DEVELOPING A PAVEMENT FEEDBACK DATA SYSTEM

by

R. C. G. Haas

Research Report Number 123-4

A System Analysis of Pavement Design
and Research Implementation

Research Project 1-8-69-123

conducted

in cooperation with the
U. S. Department of Transportation
Federal Highway Administration

by the

Highway Design Division Research Section
Texas Highway Department

Texas Transportation Institute
Texas A&M University

Center for Highway Research
The University of Texas at Austin

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PREFACE

Project 123, "The Development of a Feasible Approach to Systematic Pavement Design and Research," was initiated in 1968 as a cooperative effort between the Texas Highway Department, the Center for Highway Research of The University of Texas, and the Texas Transportation Institute of Texas A&M University. The report was prepared by Dr. R. C. G. Haas during his stay at the Center for Highway Research.

There have been several significant accomplishments in this project, the primary one being the development of a working system for flexible pavement design. The system is currently undergoing trial implementation and is described in Research Report 123-1, "A Systems Approach Applied to Pavement Design and Research," and in Research Report 123-2, "A Recommended Texas Highway Department Pavement Design System User's Manual."

It was realized in the formulation of Project 123 that some means for continued evaluation of the design system must be established. An efficient feedback data system was considered as necessary for this purpose. Work began on the system in the spring in 1970 and the planning and initial development are described in detail in this report. As well, a framework and guidelines are presented for the future development and implementation.

This project is supported by the Texas Highway Department in cooperation with the Federal Highway Administration Department of Transportation. Their sponsorship and support are gratefully acknowledged.

W. Ronald Hudson
B. Frank McCullough
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James L. Brown

PRINCIPAL INVESTIGATORS
Project 123

August 1970

LIST OF REPORTS

Report No. 123-1, "A Systems Approach Applied to Pavement Design and Research," by W. Ronald Hudson, B. Frank McCullough, F. H. Scrivner, and James L. Brown, summarizes the first year results of a long-range comprehensive research to develop a pavement systems analysis, describes a realistic approach to analysis of pavement design and presents a working systems model.

Report No. 123-2, "A Recommended Texas Highway Department Pavement Design System Users Manual," by James L. Brown, Larry J. Buttler, and Hugo E. Orellana, offers instructions for obtaining and processing data involving the "THD Flexible Pavement Design System."

Report No. 123-3, "Characterization of the Swelling Clay Parameter Used in the Pavement Design System," by A. W. Witt, III and B. Frank McCullough, gives the results of a study of swelling clay parameter. The report offers a design equation.

Report No. 123-4, Developing a Pavement Feedback Data System," by R. C. G. Haas, gives an account of the initial planning and development of a pavement feedback data system.

ABSTRACT

The design and management of pavements rely on an imperfect technology. One of the most efficient means for continuous improvement of the design and management process lies in the development of comprehensive and systematic information systems.

This report describes the planning and initial development of a pavement feedback data system as a part of a larger project titled "A System Analysis of Pavement Design and Research Implementation." The general principles underlying data system development and use are presented and the specific functional and operational requirements of the pavement data system are discussed. Integration of the system with other data acquisition and processing operations of the Texas Highway Department are considered.

A set of factors is identified and categorized into a master file and six subfiles. These factors have been coded and coding forms have been prepared.

Several example sets of data retrieval from the system are presented. It is recommended that future work in the project should be primarily concerned with developing a sampling plan and guides, with the continuing of software development and a trial implementation of the data system.

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SUMMARY

For many years, engineers associated with research and design of highway pavements have realized that a pavement feedback data system would be a valuable aid to improving pavement design technology. This report describes the initial planning and development of a comprehensive highway pavement feedback data system. The pavement feedback data system forms a basic part of the pavement design system that has been developed and is being implemented on a trial basis into the Texas Highway Department.

In the early stages of development of the pavement design system, it was realized that some means of planned, continued evaluation of the design system must be established. The development of an efficient feedback data system was considered as necessary for this purpose. The major goals for this feedback data system are

(1) to supply selected physical and cost data acquired on a regular schedule from selected sections of highway to the research arm of the Texas Highway Department for use in evaluating the pavement design system and

(2) to ultimately supply District and State levels of management with certain physical and cost data in a form convenient for use in managing the pavements within the District and the State.

These goals will make it possible to improve the reliability of various sub-systems based on observations of in-service pavements. The feedback data system and subsequent evaluation will include the areas requiring additional study thus establishing priorities for research projects. The availability of the data will allow the District personnel to design projects based on up-to-date performance data as well as to have a reservoir of information from which to select.

When completely developed and implemented into the daily activities of the Texas Highway Department, this computerized system will be a valuable tool for the highway administrator as well as the highway researcher. Since the design and management of pavements rely on an imperfect technology, continuous improvement of the design and management process is necessary.

IMPLEMENTATION STATEMENT

The feedback data system is an important part of the flexible and rigid pavement design systems. The feedback system will be put into actual use by the Texas Highway Department as soon as the sampling plans and storage and retrieval programs have been developed. It will be implemented on a trial basis using selected projects designed by the flexible and rigid pavement design systems. In future years, the feedback data system will finally include most of the highway pavements designed, constructed, and maintained by the Texas Highway Department. The feedback data system must be implemented as soon as possible as it will provide a valuable basis for checking the existing design system and for improving the models.

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CHAPTER 1. INTRODUCTION

The Role of Data Systems

Data have been collected for decades on various natural and man-made systems. The transportation system has, because of its complexity, required unusually large amounts of data to be collected for effective planning, design, and operation. Urban traffic studies were perhaps the first component of this system to systematize the collection, processing, and analysis of their data. Other areas followed rapidly, and today extensive data banks have been established for a variety of technical, economic, social, and political purposes. In transportation, similar development has taken place, except in pavement design and management.

A data system involves more than just the collection of data. It also includes the processing, storing, retrieving, and analyzing of the information, with automation providing the capacity to handle large amounts of data. Since most of our existing technology is far from perfect — and this includes the pavement field — such data systems can provide a most useful feedback function. This feedback role involves the efficient use of information from operating systems, both to improve the performance of these systems and to upgrade or update the technology.

Project 123 and the Feedback Data System

Project 123 involves the development of a comprehensive working system of pavement design and management for the Texas Highway Department, as detailed in a previous report (Ref 1). This working system makes extensive use of the computer and is based on the principles of systems engineering.

The basic philosophy of the project was that a working system should be instituted as soon as possible rather than when the ideal method is available, which may be far into the future. Rather, it was argued that such a working system could incorporate the best of existing technology and knowledge and that it could be organized so as to readily incorporate new knowledge as it became available. In other words, continual updating and improvement of the system was envisioned.

To accomplish these improvements with time, one of the explicit objectives of Project 123 was to develop and implement a pavement feedback data system. The systematic collection, storage, retrieval, and analyses of data on pavements designed and constructed by the working system was considered as the necessary mechanism for these improvements.

Scope and Objectives of the Report

This report is concerned with the progress to date in planning and developing the feedback data system of Project 123. The specific objectives of the report are

(1) to outline the general principles of data system development,

(2) to outline the requirements for the Project 123 system,

(3) to describe the planning and development to date of the pavement feedback data system, including coordination with other highway department data files, and

(4) to comment on implementation plans for the data system and to briefly discuss the necessary software development for retrieval and analyses of stored data.

This report is the first from the feedback phase of Project 123. Similar to Report 123-1, it basically describes the work accomplished to date and is a background document or framework for future work.

CHAPTER 2. GENERAL PRINCIPLES OF DATA SYSTEM DEVELOPMENT

Scope and Function of a Data System

A data system can be simple in concept but comprehensive in scope. Its basic function of course is to provide information, efficiently, quickly, and cheaply, for planning, design, and operating needs. Thus, the concept is simple but the scope of a data system involves the following general aspects:

(1) proposed use of the data,

(2) collecting data,

(3) organizing and processing data,

(4) storing data,

(5) retrieving data, and

(6) analyzing data.

If the function of a data system is to provide planning or design information based on large amounts of data, an automated means for processing, storing, and retrieving these data is required. The design and use of a computer-based system is again relatively simple in concept. However, past experience has shown that it is very easy to underestimate the effort required to institute and maintain a comprehensive data system of this sort. Consequently, while the scope of the system may be broad, as shown in the foregoing list of aspects, its particular function or purpose within an agency must be most carefully considered and detailed.

The Overall Highway Data System

Any particular highway department maintains data files on practically all aspects of its operation and some of these are automated. However, the establishment of an overall, automated, and integrated data system for the entire department is a complex and comprehensive task. Nevertheless, the state of Wisconsin Department of Transportation has recently reported their efforts in establishing a "Highway Network Data and Information System" (Ref 2) as part of their Integrated Operations System. The Texas Highway Department (Ref 3) had previously reported their attempts to analyze and to automate where possible, a major portion of their planning information (including traffic and general road, bridge, and financial inventories.

Since a pavement data system must be developed within the context of such a broader highway data system, it is useful to briefly explore some of the major considerations involved. These would include the following:

(1) relationship of data system to planning,

(2) basic design and use criteria, and

(3) indexing, control, and coordination.

Many highway departments are currently either considering or implementing systems for resource allocation over some time span, often referred to as a planned-program-budgeting system (PPBS). The effectiveness of the decisions to allocate resources is directly related to the level of support information available on economic and physical factors. A properly designed and operated data system can provide as an output function this necessary support information.

The basic design and use criteria involve the fact that while data is acquired and stored in a single-element manner, it may be required by a number of individuals in the department. Many data systems, however, allow processing only within that particular system, which results in considerable duplication and inefficiency. Obviously, it would be desirable to institute common controls in order to provide the capability of requesting data from all the systems in use. On an even broader basis, planning is currently underway for developing a statewide information management system in Texas (Ref 4). This would be conducted through an information systems coordinator in the Governor's office on a sort of "brokerage" basis, with the capacity to access individual departmental or agency data banks.

Proper indexing, control, and coordination are the key to satisfying the previously noted basic design and use criteria. A common locational index is probably the best method for accomplishing this, and ideally it would provide capability for three types of referencing:

(1) route location and number (i.e., highway number, section, mileage, etc.);

(2) geographical coordinates, a type with particular application to urban transportation planning and the Universal Transverse Mercator Grid is probably most applicable (Ref 5); and

(3) project number.

