrade (5) Total thickness of surfacing (7) Date of last seal (8) Date of last overlay (9) Thickness of last overlay (10) Rehab Technique (Milling, etc).

For jointed pavements a tentative list would include (1) Slab thickness (2) Base Thickness (3) Subgrade Type (4) Shoulder Type (5) Joint type (6) Construction date (7) Total asphalt overlay thickness (8) Date last overlay (9) Thickness last overlay (10) Rehab. technique (Fabrics, etc).

For continuously reinforced concrete pavements a tentative list would include (1) Slab thickness (2) Coarse Aggregate type (3) Base type (4) Shoulder type (5) Construction date (6) Total asphalt overlay thickness (7) Date last overlay (8) Thickness last overlay (9) Rehab. technique.

The location accuracy required will be one-tenth mile. Procedures will be developed so that ongoing Maintenance, Rehabilitation and Reconstruction activities will be stored. Most of this information is available in existing logs, some will require additional coring.

In the third and fourth years of implementation the SH and FM routes will be included.

Task 2.4 Pavement and Bridge Inspections (Continuing)

District forces will still be expected to complete all evaluation. In years 3 and 4 a 100% network survey of ride and condition will be completed. In subsequent years the survey will drop to less than 50% of the network.

REGIONAL CENTERS

Task 3.1 Collect HPMS data elements on entire Interstate System and U.S. Routes (Months 6-24)

The PMS support group will identify the additional capacity and geometric information required by the HPMS analytical package. The regional centers will be responsible for assembling this information initially on all IH and U.S. Routes and collecting network and project level information when and where required.

DATABASE DEVELOPMENT GROUP

Task 4.1 Reconfigure PES Master File (Months 6-continuing)

The existing PES master file needs to be redesigned as follows;

(1) Convert to a Roadway based file - a separate record for each direction on divided highways and for frontage roads.

(2) Convert from a two mile file to a one-tenth mile file.

(3) Permit the storage of inventory and condition items where they are collected on the roadway.

(4) Add capabilities of storing additional inventory data items as specified by Network Analysis Group.

(5) Provide procedures to combine information into any user specified milepost limit.

(6) Develop procedures so that the Districts can easily and routinely update this file with maintenance, rehabilitation and construction information.

This is a major programming effort which will be transparent to the majority of users. This one-tenth mile master file will be the heart of the PMS. It will be a major file maintained on mainframe computer and will eventually contain approximately one million records. A flat file design is recommended for the initial PMS to expedite implementation, although alternate relational file structures should be researched in subsequent years of the development effort.

Task 4.2 File Linkages (Months 12-24)

The RI2-TLOG is already linked to the existing PES Master file. Additional links should be constructed to the following three systems, Bridges (BRINSAP), Accidents (MVTA), Maintenance History (MMH). The record in the master file containing the Bridge should be flagged with the appropriate bridge identification number. The accident information and maintenance history information can be produced in a format which is readily merged with the PMS Master File. For example, a file showing the total number of accidents and number of fatal accidents in the previous 12 months on every one-tenth mile segment of the highway network can readily be produced. Similarly a file showing the total maintenance expenditures can be easily obtained for every one mile segment of highway from the proposed MMIS System.

Task 4.3 Graphic Information System (Months 9-Continuing)

Graphical displays of PMS information is a high District priority. In the first four months of this task a feasibility study should be undertaken to determine how best the State can exploit GIS. Included in this feasibility study should be (a) description of current GIS systems (b) assessment of Department's current capabilities (c) proposed system (d) cost estimate.

GIS will eventually give the Districts the ability to automatically generate District maps with deficient road segments highlighted.

Task 4.4 Assist with Pilot Scale Test (Months 6-12)

Support the network analysis group in the pilot testing of the proposed system.

Task 4.5 County Maps (Months 9-18)

Produce an updated set of County Maps. These maps will show the milepost locations and one-tenth mile break points.

Task 4.6 Evaluation of Improved Data Storage Structures (Months 16-24)

In a research effort evaluate more efficient procedures for storing and reporting the large volumes of data required to be stored and processed within the PMS.

DATA COLLECTION

Task 5.1 Equipment Maintenance, data collection and Region Support (Continuing)

This group will continue to support the regional centers with training and equipment maintenance. It will also be required to collect both network and project level data when and where required, and provide training and support to District personnel in PES evaluation techniques.

Task 5.2 Skid Equipment Development (Months 3-12)

Skid measurements were ranked as very important by the Districts. Efforts should be made to develop low cost skid equipment. Evaluations should be made of low cost non-contact probes.

Task 5.3 Evaluation of ARAN Unit (Months 3-12)

This task will address the following: Should the Department buy additional ARAN units or construct more specialized equipment itself. For example devices to measure grades and curves could be developed relatively inexpensively. If the decision is to purchase more ARAN then document operator and support requirement and include these in a cost estimate.

Task 5.4 New Technologies (continuing)

Continue researching new technologies which fit within the overall PMS framework. This includes Ground Penetrating Radar, Lasers, and others.

Task 5.5 Moving from Regional to District data collection (Months 12-24)

The regional centers will be adequate for years 1 and 2 of this implementation effort. However in years 3 and 4 efforts should be made to move the equipment to the District level, the anticipated equipment requirements are shown below.

Ride Equipment	1 per District
Deflection Equipment	1 every two Districts
Skid Equipment	1 every two Districts

Specialized equipment; such as profilometer, videologgers, and others, can still be managed by regional centers. This tasks calls for the development of a plan for the purchase, operation, and maintenance of pavement evaluation equipment for District use.

NETWORK ANALYSIS

Task 6.1 Network Summary Sheets (Months 3-6)

In cooperation with Districts, develop a format for Network Summary sheets similar to those shown Appendix B. Include on these all the information considered essential by District personnel in an easily understood format.

Task 6.2 Pavement Layer Information (Months 3-6)

With reference to Division and federal requirements determine which items of layer information need to be obtained. Identify sources of information, coding instructions and data accuracy.

Task 6.3 District Output Requirements (Months 3-9)

Develop output formats and analysis procedures to address the Districts information requirements. The top 10 needs of Table 2 should be addressed.

Task 6.4 Pilot Test (Months 7-13)

Pilot test the complete inventory gathering and reporting process on a small portion of the states network. The Interstate pavements in District 14 would be a good choice. During this pilot study perform the following;

(1) Collect all pavement layer information
(2) Evaluate the need for mileposts on frontage roads
(3) Collect distress, ride, skid, deflection data on all roadways.
(4) Access the accident files to determine the number of fatal and nonfatal accidents.
(5) Access the MMIS system to determine maintenance expenditures.
(6) Collect all inventory items required by PES and HPMS and store these in the same data file. Run PES and HPMS Analysis packages from the same base file.

(7) Produce Network Summary Sheets for pilot Study area.

(8) Produce estimates of remaining life, maintenance, and rehabilitation cost estimates.

In the last month of this pilot test a presentation will be made to the Executive Committee, with recommendations for the future.