Using all three means of indexing expands the capacity for communication between the user and the data base containing the various individual data files. However, it may be feasible to use only one or two methods for a particular department and this should be satisfactory, provided the entire network can be referenced.

The development of a data management system on a widespread basis requires the inclusion of a very large number of comprehensive data files. Wisconsin (Ref 2) has emphasized that this requires many years, and consequently the implementation must be done in stages.

Types of Data Systems

The type of data system required for any particular purpose depends upon a number of factors. It was pointed out in the previous section that common indexing and access to all data files is desirable. While this could be accomplished with a manual system, it is most easily and efficiently accomplished with the last of the available data systems which are listed below:

(1) manual data system,

(2) manual data system with semi-automatic retrieval capability,

(3) punched cards,

(4) "basic" computer system, and

(5) "integrated" computer system.

Figure 1 illustrates these categories of data systems in order of increasing capability, together with some comments on their principal features. Types one, three, four, and five have been well described and discussed in relation to accident reporting systems by Row (Ref 6). He has pointed out the advantages and limitations of each type and all four are generally applicable to an overall highway information system or to one of its component data systems.

The second type shown is often referred to as a "peak-a-boo" card system and has found use in a number of situations (e.g., the Canadian Good Roads Association uses this to retrieve information on research in progress). It simply involves punching holes in plastic cards containing a 100-by-100 matrix, with each point in the matrix representing a key word, data field, etc. Matching cards for common holes enables the information searcher to very rapidly determine the particular documents relevant to the search.

In view of the computer hardware available to most highway departments, it seems that the integrated computer system can be achieved as easily as any of the others. Certainly, it has more capability and should require no extra manpower resources over the other types of data systems available.

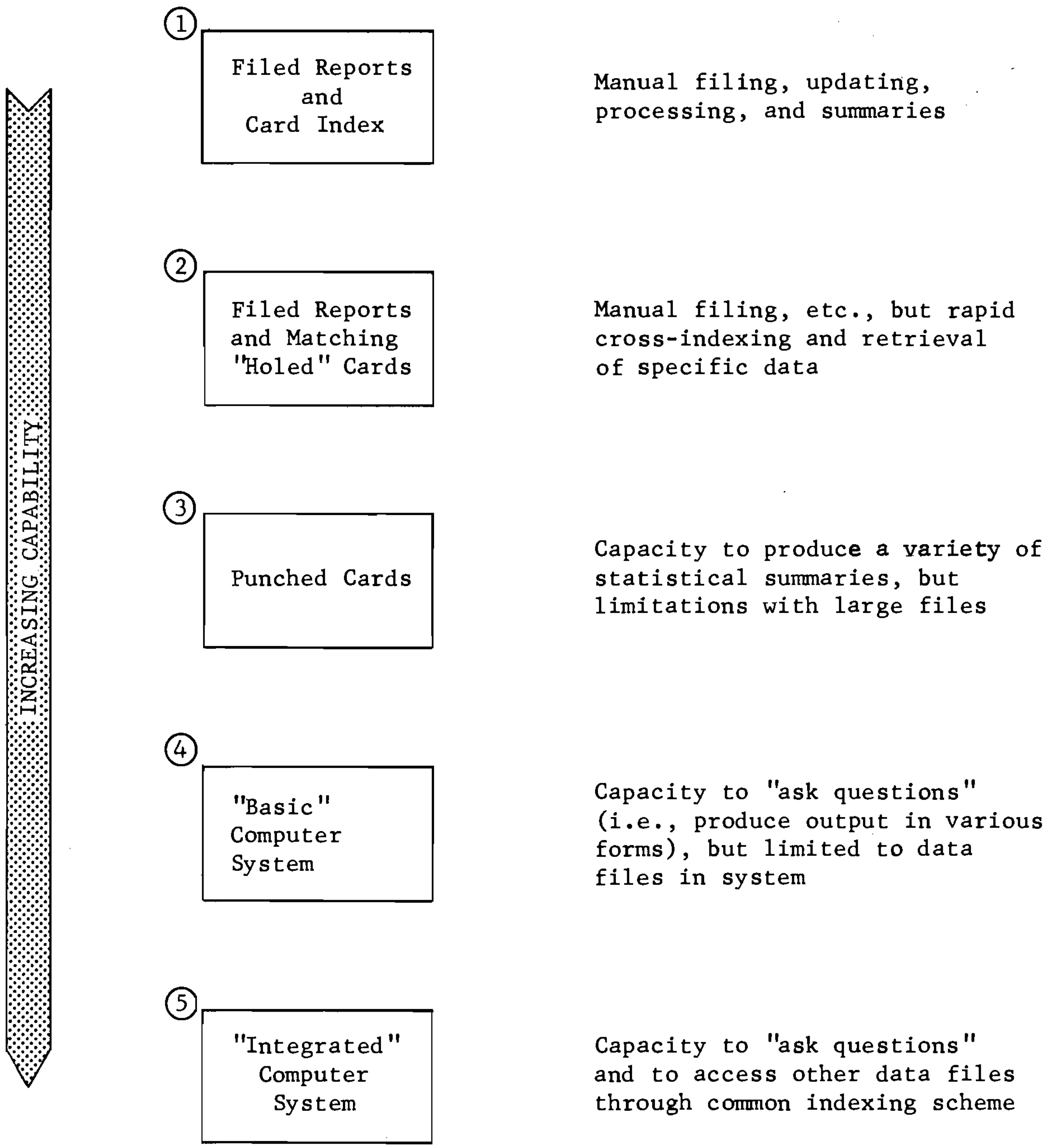

Fig 1. Types of available data systems in order of increasing capability.

Prior Work in the Pavement Area

An introductory report (Ref 7) outlined some of the basic concepts involved in developing a pavement data system. Its basic purpose was to define some of the broad steps or phases of this development and also to provide an overall understanding of the principles involved as a prelude to efficiently coping with the many particular details and special requirements involved in the actual development and implementation.

These general principles as applied to pavements were previously discussed by Hutchinson and Haas (Ref 8). More recently, Haas and Hudson (Ref 9) have outlined the role of a feedback data system within the context of a pavement performance evaluation scheme. Data banks for one or more specific pavement performance factors are known to have been established by several agencies, but the work has generally not been reported. Consequently, there is very little available literature relating to pavement data systems. However, because of the progress made in other areas of transportation, the pavement field can make use of much of the experience gained. This has provided some of the background for the following sections.

Role of Performance Evaluation and Data System in Pavement Management

The overall goal of Project 123 is to develop a comprehensive pavement management system. Consequently, it is useful to demonstrate the role of performance evaluation as a major management activity and, in turn, the role of the data system as a major component of performance evaluation.

Figure 2 is a condensation from Haas and Hutchinson (Ref 10) and shows the principal elements of pavement management as well as the role of performance evaluation in this system. The information flows, as shown, result in a continuous process of feedback. Developing and implementing a performance evaluation scheme as a portion of this overall management system can be

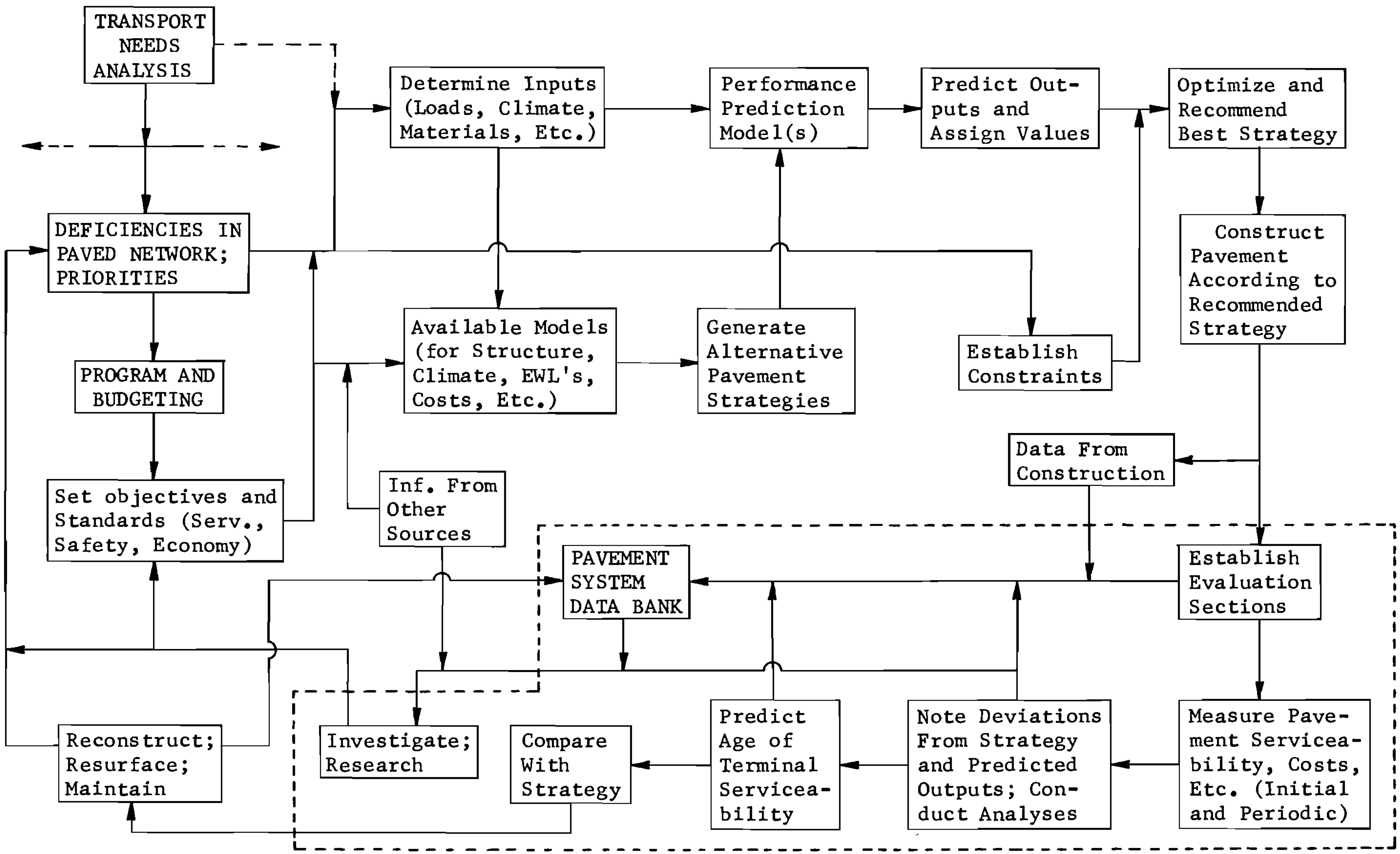

Fig 2. The role of performance evaluation in a generalized pavement management system.

a comprehensive task within itself. Several aspects of this are discussed in the following section.

Developing and Implementing a Pavement Performance Evaluation Scheme

The method for evaluating pavement performance by any particular highway department may be quite sophisticated in certain aspects, or it may be relatively casual. Whatever scheme is used, it is a subsystem of their overall pavement management system, whether explicitly recognized as such or not.

Figure 3 shows the major phases or steps involved in developing and implementing a performance evaluation scheme. The top of the diagram shows that performance evaluation has been recognized explicitly as a distinct management activity or subsystem. Moreover, Fig 3 is constructed to emphasize the data system portion of the performance evaluation scheme.

The major phases of this performance evaluation scheme, as represented by Fig 3, may be listed as follows:

(1) preliminary planning, including an inventory of present practices and data collection resources (manpower and equipment), a review of other systems in use, a statement of goals and objectives as they relate to both the collection of performance data and to the user, a statement of constraints, and a preliminary estimate of costs in relation to a feasible schedule for the scheme;

(2) identification and classification of all factors (climatic, materials, load, construction, maintenance, etc.) and their interactions that affect pavement performance or are measures of the performance achieved and/or the design strategy selected; this includes an initial selection of key factors (subject to future additions or deletions) based on

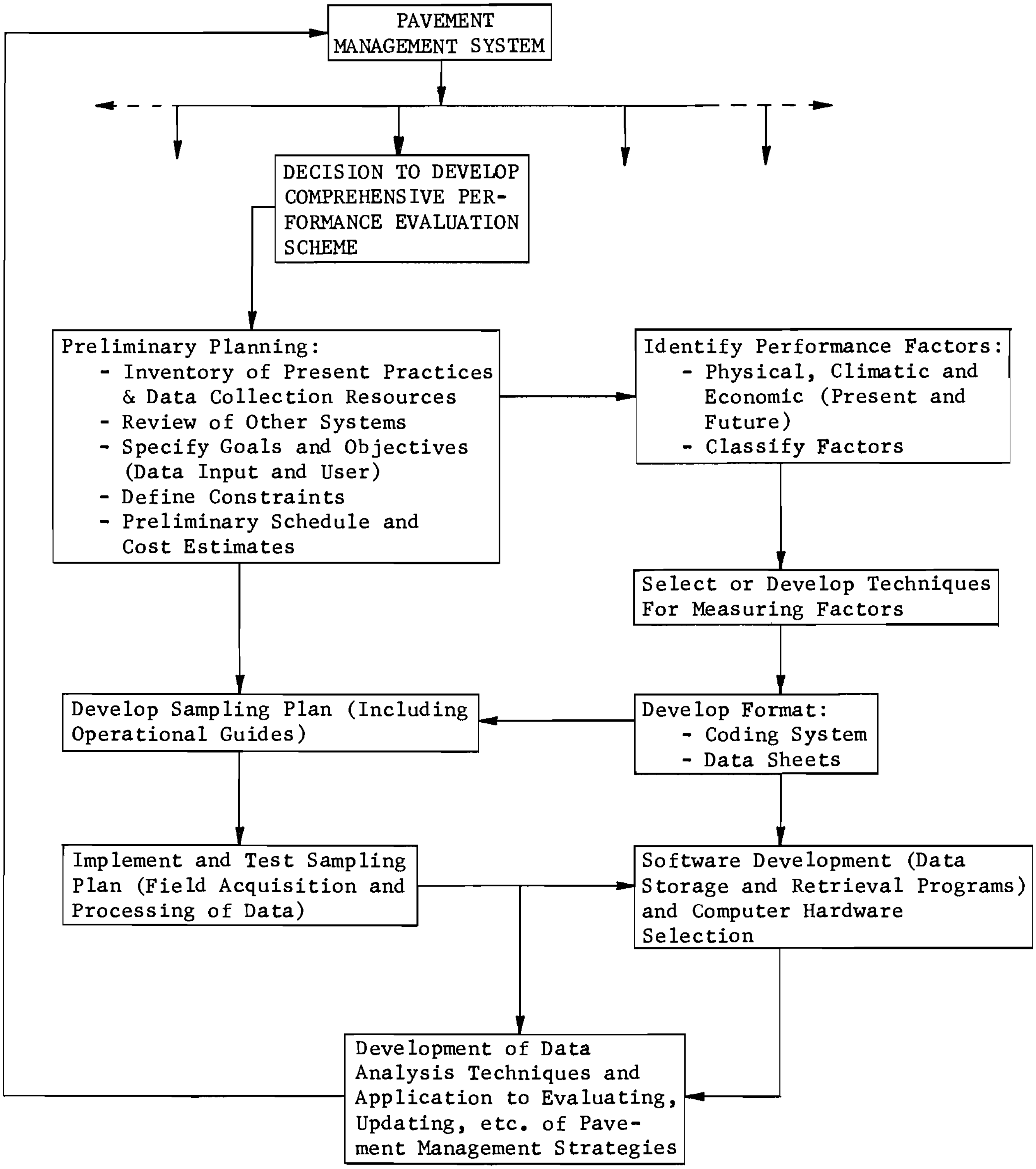

Fig 3. Major phases in developing and applying a pavement performance evaluation scheme.

(a) how many factors can be practically incorporated within the constraints of available resources, and

(b) what variables are recognized as most important by current technology;

(3) selection or development of techniques and/or units for quantitatively measuring the performance factors which, for the most part, would likely be those currently in use for measuring deflection, identifying costs, determining material properties, measuring serviceability, and so on;

(4) development of a format for the various factors, including coding sheets, etc., the design of which may be in accordance with the files on serviceability, materials, costs, etc. Formats must be files on serviceability, materials, costs, etc. and must also be in accordance with various software considerations, as shown in Fig 2;

(5) development of a sampling plan for acquiring data on the various evaluation segments (The assumption is made that it is not possible to obtain data on the whole network; consequently, representative evaluation segments will have to be established.) which would include operational guides or manuals for actually obtaining measurements and recording them;

(6) implementation of the sampling plan, which would likely require initial testing of the plan, on a trial basis;

(7) design and implementation of the data bank itself, including primarily software development for data storage and retrieval (assuming that computer hardware requirements pose no special problems); and

(8) development of analysis techniques on stored data for

   (a) checking and updating management (including design) models,

   (b) establishing sensitivity of performance factors,

   (c) evaluating the effects of maintenance, and

   (d) predicting terminal serviceability (or updating predictions) for programming or budgeting purposes.

CHAPTER 3. EXISTING DATA FILES IN THE HIGHWAY DEPARTMENT

General

The Texas Highway Department has 16 Headquarters Divisions, 25 Districts, and the Houston Urban Project, which all acquire and use data of various forms. Obviously, there are a very large number of data files in existence in the Department and it would be a massive task to document all of these. However, one portion of the Highway Department, the Planning and Survey Division (D-10) provides much of the potential documentation relevant to this project, as demonstrated by the following statement of their overall function (Ref 3):

> The mission of the Planning and Survey Division is to provide services to and in behalf of the Texas Highway Department. Essentially, these include mileage, traffic, financial statistics, and such tables, reports, studies, and maps as necessary for use in planning, constructing, maintaining, and financing the various road systems which are the responsibility of the Department.

D-10 is therefore the principal repository for a large amount of information and the extent of this has been documented in a previously noted report (Ref 3). It is not practical to list and describe all their data files but a partial list of more direct interest to Project 123 is useful. This is shown in Table 1 and represents data files that have been converted to an automated or semi-automated basis.

A considerable amount of information of relevance to Project 123 is also acquired by the Materials and Tests Division (D-9), the Construction Division (D-6), the Maintenance Operations Division (D-18), and by the various Districts. However, because of the nature of the work involved, much of these data must be

TABLE 1. PARTIAL LIST OF DATA COLLECTED BY D-10

No.	Name and Description	Status of Data Storage
RI-1	"Straight Line Diagram". Covers all highways and manual recording of numerous field inventory data.	Binders.
RI-2	"State Roadway File". Coding of RI-1 data and annual revisions and updating.	Binders and punched cards, magnetic tape.
RI-6	"County Roadway File". Coding of county road notes (RI-5) and average annual daily traffic.	Folders and punched cards, magnetic tape.
	"State Maintenance Road Log Cards". Similar to RI-2 but kept current by Maintenance Operations Division (D-18) and sent to D-10 annually. Used for tabulations of maintenance mileages by surface and highway type, by District, etc.	Punched cards, magnetic tape.
	"Roadway Construction Record File". Detailed record of type and design of construction and dollar investment by construction component of each completed job. Data is coded and then plotted in straight-line form on strip maps (RL-2).	Roadway construction forms, punched cards.
	"Permanent Traffic Recorders". Continuous traffic record for various output reports (see pp 173-179 of Ref 3).	Paper tape to punched cards.
	"Annual Traffic Volume Study". Volume coverage counts at designated locations for annual state, district, and county maps.	Files and maps.
	"Loadometer Study". Weighing of trucks (and counting of all vehicles) at specified locations on various type highways during summer months; also axle spacing measurements, and basis for various output reports.	Field report files, punched cards, and magnetic tape.
	"Manual Classification Counts." Manual counting and recording by vehicle type at various stations.	Files and punched cards.
	"Special Data Studies — Traffic Forecasts". Estimates of future volumes, classification, and weights by historical trend analysis, supplemented with additional field data acquisition when necessary.	Dependent upon study.

kept in manual form. Thus, even though a considerable amount of data, such as that involved with pavement materials, is of interest to Project 123, it will likely only be possible to make use of it on a specialized or research basis. If any of these data are converted to an automated format in the future and if the indexing and control is similar to that used by D-10 in setting up their data files, then it will become more accessible to the requirements of the project. Such conversions, though, would be a massive task and, consequently, for the foreseeable future, the Project 123 data system will likely have to make its own entries of data on materials, etc. It should be emphasized, however, that this would still be the data collected by D-9, D-6, D-18, and the Districts and would have to be with their full cooperation but would be processed within the Project 123 data system, as subsequently discussed.