Task 6.5 Pavement Deterioration Models (Months 12-continuing)

Assemble as complete a set of network level pavement deterioration models as possible from historic data, other research and expert opinion. These models must be compatible with the data stored in the PMS Master file.

Task 6.6 Training of District Personnel (12-continuing)

Initiate training programs for the District pavement managers, on how to best utilize the information stored within the system.

PROJECT SELECTION

Task 7.1 Maintain the existing fund allocation process (continuing)

Task 7.2 Evaluate adequacy of funds in meeting current and future needs (Months 12-continuing)

As the expanded PMS master file becomes available and additional applications are developed there is a need to evaluate adequacies and inequities in current funding procedures. Develop and evaluate procedure for making 10-year estimates of statewide funding for maintenance and rehabilitation based on condition. Compare these with the allocated funds and make recommendations for future changes.

PROJECT DESIGN

Task 8.1 Using the FWD for Design (Months 3-15)

Structural pavement design input for FPS can only be obtained from Dynaflect testing. However, the Department has largely moved to Falling Weight Deflectometer testing. Provide a means by which either Dynaflect or FWD data can be used in design process.

Task 8.2 New Design Reports - Specifications (Months 3-9)

Section 2.3 of this report describes new design reports which were proposed by D-8 to meet federal reporting requirements. These reports contain

several new features including Pavement Type Selection Analysis (asphalt v. concrete, black base v. granular base, etc.), Structural Distress Analysis and Life Cycle Cost Analysis for pavement rehabilitation. Prior to developing these reports, D-8 should write detailed specifications on the report contents.

Task 8.3 Developing New Design Reports (Months 10-continuing)

D-8 should be allocated resources to develop the design procedures according to their specifications. The funding requirements to develop these procedures is estimated to be $600,000 and the development time is two years.

Task 8.4 Premature Pavement Failures (Months 6-continuing)

The project design group should establish a multi-disciplinary team to assist the Districts in failure analysis. Members of this team will be drawn as required from the PMS Support Group, D-9 Materials and Test, the Universities. Different team members should be assigned based on the pavement type being investigated.

At the end of each investigation a standardized report will be produced which documents the findings and makes recommendations for the future.

Task 8.5 Pavement Modelling (Months 15-continuing)

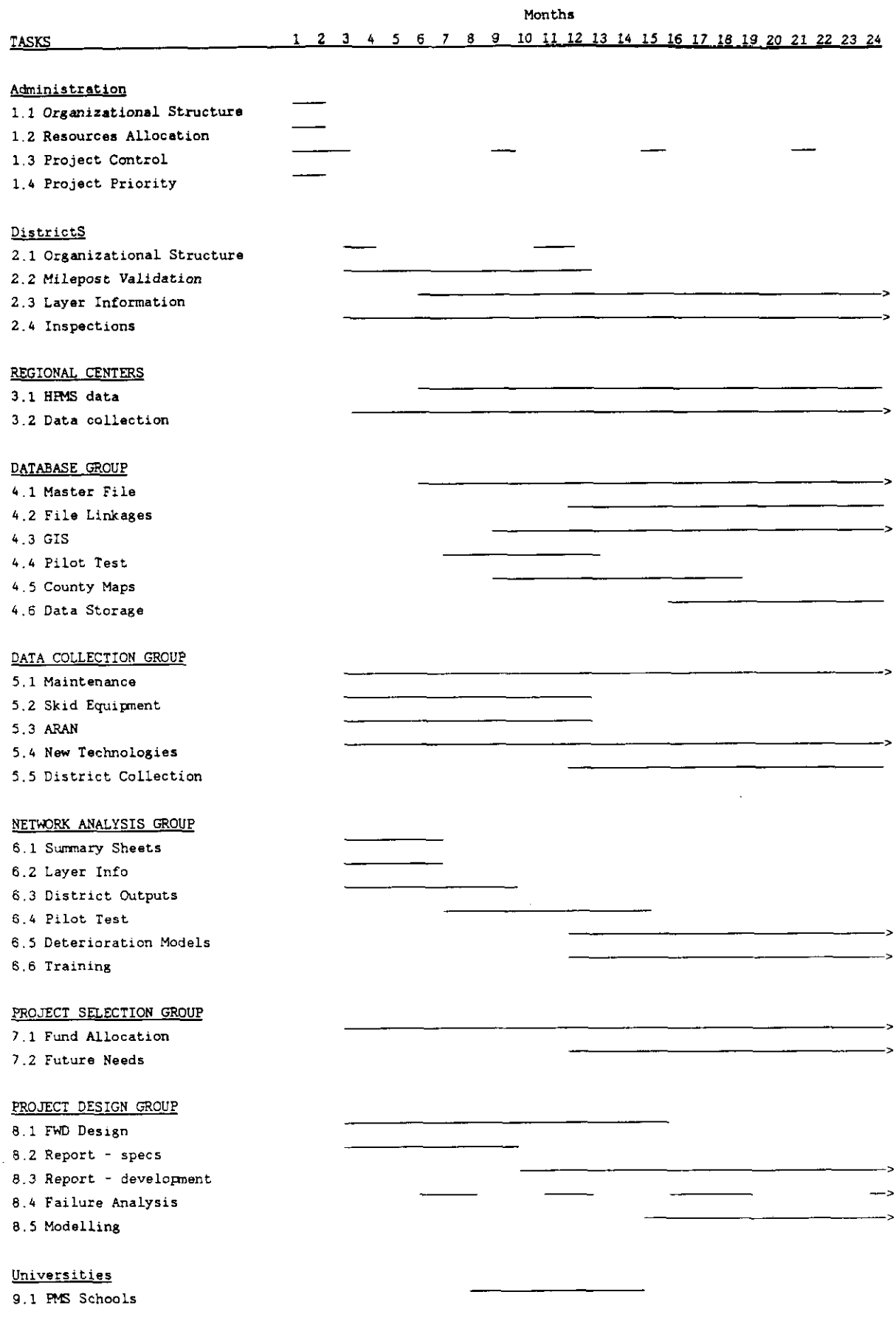
Project-level pavement deterioration models should be developed from the information stored in the PMS Master File and other sources which include research data bases and the SHRP effort.

UNIVERSITIES

Task 9.1 Pavement Management Schools (Months 6-12)

The Universities need to develop four-week courses in Pavement Management (to be held during the summer months) and one-year Master's degrees. The four-week courses will be aimed at the District Pavement Managers. The Master's degree programs will be aimed at junior engineers wishing to make careers in pavement design and management.

TABLE 4 PMS IMPLEMENTATION TIME CHART



3.8.3 Resource Requirements

This section identifies the resources (manpower and equipment) necessary to implement the proposed Pavement Management System.

Staffing Levels

1) The staffing level of the Austin-based PMS support group to handle current and anticipated PMS efforts is shown below:

	Recommended Level	Current Level
1. Section Head	1	0
2. Database Development	6	2
3. Data Collection	18	14
4. Network Analysis	8	7
5. Project Selection	3	2
6. Project Design	8	6
	44	31

The majority of the required staff are existing employees and can be assigned to this development effort. The only new group is the database development group which can be made up of employees from D-10 and D-19. The data base to be developed will support the Pavement Management effort only, not the proposed Department-wide information system. The start-up staffing requirement in this area is estimated at 6; this should drop to 3 once the system is implemented. The Project Selection group is responsible for developing the Project Development Plan and maintaining the current fund allocation system. It will not be significantly impacted during the first two years of the effort.

2) The ultimate recommended staffing level for the average District PMS group is shown below:

1. Pavement Manager	1
2. Data Collection	2
3. Data Entry	1
4. Technical Support	2
	6

This group will be larger in the urban Districts and smaller in rural Districts, but an average staffing level of 6 is thought to be appropriate. It is not required immediately, but should be in place by year 3 of the effort when the new pavement design procedures become available.

3) The staffing level of the Regional Centers is shown below:

	Recommended Level	Current Level
Data Collection	5	3

The regional centers are responsible for the operation of sophisticated data collection units. To provide quality data, it is necessary to staff the centers with full-time operators who can be given the necessary training.

Equipment Requirements

The regional centers will be adequate for years 1 and 2 of this implementation effort. However, in years 3 and 4, efforts should be made to move the equipment to the District level. The anticipated equipment requirements are:

Ride Equipment	1 per District
Deflection Equipment	1 every two Districts
Skid Equipment	1 every two Districts

Specialized equipment, such as profilometers and videologgers, will still be managed by the regional centers. The following new equipment will be required in year 3 of the development effort:

Ride Meters - 6	(estimated cost @ $20,000 per unit)
Skid Trailers - 6	(estimated cost @ $120,000 per unit)
Videologging - 4	(estimated cost @ $290,000 per unit)

Research and Development Cost

The two Universities can greatly assist the development effort through the existing HPR research program. The PMS Support Group should identify and specify needs which can be addressed. However, additional outside development costs will be required in the following two areas:

$600,000 - New Pavement Design Procedure Development and Implementation
$500,000 - Geographic Information System and Database Development

Totals

The incremental system development costs are estimated as follows:

One-Time Equipment and Development Costs

Equipment Purchase	$2,400,000
Development Costs	$1,300,000
Total	**$3,700,000**

These costs include a 20% contingency estimate. They can be spread over the four year development effort, with the majority of the equipment being required in years 3 and 4.

Appendix A PMS Questionnaire

Figure A1 is the PMS questionnaire sent to each District

Figure A2 shows the District's responses to question 1, identifying and prioritizing what the District view as critical functions of a PMS

Figure A3 shows the District's responses to question 2, identifying the type and frequency of data collection.

This is followed by each Districts written response to questions 3 and 4 of the questionnaire.

PMS Questionnaire

District _____

1. District'S PMS NEEDS

If your District has access to an inventory file with complete information regarding current pavement condition how would you use this information. Below are listed 20 possible uses, please prioritize them A, B, C or D according to the following.

A = must have

B = very important

C = nice to have

D = Not important

Also add any additional applications you can think of;

1. Plots of Current Pavement Conditions - maps highlighting substandard sections.

2. One year Maintenance Needs Estimates (Routine/Seals/Thin overlays).

3. One Year Rehabilitation Estimates

4. Multi-Year Maintenance Needs Estimates

5. Multi-Year Rehabilitation Estimates

6. To permit the District to maintain a project backlog should program calls be made.

7. Prioritize Projects

8. Assist in fund allocation to residencies or sections within a District.

9. Evaluate performance of maintenance sections

10. Evaluate materials performance. (for example polymers v regular emulsions, different aggregate types, etc...)

11. Evaluate treatment/design performance (for example seal coat lives, effectiveness of recycling, CRCP v Jointed, etc....)

FIGURE A1 - PMS QUESTIONNAIRE - Page 1

12. Make quantity estimates for routine maintenance projects (crack seals, seal costs, etc...)

13. Make planning estimates (20 year plans) including Capacity/Condition/Safety considerations.

14. Identify accident black spots

15. Identify the consequences of different funding levels

16. Identify impact of special users (timber, grain, etc....)

17. Assist in identifying candidates for load zoning or removal of load zoning.

18. Provide links to Flexible and Rigid Design systems so that "first cut" design estimates can be made.

19. Assist in analyzing the cause of premature pavement failures.

20. Assist Districts in allocating monies by function (maintenance v rehabilitation v reconstruction v capacity improvement).

21.

22.

23.

FIGURE A1 - PMS QUESTIONNAIRE - Page 2

2. FREQUENCY OF DATA COLLECTION

Using the same A, B, C, D ranking identify how important you view the following items, also indicate how frequent)

Item	Urgency	Frequency of Data Collection
Condition Rating (Ruts, cracking, etc...)		
Roughness (Mays Ride)		
Deflection		
Skid		
Accident Rates		
Maintenance Cost		
Shoulder Condition		
Capacity Level		
Geometrics		

FIGURE A1 - PMS QUESTIONNAIRE PAGE 3

3. What I want from a PMS

Write one paragraph (or more) what your District views as the crucial issue you want addressed by the PMS

FIGURE A1 PMS QUESTIONNAIRE PAGE 4

4. Do's and Don'ts

We are in the process of deciding how we can modify the existing PES system to better address District needs.

Make a list of things we should do and things we should not do in putting together this plan. For example a do might provide more personnel in Districts to collect data or more training a don't might be don't make it too complex.

Do's

Don'ts

FIGURE A1 PMS QUESTIONNAIRE PAGE 5

FIGURE A2 DISTRICT PMS NEEDS

Responses to Question 1 of PMS Questionnaires

3 = Must Have (A) 1 = Nice to have (C)
2 = Very Important (B) 0 = Not Important (D)

POSSIBLE USES OF PMS IMFORMATION

District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	2	3	3	2	2	2	2	1	1	1	1	1	1	2	1	1	2	2	2	1
2	1	3	3	2	2	2	2	0	1	1	2	2	3	3	2	1	1	2	2	1*
3	2	2	2	2	2	2	2	1	1	2	2	1	1	2	1	1	3	1	3	2
4	3	3	3	3	3	3	3	1	1	2	1	2	2	0	0	0	1	2	2	0
5	3	3	3	1	2	2	1	1	0	1	0	1	0	1	0	2	1	1	1	1
6	1	0	0	2	2	2	1	0	0	0	1	0	0	2	2	1	1	2	2	0**
7	3	1	1	0	0	1	1	0	0	2	2	1	0	1	0	0	2	1	2	0
8	3	1	1	0	1	1	2	0	0	0	0	0	0	0	1	0	2	1	2	0
9	2	2	2	1	1	2	3	0	0	1	1	1	0	3	1	1	2	1	1	0
10	3	0	0	0	0	0	0	0	0	1	2	1	0	2	0	2	2	1	2	0
11	1	2	2	2	2	2	2	1	1	2	1	1	1	2	2	1	1	1	1	1
12	3	2	2	2	2	2	2	2	1	2	2	1	1	2	1	0	1	2	2	2***
13	1	1	1	2	2	2	1	2	1	1	1	2	1	2	3	3	3	2	2	2
14	2	3	2	2	1	2	3	1	1	2	2	3	2	3	2	2	1	2	2	3
15	1	0	1	1	2	1	2	2	0	3	2	0	0	3	2	2	1	0	2	1
16	2	3	3	0	0	2	0	0	3	1	1	1	1	1	2	2	3	3	1	1
17	3	3	3	3	3	2	2	2	0	1	1	1	3	3	2	1	1	2	1	2
18	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	2	3	3	3	3	2	3	1	1	2	3	1	2	2	2	3	1	2	3	3
20	3	1	1	3	2	2	2	1	2	3	2	2	1	2	2	2	1	2	2	1
21	3	3	3	3	3	3	2	2	1	2	2	1	1	3	1	1	2	1	2	1
23	2	1	2	1	1	1	1	0	2	2	2	1	0	2	1	2	1	0	2	2
24	2	2	3	3	3	2	1	1	0	1	2	1	2	1	1	1	3	1	1	2
25	3	0	0	1	1	1	1	0	0	1	2	0	0	1	0	1	1	0	1	0**