Examples of Particularly Relevant Data Files and Output Reports From D-10

Table 1 has summarized the types of data currently collected by D-10 and of direct interest to Project 123. As an example of a data file within this list, Fig 4 is the coding sheet for RI-2, the "State Roadway File". It shows the type of information acquired and from this, it is obvious that a considerable variety of output summaries could be prepared. Reference 3 details those that are currently prepared from the RI-2 file, and from the other D-10 data files. Figure 5, which is a flow chart representation of the inputs, operations, and outputs associated with the RI-2 file, shows the output reports (on the second sheet of the diagram) prepared by D-10 from this file.

The "Roadway Construction Record File" listed in Table 1 is also of major relevance to Project 123. Figure 6 represents the type of code sheet being used, while Fig 7 is again a flow chart of inputs, operations, and outputs. From data of this sort, a variety of output reports and analyses can also be performed. One such analysis, which could be similarly performed

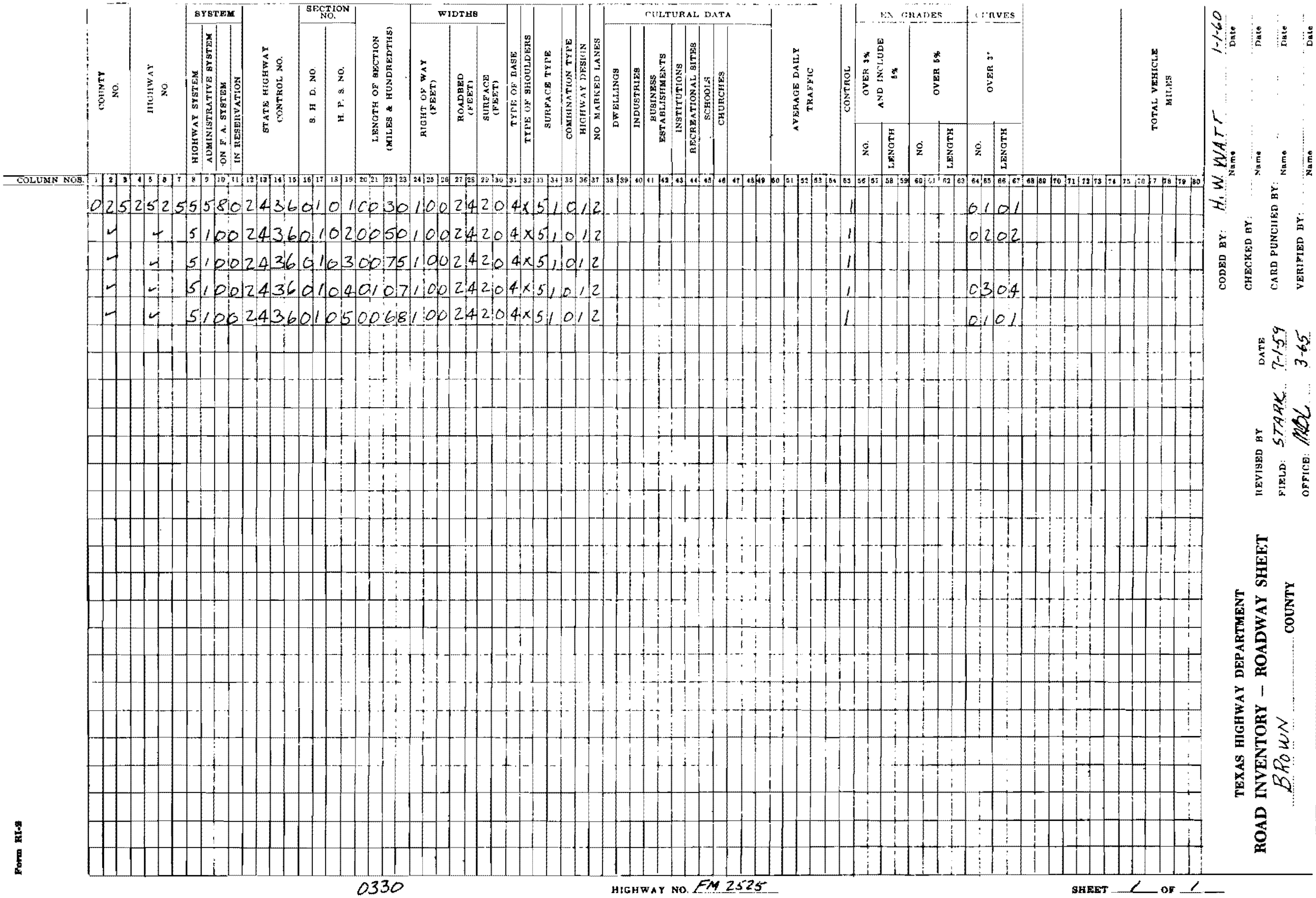

Fig 4. Coding sheet for "State Roadway File" (RI-2). (from Ref 3)

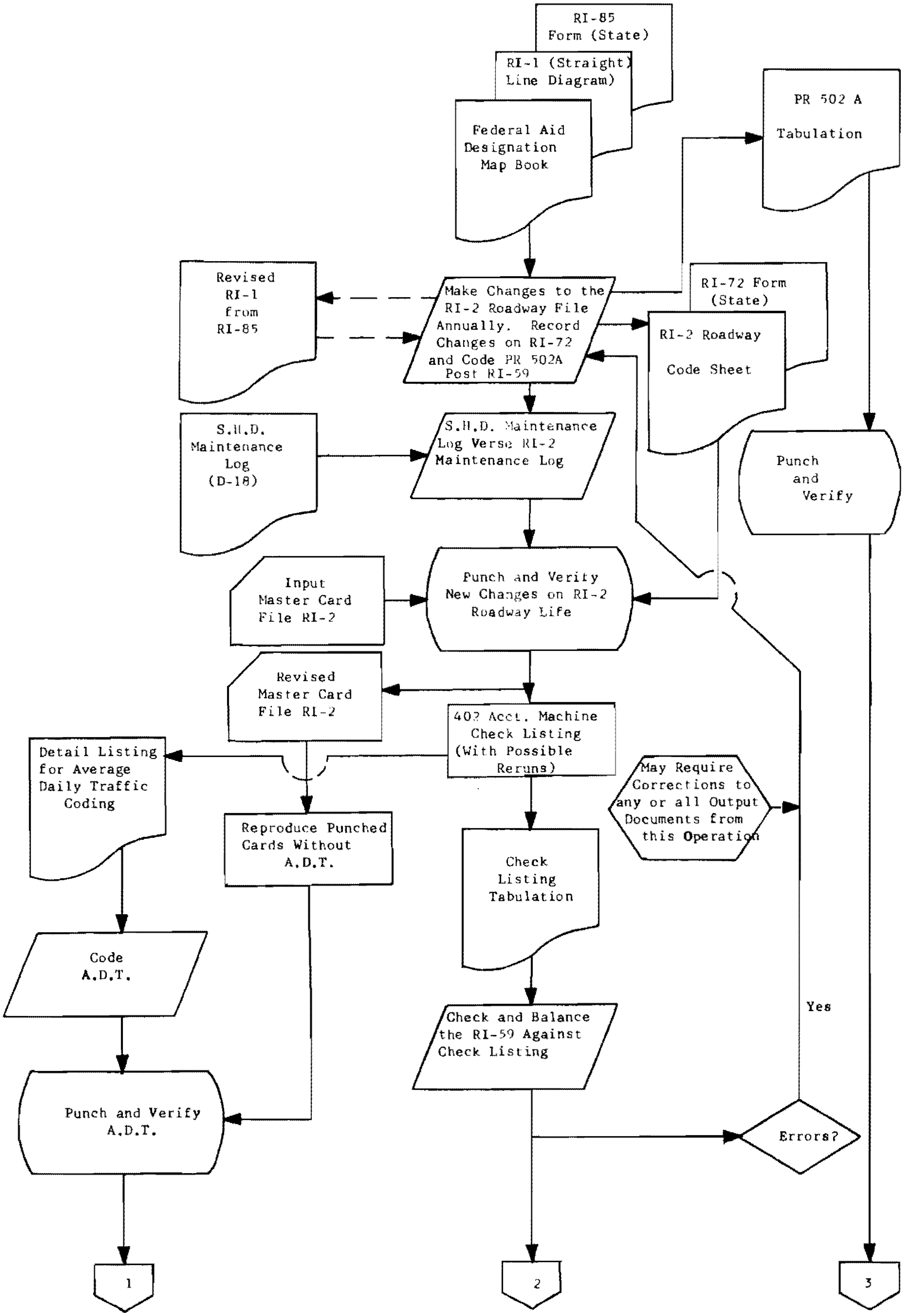

Fig 5. Inputs, operations and outputs for "State Roadway File" (RI-2). (from Ref 3)