*Also Complete history of CSJ, remaining life, time when overlay required, accumulated 18 kips todate.

**Historical data

***Accumulative 18 kips, Geometric/Safety Adequacy

FIGURE A3 DISTRICT RECOMMENDED DATA COLLECTION REQUIREMENTS

R = Urgency Ranking F = Frequency of Data Collection in years

3 = Must have (A)
2 = Very Important (B)
1 = Nice to have (C)
0 = Not Important

ITEM	VISUAL		RIDE		DEFLECTION		SKID		ACCIDENT RATES		MAINT. COSTS		SHOULDER COND.		CAPACITY LEVEL		GEOMETRIC	
DISTRICT	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F
1	2	2	2	2	2	2	3	2	3	1	1	2	1	2	1	2	2	2
2	3	1	3	1	3	5	3	2	3	1	2	1	1	1	-	*	0	
3	2	1	2	2	2	2	3	1	3	1	2	1	2	2	2	2	2	2
4	3	1	2	1	1	2	2	2	1	1	3	1	1	1	1	2	1	2
5	2	2	1	2	1	5	2	2	1	5	3	1	2	2	1	2	1	5
6	2	2	2	2	2	*	2	2	2	1	0		0		0		0	
7	2	2	2	2	2	*	2	*	3	1	3	1	1	3	1	*	1	*
8	2	1	2	1	2	2	3	3	1	3	2	1	2	1	2	2	2	3
9	3	1	3	1	1	*	2	1	2	1	1	1	1	2	2	2	1	*
10	3	1	3	2	2	4	2	2	3	1	3	1	1	4	1	4	1	*
11	2	1	2	1	2	2	2	1	2	1	2	1	1	2	2	1	2	2
12	3	2	3	2	3	2	3	2	3	1	3	1	-		-		-	
13	2	1	2	2	1	2	2	1	2	1	2	1	1	2	1	5	1	5
14	3	1	2	2	2	2	3	1	3	1	1	2	3	1	2	2	2	2
15	3	1	3	1	3	2	2	1	2	1	1	x	3	1	2	2	2	2
16	3	2	3	2	3	2	1	xx	1	3	1	2	1	2	1	2	1	2
17	3	2	2	2	2	5	3	2	3	1	1	5	1	2	0		3	2
18	2	1	1	1	2	1	1	2	1	1	1	1	2	1	1	3	1	3
19	3	3	2	2	3	*	3	3	2	-	1	1	1	3	0		0	
20	3	1	3	1	3	3	3	1	3	1	-		-		-		-	
21	3	1	3	2	3	2	3	1	3	1	3	1	2	2	2	1	2	**
23	2	1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	2	2
24	3	1	3	1	3	1	3	1	2	1	2	1	1	5	2	2	1	5
25	3	xx	3	xx	3	xx	3	xx	3	1	3	1	1	3	0		1	*x

*Collect on project not network level

**as changes occur

xMoving average

QUESTION 3: What I want from a PMS

Write one paragraph (or more) what your district views as the crucial issue you want addressed by the PMS.

RESPONSES:

District 1 A tool that shows changes in roadway conditions that would indicate future maintenance or rehabilitation needs.

District 2

1) A pavement management system could become the backbone for all the rehab and pavement maintenance accomplished by the Department.
   - FPS included projected overlay times
   - Rigid design is for a projected time based on 18K loads.
   - PES gives condition ratings and could provide rates of change for evaluation.

2) A pavement management system could tell us when we are using up the life of the pavement by too many and too heavy loads and indicate to some extent when and where new routes are needed.
   - Increased rates in PES score decline.
   - Pavement needing repairs or rehab before projected lives are up.

3) Optimization of preventive maintenance methods, rehab and reconstruction comparing cost vs. service life, much like the FPS program does.

District 3 District 3's use of the Pavement Management System is as a management aid in program development and maintenance activities.

District 4 As I see it, the PMS will help me in three general areas. first, it will keep one appraised as to the condition of the system. Secondly, it will allow me to create strategies to keep the system in optimum condition based on varying resources. Finally, it will give me the time necessary to select the optimum design within the available resources.

District 5 Taking ratings in spring after winter damage has occurred and prior to repair and seal coats.

District 6 We see PMS as a management tool to assist us in selecting rehab projects and providing some insight on different rehab strategies. This would allow us to schedule these 2-3 years in advance. We intend to schedule seal coat projects on an age basis with a seven year cycle as our goal. The historical data shown would be the basis of selection of these. If good meaningful structural measurement data of existing conditions can be obtained, then this could be a useful tool in evaluating rehab strategies and possibly even predicting rehab projects 5-6 years in advance. More reliable information is also needed to do pavement designs. We don't really know what the load carrying

capacity is for various kinds of hot mix that is being produced. It seems that, at present, pavement design is mostly theoretical and doesn't seem to really represent field conditions. It should be based on a mix with a certain stability or something measurable in the field so you say you put down material you designed. Then maybe we could work on rutting and cracking problems.

We would also like to tie this in with graphics so you could look at a map, say of all sections of road with pavement score of 35 or less highlighted on a color graphics screen.

District 7 PMS should provide basic, generalized data defining the overall pavement condition of a highway section.

District 8 A system that is manageable and able to fit the needs of the entire district. This system should be able to be used by the programmer, the designer, and the maintenance organization. A PMS should be inclusive of data for all needs and not fragmented for the different users. One data collection period and report use be tailored to fit the majority of needs. Presently, we are having to collect data to determine the status of our system's pavements, and collect independent data for our design needs.

District 9 We would like to have a more consistent method of selecting rehabilitation and preventative maintenance projects and then properly prioritizing them. At present, we rely on input from the resident engineers and maintenance foremen to determine which highways need to be included in these particular programs. Both selection and prioritization work fairly well within the area of one supervisor's responsibility, but we do not always get totally valid results on a district-wide basis. some reliable method comparing roadway conditions from different areas of the district is needed. A PMS program, properly used, could satisfy this need and help insure that we utilize our resources in the most cost-effective way.

District 10 The District wants a PMS that is simple to use in assisting District Management in evaluating Pavement Management Strategy.

District 11 PMS should be a management tool and serve the user and not dictate or direct actions of the user.

PMS should identify condition of system for managers; i.e., network; but more importantly be project specific.

The District feels that accident data and geometrics should be included within the system; not necessarily in the beginning but can be incorporated at a later date.

To meet the needs of the District, it is essential that a 100% sample be taken.

District 12 1. What is the distress, ride, skid, deflection, traffic, and

cross section at time of the initial inventory?
2. What is the distress, ride, skid, deflection, traffic at some later time (i.e., an interval time after the initial inventory)?
3. Identify rate of change for items listed in the Must Have and Very Important data items.
4. Forecast future needs based on rate of change of parameters.
5. Fine tune PES rating system and incorporate with HPMS.

District 13 The Pavement Management System should be a system that will be "user friendly," borrowing a term from automation jargon. All of the data collected, assembled and provided to a District or user should be easy to work with to obtain the desired information necessary to determine pavement strategies.

Consideration should also be given to the different geographical regions that some districts encompass. Identification of these areas need to be accounted for in the data collection process so that "like" areas can be grouped together. Rehabilitation and maintenance strategies will differ from one area to another. This affects costs, construction methods, pavement designs, etc. If a District or the State's needs were developed with the different regions not taken into account, an unequitable disbursement will result since some areas require less construction and maintenance dollars and some more for the same type of work.

District 14 District 14 would like to use PMS as a tool in monitoring, scheduling routine maintenance activities, maintenance contracts and construction contracts by priorities.

District 15 The District feels that having data such as condition ratings, roughness, skids and shoulder conditions available to assist in making comparative ratings would be beneficial. However, we do not feel that project selection and prioritization should be based on computerized ratings instead of determination by qualified experienced personnel with personal knowledge of historical performance.

District 16
1. Computer format to allow Districts the capability to access the information included on Sheets 1 & 2.
2. Correlate dynaflect values with falling weight deflectometer values for use in the FPS.

District 17 The Pavement Management System should establish base data for a long-range rehabilitation plan. It should provide information to evaluate strategies for programming both rehabilitation as well as maintenance funds. It should provide data on the total highway network over a two year period.

District 18 We feel PMS should provide a documented system that will enable us to quickly determine pavement conditions and alternatives for corrective actions with associated costs ranging from seal coats to complete reconstruction. The system should be designed as a

tool but not a substitute for administrative decisions. A log of such data would be available for addressing program calls and annual maintenance or rehabilitation needs. The system as such would help determine when work should be scheduled.

District 19 The most important thing a PMS should do is to identify projects that are in need of rehabilitation. If the PMS does not do this, then the expenditure of time and money is very questionable. the PMS should consider pavement condition (rutting, cracking, patching, failure, etc.), ride quality (Mays Meter) and traffic (ADT and 18 KSA). The PMS should assign a "Pavement Score" that will not only identify projects that are in need of rehabilitation, but should rate these projects in order of most/least needed. A PMS that will do this would be an important tool with which to select and rate rehabilitation projects.

District 20 Ride, Safety, Structural conditions.

District 21 A program based on a strategic forecasting strategy that will assist the user when moderate to heavy maintenance could be reasonably expected. This program should also be able to track pavement conditions to predict when rehabilitation may be required.

District 23 This District needs a database with as much information as possible concerning the pavement condition on our highways. We should be able to access the database for various kinds and types of information to assist in our programming and prioritizing projects.

District 24 Subjectively, I feel this attempt to reduce highway maintenance problems to neat formulated data is a philosophically worthy idea. In practical terms it doesn't really seem worth the time. Not a popular opinion, naturally. There's too much individual evaluation to create a wonderfully simple equitable method of allocating insufficient funds. An interesting theory to temporarily sedate some lawyers in legislative positions. But would a person want their physical problems treated by a doctor that way or have their legal problems handled by a lawyer that way? Highways have that much individuality and it effects people's health and legal well-being in a similar fashion.

District 25 The system should be designed to be a tool for management of highway system needs and offer management type reports. It is important that the PMS not replace engineering judgement by containing arbitrary controls which constrain the manager's ability to direct resources wherever needed, based on a wide range of factors outside the PMS.

QUESTION 4: DO'S AND DON'TS

We are in the process of deciding how we can modify the existing PES system to better address district needs.

Make a list of things we should do and things we should not do in putting together this plan. For example, a do might provide more personnel in districts to collect data or more training; a don't might be, don't make it too complex.

RESPONSES:

	DO'S	DON'TS
District 1	We feel you should develop an eight (8) hour Advanced Pavement Evaluation System Rater Refresher School for personnel who have been involved in PES Data collection for more than two (2) years.	
District 2	1) Try to eliminate some of the "Kingdom building," each Division doesn't need their own program to do the same thing. 2) Take into account previous money spent on a roadway. Certain roadways may look good on the day of testing, but it may have had to be sealed every year for the past five years. 3) Keep a job history of the roadways. 4) Make the information readily available on one system or by one means. There is information available that is too difficult to retrieve. Programs have to be developed to access so many files and personnel are not there to accomplish the task.	1) Don't change the skid program. The "CAN" method used today gives us the data that can be used in materials studies. A change to the old "Hanson" method of data collection would make the data useless for materials evaluation. 2) Don't limit the PMS to PES.

	DO'S	DON'TS
District 3	More training for district personnel.	
District 4	1. Sample 100% of system. 2. Provide needed resources to regional data centers. 3. Determine optimum frequency for collecting data. 4. Include geometry data. 5. Include date last surfaced in data. 6. Combine skid data. 7. Consider rating of pavement by maintenance foreman. 8. Write programs for easy access to data in sorted form. 9. Keep simple. 10. Staff each District with a pavement manager to oversee PES. 11. Use as management tool to see effectiveness of construction and maintenance programs in District.	1. Don't make too complex. 2. Don't use to allot monies to Districts. 3. Don't consider to be "Final Word," but as a tool to help to manage resources.
District 5	Make the program results simple to interpret.	1. Don't make it too complicated. 2. Don't secure a lot of data that requires a great deal of time and personnel to gather for a small amount of useful information.

	DO'S	DON'TS
District 6	Data collection of this magnitude and quality will require more people and more equipment will require "pavement specialists" in the Districts. But, if we are going to do it, it should be accurate and useful to the Districts on a project level. Make on-demand reports that can be selected by county, highway, pavement score, year of last surface, etc.	Don't make it too complex to predict things such as one-year maintenance costs, quantity estimates, geometric evaluations, fund allocations by function that are massive when trying to make a formula to represent. This can easily mushroom into a system that runs us instead of us running the system. This should only be a management tool, not an absolute. We need to improve what we know about HMAC such as how to prevent rutting, before a computer can get specific enough to allocate money.
District 7	Provide enough basic data to define generalized pavement conditions.	Do not get into project-specific data which would be needed only for design purposes on an actual project. For example, it does not appear to be practical to maintain deflection data on the entire highway system. This data should be collected on an "as-needed" and "when-needed" basis. Please keep in mind that if PMS is to be successful, all of the data must be current. The cost of maintaining an excessively elaborate system could become prohibitive.