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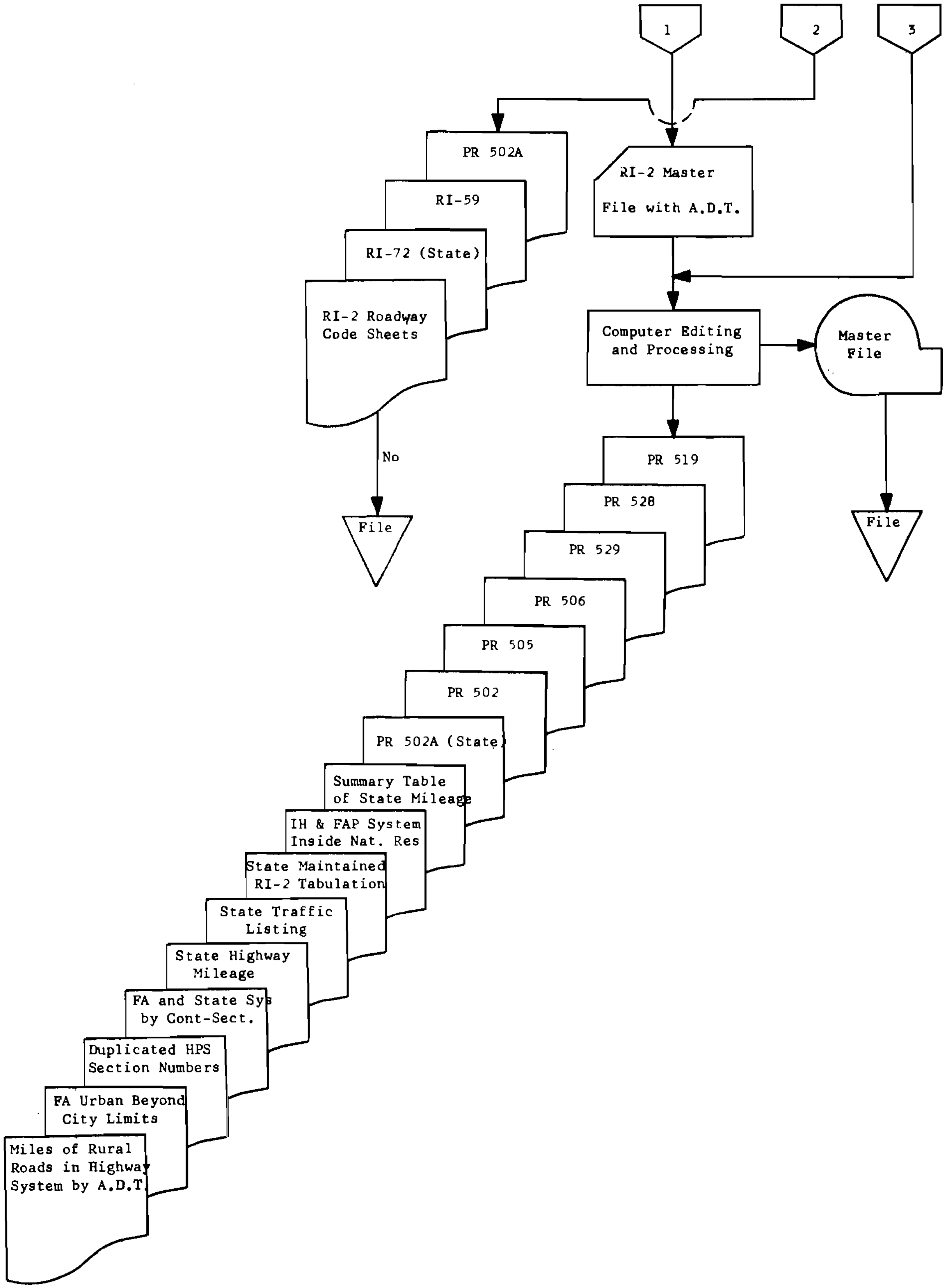

Fig 5. (Continued)

TEXAS HIGHWAY DEPARTMENT

ROAD LIFE STUDIES

CURRENT CONSTRUCTION CODE SHEET

File 10.364

District	County	Road System	Project Class	Control Number	Section Number	Job Number	Date Let		Date Completed		Kind of Work	Miles	Amount Dollars	Class of Highway	City	Travelled Interstate
							Month	Year	Month	Year						
1 2	3 4 5	6 7	8 9	10 11 12 13	14 15	16 17 18	19 20	21 22	23 24	25 26	27	28 29 30	31 32 33 34 35 36 37 38	39	40 41 42	43
12	102	21	03	0502	01	058	11	67			4	000	00005000	0	000	0
12	102	31	03	0389	05	041	11	67			4	000	00001000	1	000	0
12	102	24	03	0271	14	050	11	67			4	000	00001200	3	413	0
12	102	53	03	1258	04	014	11	67			4	000	00001600	0	000	0
12	158	50	03	0847	05	011	11	67			2	016	00054500	0	000	0
12	170	53	44	1062	01	007	12	67			1	003	00182107	0	000	0
12	170	53	02	0720	02	015	12	67			2	021	00078412	0	000	0
12	170	53	44	2744	01	003	12	67			1	036	00239985	0	000	0
13	235	11	40	0088	05	014	12	67			2	042	00760776	2	000	0
13	235	11	42	0088	05	015	12	67			2	003	00068145	2	000	0
13	235	11	40	0371	01	030	12	67			2	001	00043081	0	000	0

Fig 6. Coding sheet for "Roadway Construction Record File." (from Ref 3)

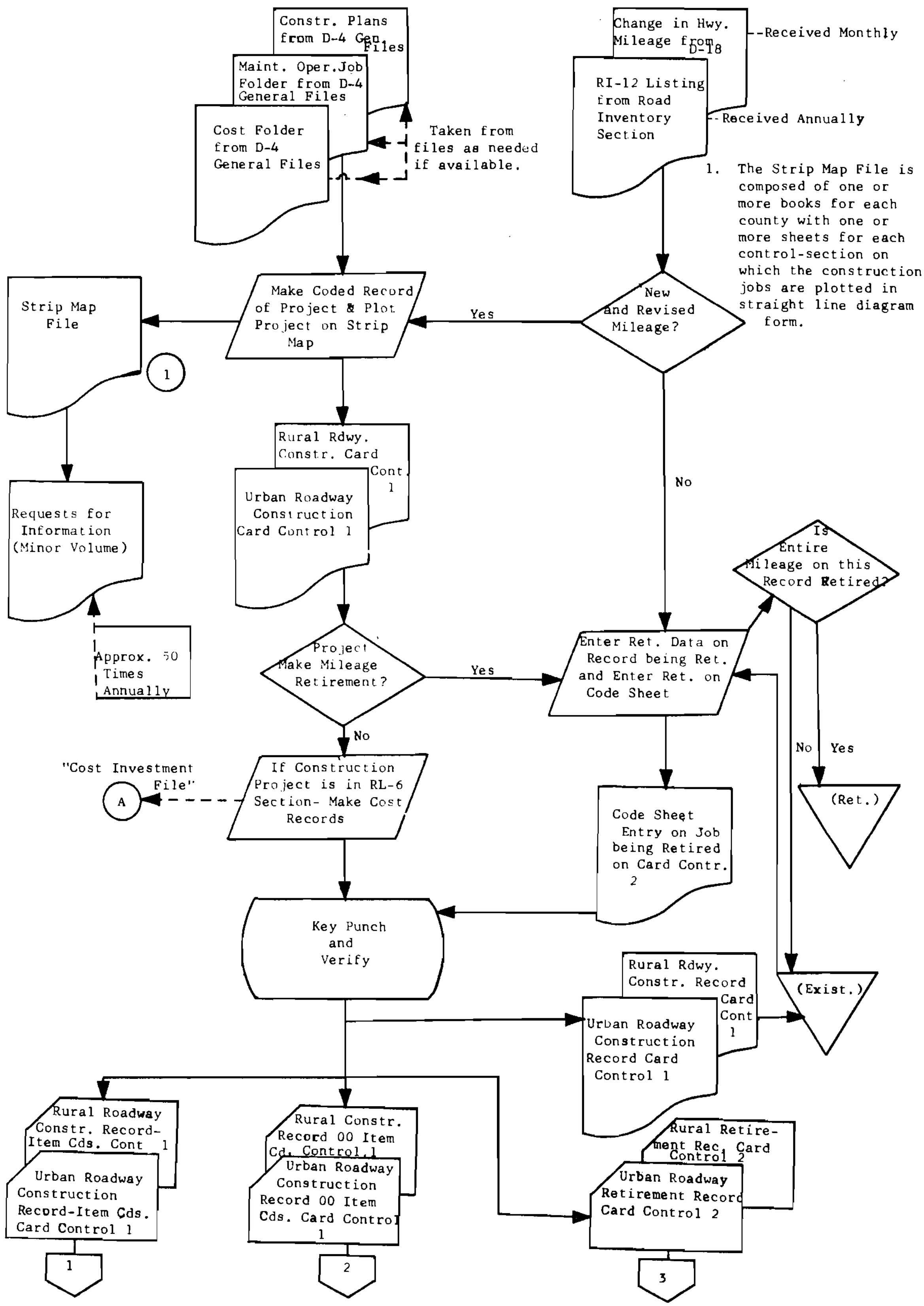

Fig 7. Inputs, operations, and outputs for "Roadway Construction Record File." (from Ref 3)

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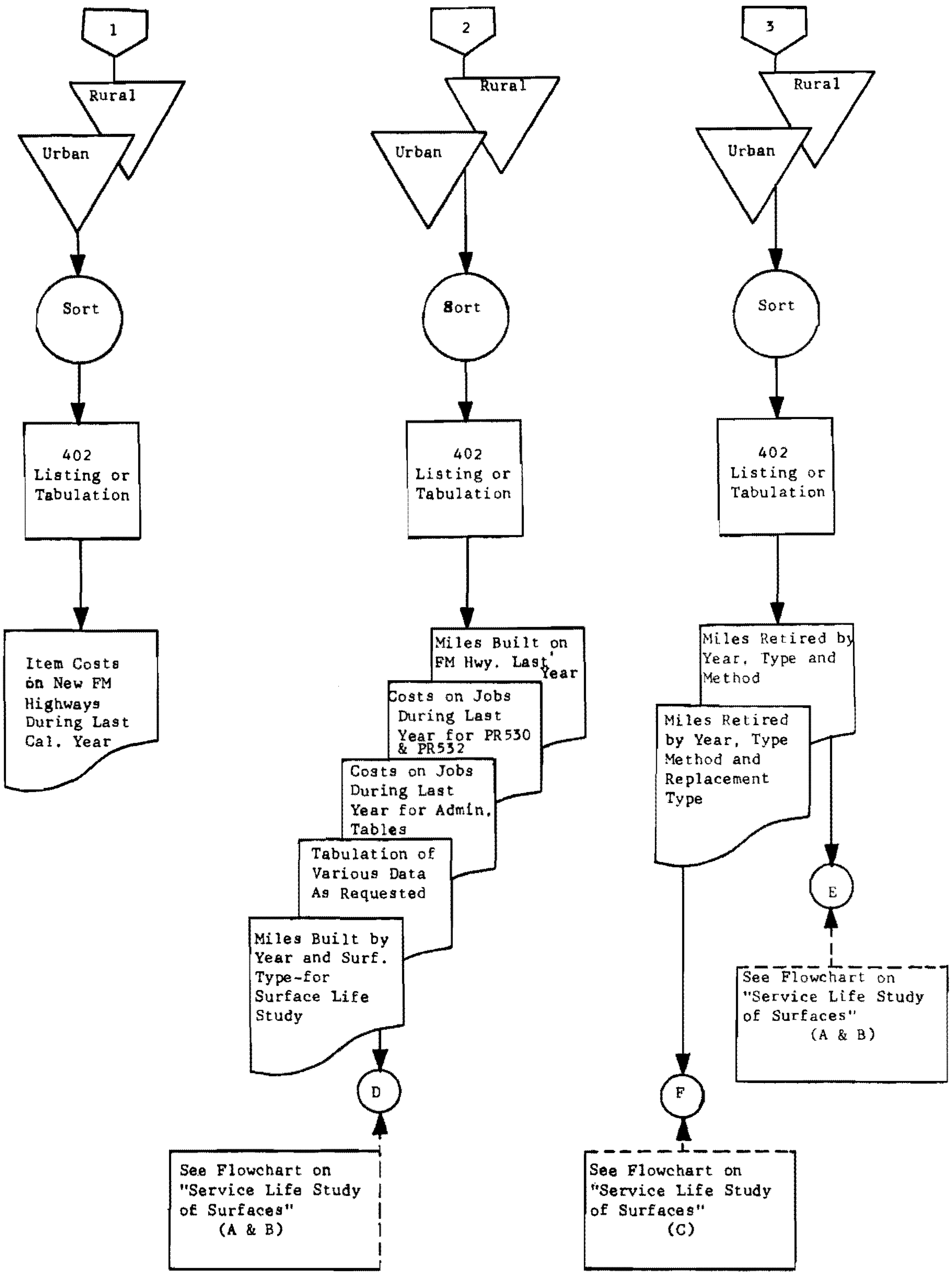