	DO'S	DON'TS
District 8	Make the FWD data interchangeable with the dynaflect for design.	Don't make the system so hard to operate that the user will not use it.
	Expand the time frame required to collect data to year-round so that the northern districts do not have to be collected in the wintertime.	Tailor this report or program to fit only the needs of maintenance, but instead include the designer and programmer.
	Provide FTEs for the five regional centers so that they can properly staff for data collection.	
District 9	We feel that raters should have additional training on entering visual evaluation data on ROSCOE terminals. This training should include instructions on entering data, retrieving information and interpretation of error messages.	We would like to see the use of video tape presentations as the primary instructional tool for JCP and CRCP discontinued or at least modified. We feel that first-year raters cannot be satisfactorily trained in this manner and more "live" presentations, with its accompanying increase in two-way communication, would be extremely beneficial.
		We would like to see alternate locations for rater training schools. Because of the heavy traffic and limited amount of representative PES sections in Austin, we feel these schools could be more beneficial if taught elsewhere.
District 10	Develop and utilize latest automated equipment to collect data.	Attempt to replace Engineering judgement with data system.
		Increase manpower for data collection.

	DO'S	DON'TS
District 11	1. Consideration should be given to staff the operation adequately, but not create another section of turf. 2. Desirable to mechanize to the maximize the data gathering process in order to reduce human resources. 3. Ultimately expand data gathering capabilities from the region concept to each individual district.	Don't make PMS complicated. Keep it simple.
District 12	Start out with a small sample size. Coordinate with Design/Construction./Maintenance/Planning and Lab. - possibly develop District Task Force to monitor development. Do allow for regional and environmental differences such as types of soil, rainfall, available materials, and cost of materials.	
District 13	Begin with a basic system and add to the system as needs develop. Provide for an impartial evaluation of the system.	
District 14	1) Budget additional personnel for the Region Center to collect data. 2) Work on Siometer program so data does not have to be collected manually. 3) Require Districts to use same traffic control personnel throughout their District. 4) School on how to collect FWD data.	1) Don't modify existing system before Regional Centers have PC-XT computers to process data collected. 2) Don't add any new system until Regional Center has personnel, equipment, and knowledge to collect valid data.

	DO'S	DON'TS
District 15	Do provide additional personnel to D-10 so that most of the data can be obtained in a uniform and coordinated state-wide manner. The equipment and collection methods would be consistent throughout the State and the resultant data base could be compared equally.	Don't let computerized selection methods override local decisions made by logical and experienced personnel familiar with the roadways. Don't let a situation develop whereby those districts, which have very diligently managed and maintained their roadway pavements, suddenly find that their funds are severely reduced in order to provide funds to those who have not maintained their roads in as comparable condition as others. You would then penalize those Districts which have been doing a good job maintaining their roads, by withholding needed funds to continue to maintain their roadways, forcing them, due to lack of funds, to allow their roadways to deteriorate to a state comparable to the roadways in those areas which did not provide a high level of maintenance management.
District 16	Need at least one full-time PES data collector. Need regional center to be responsible for complete traffic control when testing. Need training on use of siometer and personal computers for those working with PES on local level.	Don't require the Maintenance Sections to provide traffic control needs on very short notice.
District 17	1. Define a single reference system based on mile post. 2. Coordinate all data collection into one program.	Don't complicate.

	DO'S	DON'TS
District 18	1. Provide for easy access. 2. Easily understood data. 3. Provide for personnel allotments to handle system. 4. Field test data collection equipment before implement. 5. Use PES as a tool.	Don't take all information generated at face value. Allow for error.

District 19

The equation that computes the "Pavement Score" should be more sensitive to ride quality (Mays Meter), traffic (ADT and 18 KSA), and strength (Dynaflect), and less sensitive to the visual rating than the present system. Under the present system, a pavement with a fair to poor ride quality (Mays Meter) may be given a very high pavement score if it has recently had a seal coat that is covering up cracks and patches.

It is possible that two or more pavement raters would assign a slightly different pavement rating to the same pavement. for this reason, it is desirable that field pavement rating personnel be the same from one year to the next. this would give a more accurate comparison of pavement ratings for one year to the next.

The proposed PMS should identify the existing pavement structure. The PMS should, for example, identify 6: ACP, 12" Flex Base and 8" Lime Treated Subgrade.

The present pavement rating system is very heavily weighted toward the visual rating. That is, the present system is to cosmetic. A pavement with a new seal coat or thin ACP Overlay will probably have a pavement score of 90 or above. Pavements that "look good" may have substantial rutting, cracking and patching and not be very structurally sound.

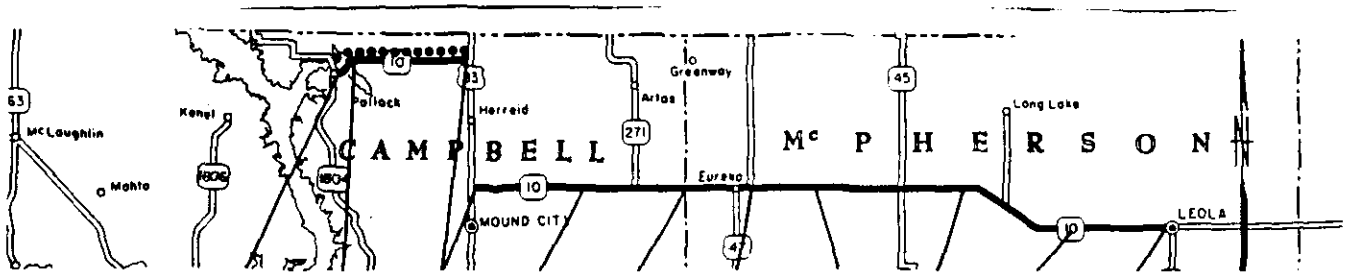
District 20		Don't try to develop a PMS based on theory. Poor maintenance can lead to disproportionate fund allocations.
District 21	1. Include skid data to assist in determining short range maintenance needs as well as an in situ evaluation of different types of materials used. 2. Need additional training of input of various data and types of reports that can be generated.	

	DO'S	DON'TS
District 23	1. Include strength data and analysis in all surveys. 2. Conduct visual inspections in late winter and early spring.	1. Don't determine funding allocations based solely on PES data. 2. Don't prioritize needed projects at the Austin level based on PES data.
District 24	-Simplify the system. -Hope that the SHRP program will produce something of value. -Rely on the people in the Districts to maintain highways that can be worthy of our Texas, traditionally best in the nation system.	-Don't keep adding sections. -Don't become inflexibly locked into a rigid numbering system. -Don't lose track of the variety of environmental non-load-bearing factors that impact highway repair costs.
District 25	1. Make it user friendly. 2. Provide management type reporting system. 3. Link various years of data to provide historical reports for a given section of road. 4. Train managers in use of system.	1. Don't provide a system that controls funding or fund distribution. 2. Don't design a system that undermines engineering judgement. 3. Don't saddle the districts with additional manpower requirements unless additional personnel allocations are increased proportionally.

Appendix B Network Summary Sheets

Within a PMS a large volume of information is stored about the current conditions of the highway network. To be of value this information must be made available to district personnel in a timely manner and in a format that is easily understood. If Texas is to spend large sums of money to build and maintain a computerized inventory it is crucial that detail plans be made as to now this information can be made available to field personnel. Several states use Network Summary Sheets to achieve this. Shown in Figures B1 and B2 are the Network Summary Sheets currently used by the South Dakota DOT. This two page summary contains a wealth of information on each highway. These log books are produced annually and are used extensively by field personnel when maintenance and rehabilitation programs are being developed.

The level of detail in these network sheets varies from state to state. However this is one of the types of output that the field personnel frequently request. It should be a top priority of the Austin based PMS support group to define an appropriate summary sheet for the State of Texas.



FA-SYSTEM VOL-GRP FUNC-CLASS DIRECTION	FAS R-RA C	FAS R-RA C	FAP R-RI A	FAP R-RI A	FAP R-RI A	FAP R-RI A	FAP R-RI A	FAP R-RI A	FAP R-RI A
BEGINNING MRM	182.37	186.00	203.22	212.00	220.24	225.24	230.00	242.00	251.00
MRM DISPLACEMENT	0.000	0.049	0.000	0.291	0.000	0.000	0.257	0.236	0.241
LENGTH	1.699	9.296	9.071	7.954	4.999	5.013	11.379	9.005	7.078
YEAR BUILT	1962	1962	1953	1956	1955	1948	1952	1952	1948
YEAR LAST SURFACED	1983	1983	1976	1978	1978	1960	1972	1963	1960
YEAR LAST SEALED			1983	1983	1983	1967	1981	1968	1967
RANK: STATE-SYSTEM	2514-1179	2645-1202	2542-2066	2564-2083	2361-1939	1563-1377	2341-1916	1195-1147	1302-1227
PCEMS NUMBER									
YEAR PROGRAMMED (FY)									
YEAR OF NEED (FY)	1996	1997	1996	1996	1997	1990	1994	1986	1987
PROJECT STATUS	1	1	1	1	1	1	1	1	1
IMPROVEMENT: TYPE	AC RESUR	AC RESUR	AC RESUR	AC RESUR	AC RESUR	SMW & AC	AC RESUR	AC RESUR	AC RESUR
COST(1000)	232,2	1,333,7	1,144,3	1,087,2	717,5	1,152,7	1,961,9	897,5	823,7
PCEMS NUMBER	504X	504X					4738		
YEAR PROGRAMMED (FY)	1987	1987					1997		
YEAR OF NEED (FY)	1983	1983	1987	1987	1987		1987	1987	2005
PROJECT STATUS	1	1	1	1	1		1	1	1
IMPROVEMENT: TYPE	CHP SEAL	CHP SEAL	CHP SEAL	CHP SEAL	CHP SEAL		CHP SEAL	CHP SEAL	AC RESUR
COST(1000)	216,5		85,8	75,2	47,3		73,0	85,1	1,501,0

FA-SYSTEM - The federal-aid designation of the segment.

VOL-GRP FUNC-CLASS - The traffic volume group and functional classification of the segment.

DIRECTION - The direction of travel for divided routes.

BEGINNING MRM - The beginning mileage reference point of the highway segment.

MRM DISPLACEMENT - The distance, in thousandths of miles, from the MRM inplace alongside the roadway.

LENGTH - Length of segment in thousandths of miles.

YEAR BUILT - The year the existing grade was constructed.

YEAR LAST SURFACED - The year the existing surface was applied.

YEAR LAST SEALED - The year the last surface treatment was applied to the surface.

RANK: State-System - All highway segments are ranked for prioritizing purposes. The first figure is the statewide rank. The second figure is the sequential rank by federal-aid system.

PCEMS NUMBER - (Preconstruction Engineering Manpower Management System) Project Control System number, used for identification and cross-reference purposes.

YEAR PROGRAMMED (FY) - The year this project appears in the currently approved highway construction program.

YEAR OF NEED (FY) - The anticipated year this segment will need improvement.

PROJECT STATUS - The present status of this highway segment.

Costs Included In Needs Summaries:
1. The segment has been analyzed for needs.
2. This phase of work will not bring the project to full design strength. At least one more stage of construction is required.
3. This phase of work is staged and when completed will bring the project up to the designed strength.

4. and 5. Unassigned.

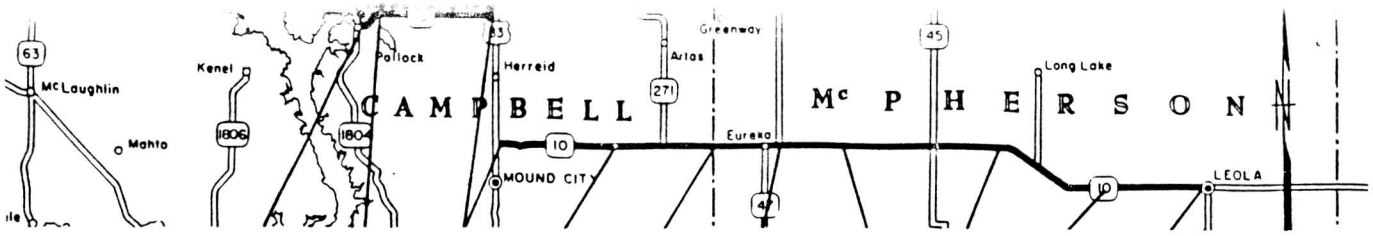
Costs Not Included In Needs Summaries:
6. Not evaluated for costs.
7. This segment is of county or local significance on the state trunk highway system.
8. An under construction project has been completed.
9. Indicates the project has been let and is under construction.

IMPROVEMENT TYPE - The type of improvement for which the cost is computed.

IMPROVEMENT COST - The estimated cost of the proposed improvement shown to the nearest $100. Costs are inflated at the current inflation rate to the year programmed, or if none, to the year of need.

●●●●● Non-state-importance highways.