Fig 7. (Continued)

for a variety of conditions, road types, etc., is shown in Fig 8. It is a survivor curve for a group of Farm-to-Market Highways and illustrates the distribution of service lives for this group.

Another set of data collected by D-10 and important to Project 123 includes various traffic information. Figure 9 shows the inputs, operations, and outputs of the "Permanent Traffic Recorders" listed in Table 1. Again a considerable number of output summaries can be prepared from these data. An example daily traffic listing at a particular station, for a particular month, is shown in Fig 10. A similar listing for average daily traffic for an entire year is shown in Fig 11.

The "Loadometer Study" is a portion of the traffic information that is very important to Project 123. Figure 12 shows the inputs, operations, and outputs involved, while Figs 13 and 14 are examples of the output presentations that can be prepared. These latter two diagrams represent the whole network but similar analyses could of course be performed for specific segments.

The "Manual Classification Counts", as listed in Table 1, can be combined with the "Loadometer Study" results to provide valuable information to Project 123. Figure 15 is an example breakdown of vehicle classification for several particular stations.

Finally, D-10 performs a number of "Special Data Studies — Traffic Forecasts" and the general form of these is shown in Fig 16. The specific output of course depends upon the request. This phase of the division's operations can be most important to Project 123, in that special load distribution and frequency data (both current and future) may be required at various times.

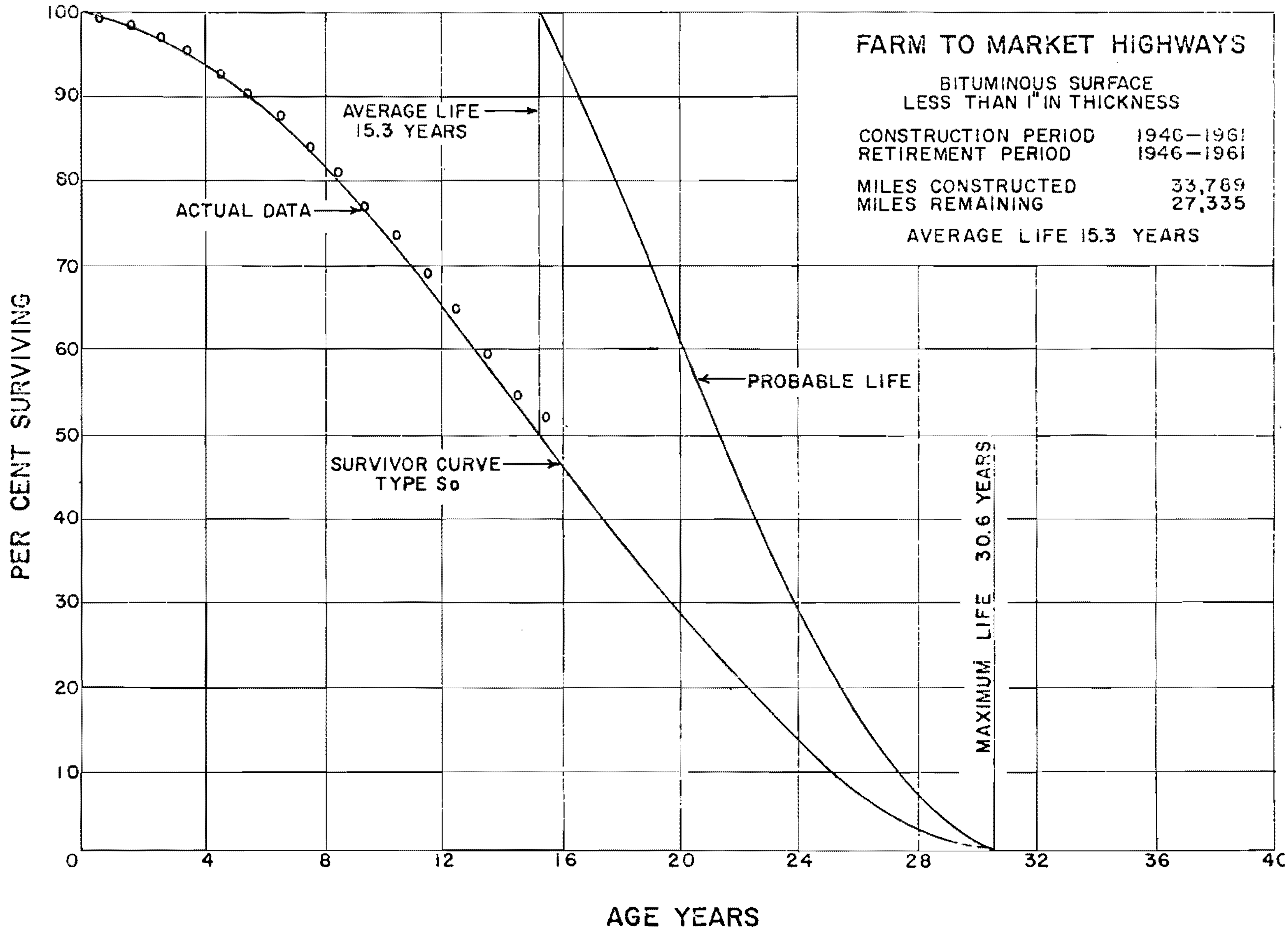

Fig 8. Service life study of a group of farm to market highways, from "Roadway Construction Record File." (from Ref 3)

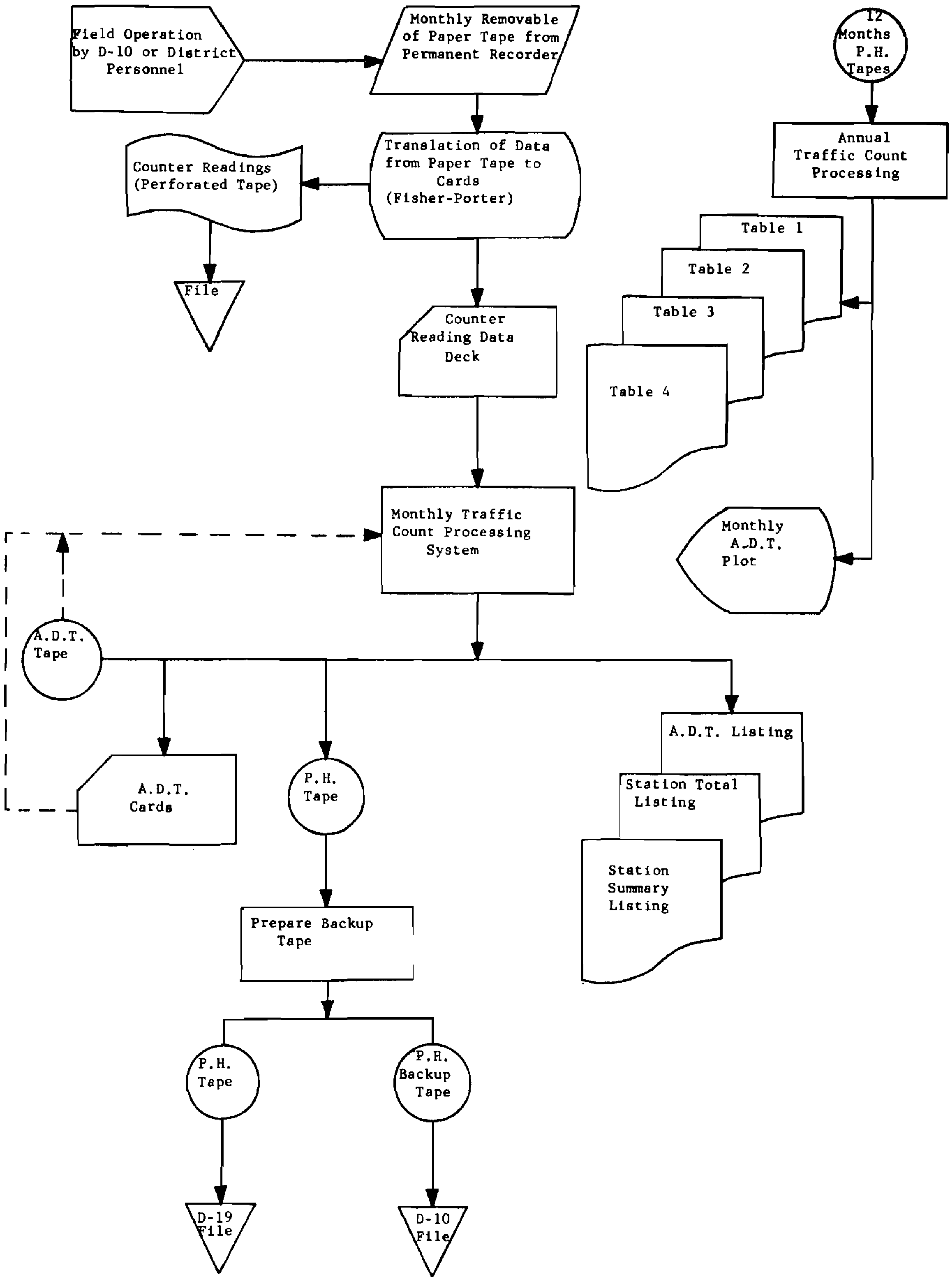

Fig 9. Inputs, operations, and outputs of "Permanent Traffic Recorders." (from Ref 3)