Figure B1 - South Dakota DOT Network Summary Sheet 1 (Project Status)



BEGINNING MRM	182.37	184.00	203.22	212.00	220.24	225.24	230.00	242.33	251.00
MRM DISPLACEMENT	0.000	0.069	0.000	0.291	0.000	0.000	0.257	0.236	0.241
LENGTH	1.699	9.296	9.071	7.954	4.999	5.013	11.979	9.005	7.079
YEAR BUILT	1962	1962	1953	1956	1955	1948	1952	1952	1948
YEAR LAST SURFACED	1983	1983	1976	1978	1978	1960	1972	1963	1960
YEAR LAST SEALED			1983	1983	1983	1967	1981	1968	1967
PSR EQUIVALENT	3.93	4.06	3.92	3.96	4.00	3.06	3.66	2.33	2.69
CURRENT ADT	446	305	585	744	920	960	933	864	865
NUMBER OF TRUCKS	105	91	50	65	91	84	82	76	74
ROADBED LAYERS 1	62-BU-42	62-BU-40	53-BU-34	55-BU-40	55-BU-40	48-BU-31	52-BU-33	52-BU-32	49-BU-32
	4.0-12.0	4.0-12.0	3.0- 9.0	3.0- 9.0	3.0- 9.0	- 6.0	6.0- 8.0	- 9.0	- 6.0
2	62-BU-38	62-BU-36	54-BU-36	56-BU-36	56-BU-36	60-AF-31	52-AF-33	52-BU-32	60-AF-25
	- 5.04	- 5.0	- 5.0	- 5.0	- 5.0	- 3.5	- 1.3	- 6.0	- 3.5
3	68	68	54-AF-24	56-AF-26	56-AF-26	67	72-AE-33	63-AF-32	67
	ASPH TRT	ASPH TRT	- 1.5	- 1.5	- 1.5	CHP SEAL	- 1.5	- 1.5	CHP SEAL
4	68	68	54	63	57		81	63-AF-24	
	CHP SEAL	CHP SEAL	CHP SEAL	CHP SEAL	CHP SEAL		SND SEAL	- 2.5	
5	83-AD-26	83-AD-26	76-AE-24	78-AD-26	78-AD-26			68	
	- 2.04	- 2.0	- 1.3	- 1.3	- 1.3			CHP SEAL	
6			83	83	83				
			SND SEAL	SND SEAL	SND SEAL				
7									
8									
9									
10									
SURFACE - ROAD WIDTH	26-38	26-36	24-36	26-36	26-36	24-31	33-33	24-32	25-32
SURFACE TYPE	BIT-MAT	BIT-MAT	BIT-MAT	BIT-MAT	BIT-MAT	BIT-MAT	BIT-MAT	BIT-MAT	BIT-MAT
SHOULDER TYPE	BLOTTER	BLOTTER	BLOTTER	BLOTTER	BLOTTER	BLOTTER	BLOTTER	BLOTTER	BLOTTER
SUFFICIENCY RATING:									
CONDITION - SAFETY	36- 29	36- 29	35- 30	35- 29	36- 28	29- 22	32- 25	20- 24	26- 25
SERVICE - NET RATING	28-093	27-092	28-093	28-092	27-091	26-077	27-084	24-068	26-077
SURFACE INDICATOR	088	084	082	082	088	066	074	039	058
AVERAGE ROUGHOMETER	3.70	4.11	4.07	4.13	3.99	3.68	4.08	3.39	3.36
AVERAGE STRENGTH	3.56	2.67	2.91	2.44	2.45	2.59	2.91	3.13	2.17
SKID TESTS:									
0 TO 20 - 21 TO 30	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0
31 TO 40 - 41 +	0- 4	0- 9	0-10	0- 8	3- 3	1- 5	0-13	0- 9	0- 7
RUTTING: % >.5"-SEVEREST	00-0.3	00-0.4	00-0.4	00-0.5	00-0.4	00-0.5	00-0.3	00-0.4	00-0.5
NUMBER OF STRUCTURES	1	1	0	0	0	0	0	0	0
FHWA RATING 1- 2	91-	91-	-	-	-	-	-	-	-
3- 4	-	-	-	-	-	-	-	-	-
5- 6	-	-	-	-	-	-	-	-	-
7- 8	-	-	-	-	-	-	-	-	-
9-10	-	-	-	-	-	-	-	-	-
MAINTENANCE COSTS($100)									
ROADWAY SURFACE	1	2	2	2	1.2	1.1	4	6	4.8
STRUCTURE	0	0	0	0	0	0	0	0	0
CONTRACT MAINT.	0	0	1.7	1.5	1.5	0	0	0	0
TOTAL	2.7	9	2.7	2.4	3.7	1.8	1.1	1.3	5.8
ACCIDENTS: RATE	1.37	1.02	.71	1.51	.79	.57	.08	.12	.92
NO. OF FATAL-INJURY	0- 0	0- 1	0- 0	0- 2	0- 1	0- 0	0- 0	0- 0	0- 2
NO. OF PROP. DAMAGE	1	1	4	3	1	3	1	1	0

BEGINNING MRM - The beginning mileage reference point of the highway segment.

MRM DISPLACEMENT - The distance, in thousandths of miles, from the MRM inplace alongside the roadway.

YEAR BUILT - The year the existing grade was constructed.

YEAR LAST SURFACED - The year the existing surface was applied.

YEAR LAST SEALED - The year the last surface treatment was applied to the surface.

PSR EQUIVALENT - Present Serviceability Rating equivalent. A numeric rating from 0.00 to 5.00 with 5.00 being a perfect rating.

CURRENT ADT - Current Average Daily Traffic.

NUMBER OF TRUCKS - Current Average Daily Truck Traffic.

ROADBED LAYERS - The first line shows the year the layer was constructed, layer type, and layer width. The second line shows the thickness of the layer. An "*" after the second line indicates the layer does not apply to the entire length of the segment; a "$" indicates the layer data refers to the combined shoulders only.

SKID TESTS - The number of skid tests are recorded in four ranges on two lines. The ranges are: 0-20, 21-30, 31-40 and 41+.

RUTTING - The first value is the percent of segment with rutting in excess of 0.5"; the second value is the most severe rut depth averaged over the worst 50 foot length.

NUMBER OF STRUCTURES - The number of structures within the highway segment.

FHWA RATINGS - The FHWA structure sufficiency rating for each structure.

SURFACE ROAD WIDTH - The measured width of the surfaced driving lanes and the total roadway width including shoulders.

SURFACE TYPE - The prevailing surface type of the driving lanes.

SHOULDER TYPE - The prevailing shoulder type along both sides of the driving lanes.

SUFFICIENCY RATING - The first line shows the condition and safety rating. The second line shows the service and the total net rating. The third line shows the surface indicator which reflects the percent of par value for all elements pertaining to the surface. Perfect ratings are:

Condition	- 40
Safety	- 30
Service	- 30
Total Net	- 100
Surface Indicator	- 100

AVERAGE ROUGHOMETER - The average of the most recent roughness readings for the segment.

AVERAGE STRENGTH - The most recent dynaflect readings along the highway segment are averaged. This value is subtracted from 5 to allow the higher number to represent a strong highway segment and a low number to represent a weaker highway segment. A value of 5 in the report indicates no test data available.

MAINTENANCE COSTS ($100) - The average maintenance cost over the last three years shown in hundreds of dollars per mile per year.

ACCIDENT RATE - The accident rate for the last three years.

NUMBER OF ACCIDENTS - The number of fatal, injury and property damage accidents for the last three years.

●●●●●● Non-state-importance highways.

Figure B2 - South Dakota DOT Network Summary Sheet 1 (Pavement Condition)