TEXAS HIGHWAY DEPARTMENT

TRAFFIC RECORDER RECORD — PLANNING SURVEY DIVISION

STATION--A020 ITALY — FOR THE MONTH-DECEMBER 1967 — SH0034 SUMMARY

1967	MON-THUR AVERAGE	MON-FRI AVERAGE	FRIDAY AVERAGE	SATURDAY AVERAGE	SUNDAY AVERAGE	DEC TOTAL	ADJUSTED AVERAGE DAILY TRAFFIC	PERCENT VARIATION WITH SAME MONTH LAST YEAR
	16 DAYS	21 DAYS	5 DAYS	5 DAYS	5 DAYS	31 DAYS	31 DAYS	
	532	541	570	644	591	17,530	563	-14.4

(CURRENT 12 MONTH PERIOD)
ADT------- 668
MONTHLY FACTOR 1.26
(MON-THUR AVERAGE)

DAY	WEATHER	AVERAGE TEMPERATURE	DAY OF MONTH	DAILY TOTAL	TOTALS	DAILY FACTOR
SUN	CLEAR	54	3	645		1.04
	SHOWER	60	10	535		1.25
	CLEAR	42	17	595		1.12
	CLEAR	48	24	705		0.95
	SHOWER	35	31	475	2,955	1.41
MON	SHOWER	50	4	470		1.42
	CLOUDY	40	11	480		1.39
	CLEAR	42	18	550		1.21
	CLEAR	50	25	765		0.87
TUE	SHOWER	52	5	375		1.78
	CLEAR	45	12	530		1.26
	CLEAR	48	19	610		1.10
	CLEAR	50	26	645		1.04
WED	CLEAR	56	6	430		1.55
	CLOUDY	42	13	480		1.39
	SHOWER	49	20	625		1.07
	SNOW	38	27	460		1.45
THR	CLEAR	59	7	555		1.20
	SHOWER	40	14	460		1.45
	RAIN	42	21	585		1.14
	CLOUDY	38	28	485	8,505	1.38
FRI	FOG	50	1	550		1.21
	CLOUDY	59	8	590		1.13
	SHOWER	36	15	475		1.41
	CLEAR	45	22	670		1.00
	CLOUDY	45	29	565	11,355	1.18
SAT	CLEAR	52	2	555		1.20
	FOG	59	9	745		0.90
	SHOWER	38	16	630		1.06
	CLEAR	45	23	775		0.86
	SHOWER	40	30	515	3,220	1.30

Fig 10. Example listing of daily and monthly traffic, from "Permanent Traffic Recorders" (from Ref 3)

TEXAS HIGHWAY DEPARTMENT
PLANNING SURVEY DIVISION
TRAFFIC RECORDER RECORD

AVERAGE DAILY TRAFFIC VOLUMES BY MONTH, DAY OF WEEK AND SEASON

FOR YEAR--1967

STATION--A030 FORT WORTH

LOCATION - US 80, 4.7 MILES WEST OF SH 183

MONTH AND SEASON								AVERAGE DAY (SUN THRU SAT)		AVERAGE WEEKDAY (MON - THR)		AVERAGE WEEKDAY (MON - FRI)	
	(SUN)	(MON)	(TUE)	(WED)	(THR)	(FRI)	(SAT)	VOLUME	PERCENT AADT	VOLUME	PERCENT AADT	VOLUME	PERCENT AADT
DECEMBER	13,203	14,246	14,476	15,428	15,491	17,187	16,746	15,254	95.5	14,910	93.3	15,366	96.2
JANUARY	12,730	14,138	13,170	14,212	13,858	15,307	15,729	14,163	101.1	13,845	86.6	14,137	88.5
FEBRUARY	13,313	14,602	13,654	14,937	14,460	16,865	17,556	15,055	92.2	14,413	90.2	14,904	93.3
(WINTER)	(13,082)	(14,329)	(13,767)	(14,859)	(14,603)	(16,453)	(16,677)	(14,824)	(92.8)	(14,389)	(80.0)	(14,802)	(92.6)
MARCH	14,260	14,602	14,904	15,219	14,949	16,248	16,676	15,265	95.5	14,919	93.4	15,184	95.0
APRIL	14,973	15,763	15,193	15,591	15,384	17,332	17,850	16,012	100.2	15,483	96.9	15,583	97.5
MAY	14,926	15,312	15,708	16,694	16,218	19,536	18,718	17,730	111.0	15,983	100.0	16,694	104.5
(SPRING)	(14,720)	(15,226)	(15,268)	(15,835)	(15,517)	(17,705)	(17,748)	(16,336)	(102.2)	(15,462)	(96.8)	(15,820)	(99.0)
JUNE	15,073	16,729	16,434	16,967	16,679	18,853	18,371	17,015	106.5	16,702	104.5	17,132	107.2
JULY	15,607	16,536	17,071	17,263	17,127	19,178	19,016	17,400	108.9	16,999	106.4	17,435	109.1
AUGUST	15,324	17,312	17,981	17,157	17,054	17,240	18,547	17,231	107.8	17,376	108.7	17,349	108.6
(SUMMER)	(15,335)	(16,859)	(17,162)	(17,129)	(16,953)	(18,424)	(18,645)	(17,215)	(107.7)	(17,026)	(106.5)	(17,305)	(103.3)
SEPTEMBER	13,542	14,895	15,600	15,555	15,814	18,091	17,451	15,850	99.2	15,466	96.8	15,991	100.1
OCTOBER	13,652	15,828	15,077	15,995	15,976	18,980	18,127	16,234	101.6	15,719	98.4	16,371	102.4
NOVEMBER	13,457	15,381	15,107	16,058	14,969	17,299	16,608	15,554	97.3	15,379	96.2	15,763	98.6
(FALL)	(13,550)	(15,368)	(15,261)	(15,869)	(15,586)	(18,123)	(17,395)	(15,879)	(99.4)	(15,521)	(97.1)	(16,042)	(100.4)
DAILY AVERAGE FOR YEAR	14,172	15,445	15,365	15,923	15,665	17,676	17,616	15,980	100.0	15,600	97.6	16,015	100.2

Fig 11. Example listing of average daily traffic for all months in year, from "Permanent Traffic Recorders." (from Ref 3)

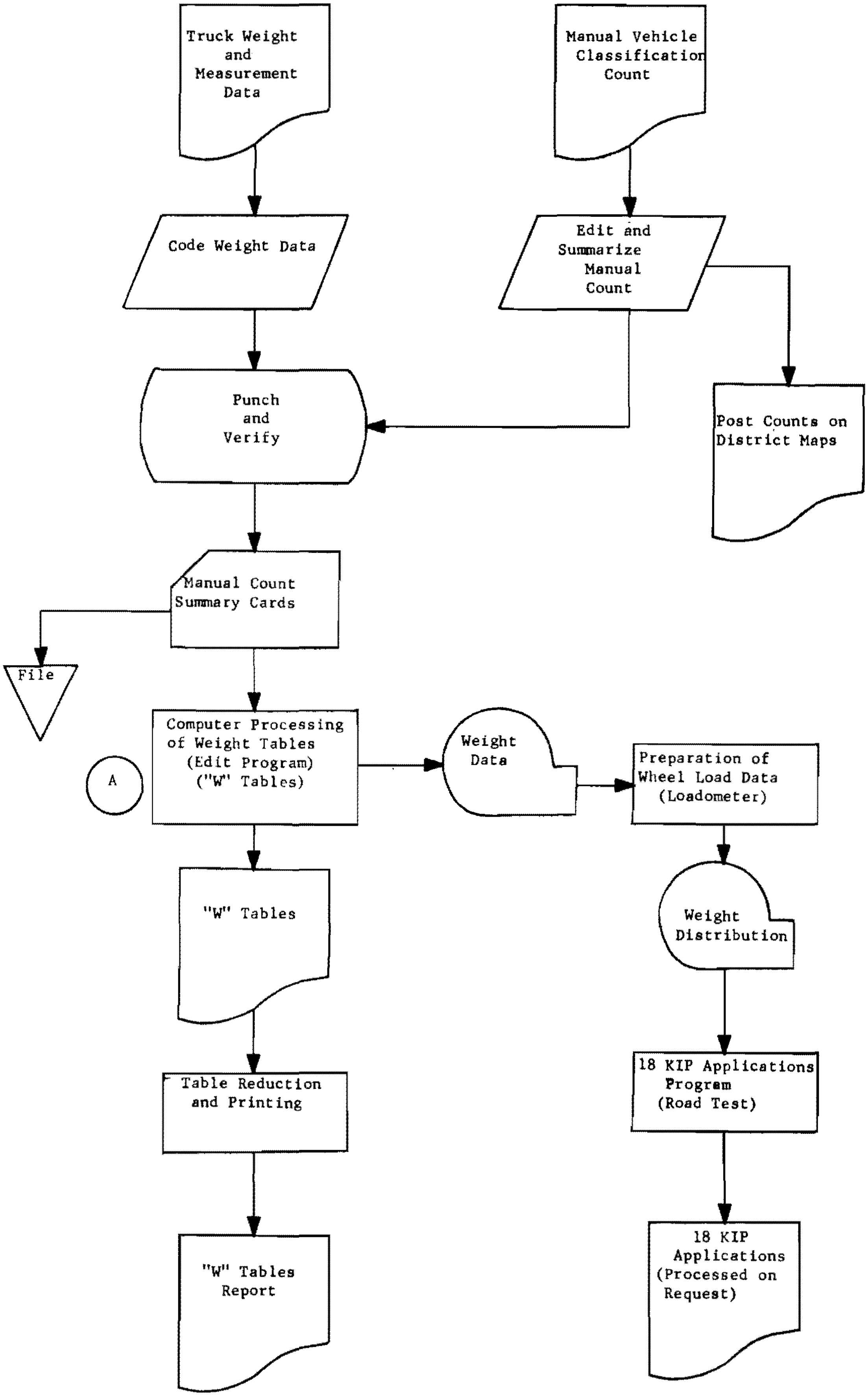

Fig 12. Inputs, outputs, and operations for "Loadometer Study." (from Ref 3)

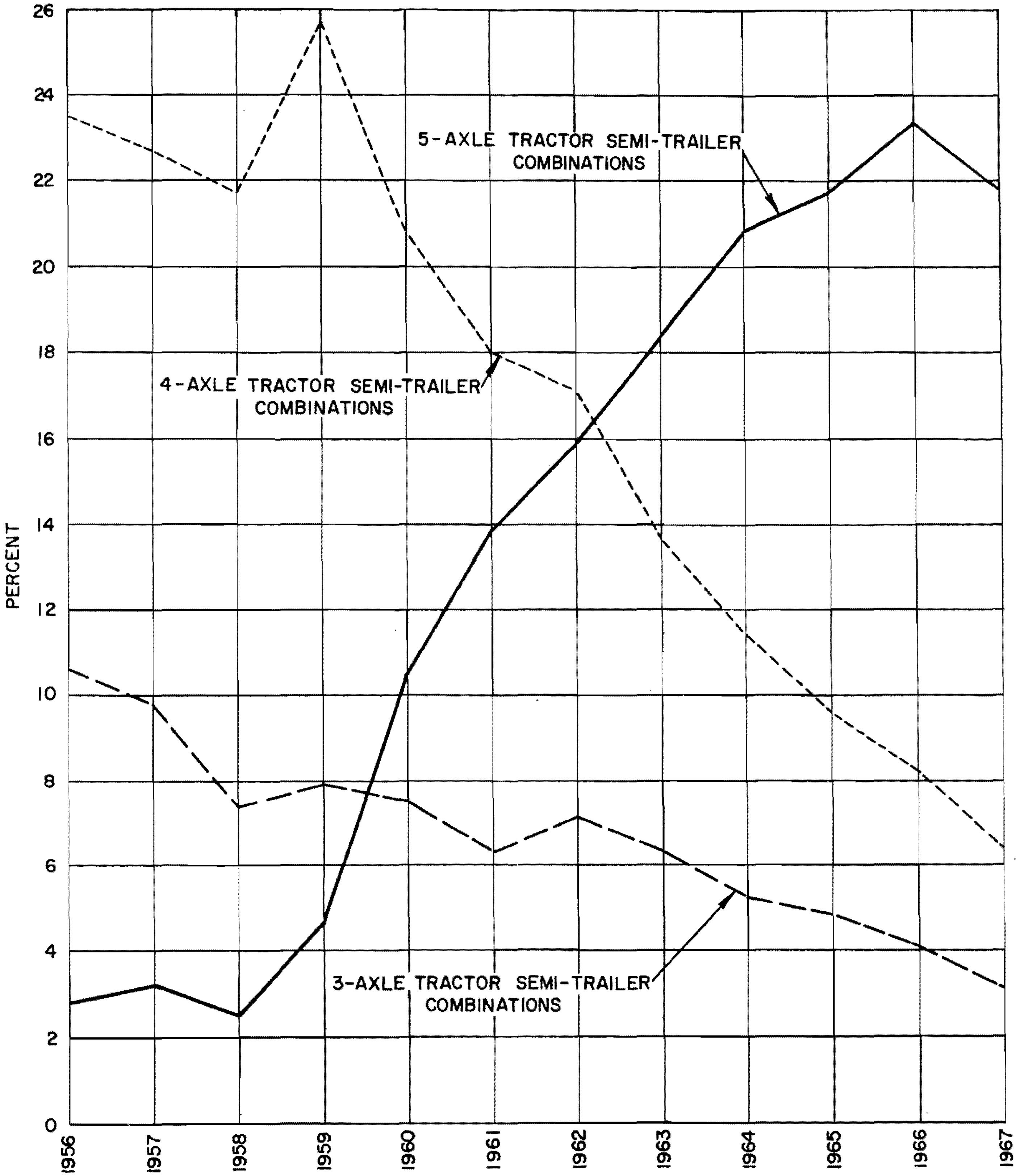

Fig 13. Percentages of semi-trailer combinations, on basis of total truck and combinations, from "Loadometer Study." (from Ref 3)

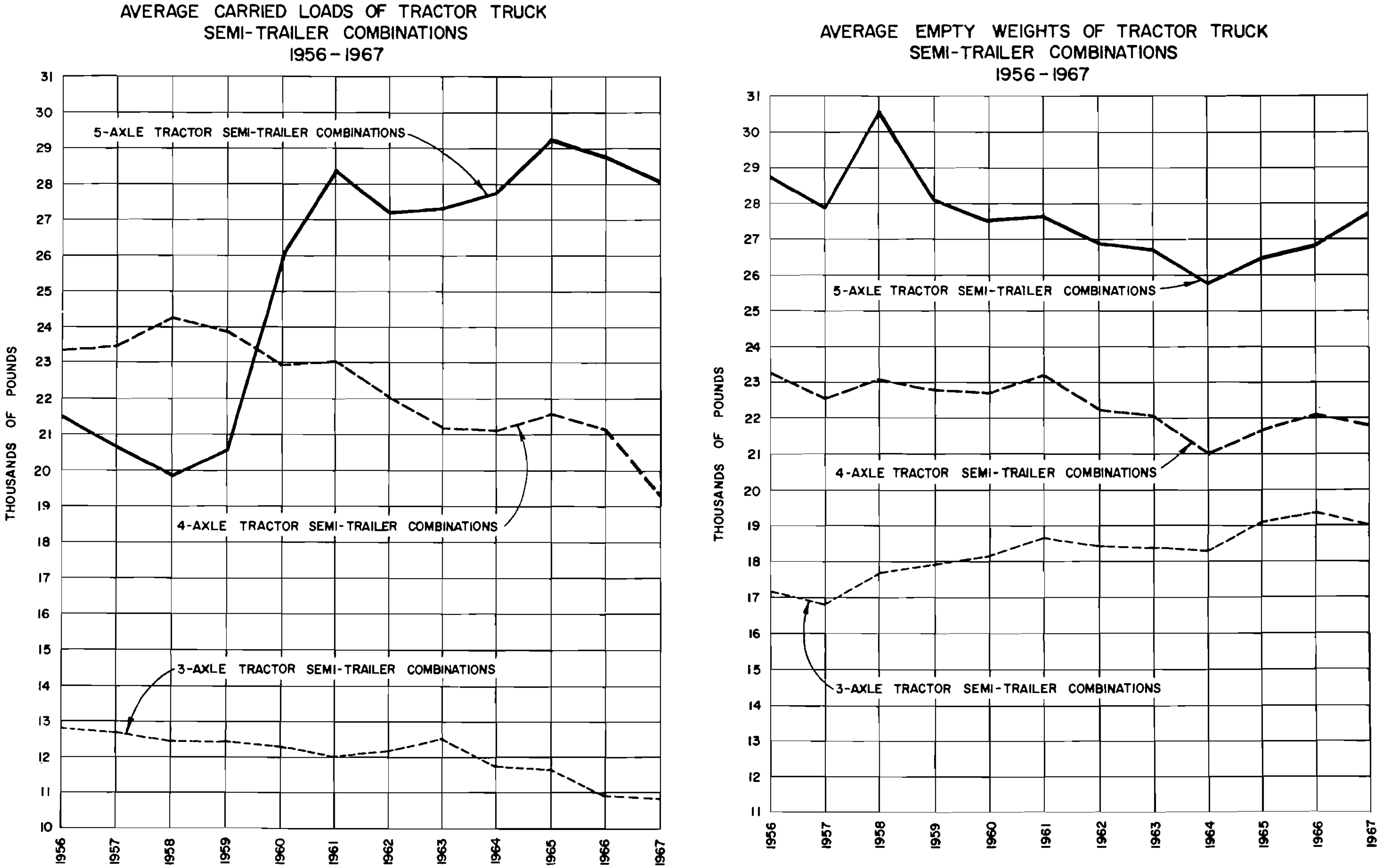

Fig 14. Semi-trailer combination loads, from "Loadometer Study." (from Ref 3)

TYPE OF VEHICLE	L-7 US 67 84	L-10 1 US 83 290	L-10 2 US 90 183	L-16 US 87	L-20 US 287	L-20 1 IH 20	L-20 2 US 80 180	L-20 3 IH 20	L-30 1 IH 30
Passenger Cars	2030	1456	3632	4708	3600	5902	10087	7145	7207
Trucks-Single Unit									
Panel and Pickup	486	392	565	1183	609	1138	2152	884	1147
Other 2-Axle, Single Rear Tire	10	8	12	32	23	38	48	21	18
Other 2-Axle, Dual Rear Tire	102	67	172	264	203	295	346	214	249
3-Axle	16	12	48	52	27	38	41	41	28
Sub-Total	614	479	797	1531	862	1509	2587	1160	1442
Truck-Combinations									
Semi-Trailer									
3-Axle	40	15	67	42	56	112	109	137	90
4-Axle	51	54	162	131	129	223	223	315	227
5-Axle or more	177	193	529	347	629	927	941	965	735
Sub-Total	268	262	758	520	814	1262	1273	1417	1052
Semi-Trailer - Trailer									
4-Axle	-	-	-	-	-	-	-	3	-
5-Axle	2	4	10	-	5	20	16	8	5
6-Axle or more	-	3	7	-	23	7	9	7	4
Sub-Total	2	7	17	-	28	27	25	18	9
Truck & Trailer									
3-Axle	5	1	4	5	2	7	4	6	3
4-Axle	2	3	6	6	14	17	14	8	16
5-Axle or more	1	1	-	5	9	4	7	6	2
Sub-Total	8	5	10	16	25	28	25	20	21
TOTAL COMBINATIONS	278	274	785	536	867	1317	1323	1455	1082
TOTAL TRUCKS	892	753	1582	2067	1729	2826	3910	2615	2524
Buses									
2-Axle	1	12	22	18	9	19	23	11	12
3-Axle	7	9	13	2	11	30	27	15	12
TOTAL BUSES	8	21	35	20	20	49	50	26	24
MOTORCYCLES AND MOTORSCOOTERS	-	-	1	5	1	3	13	4	5
TOTAL 24-HOUR ANNUAL AVERAGE TRAFFIC FOR 1967	2930	2230	5250	6800	5350	8780	14060	9790	9760

Fig 15. Example breakdown of vehicle types at specified stations, from "Manual Classification Counts." (from Ref 3)

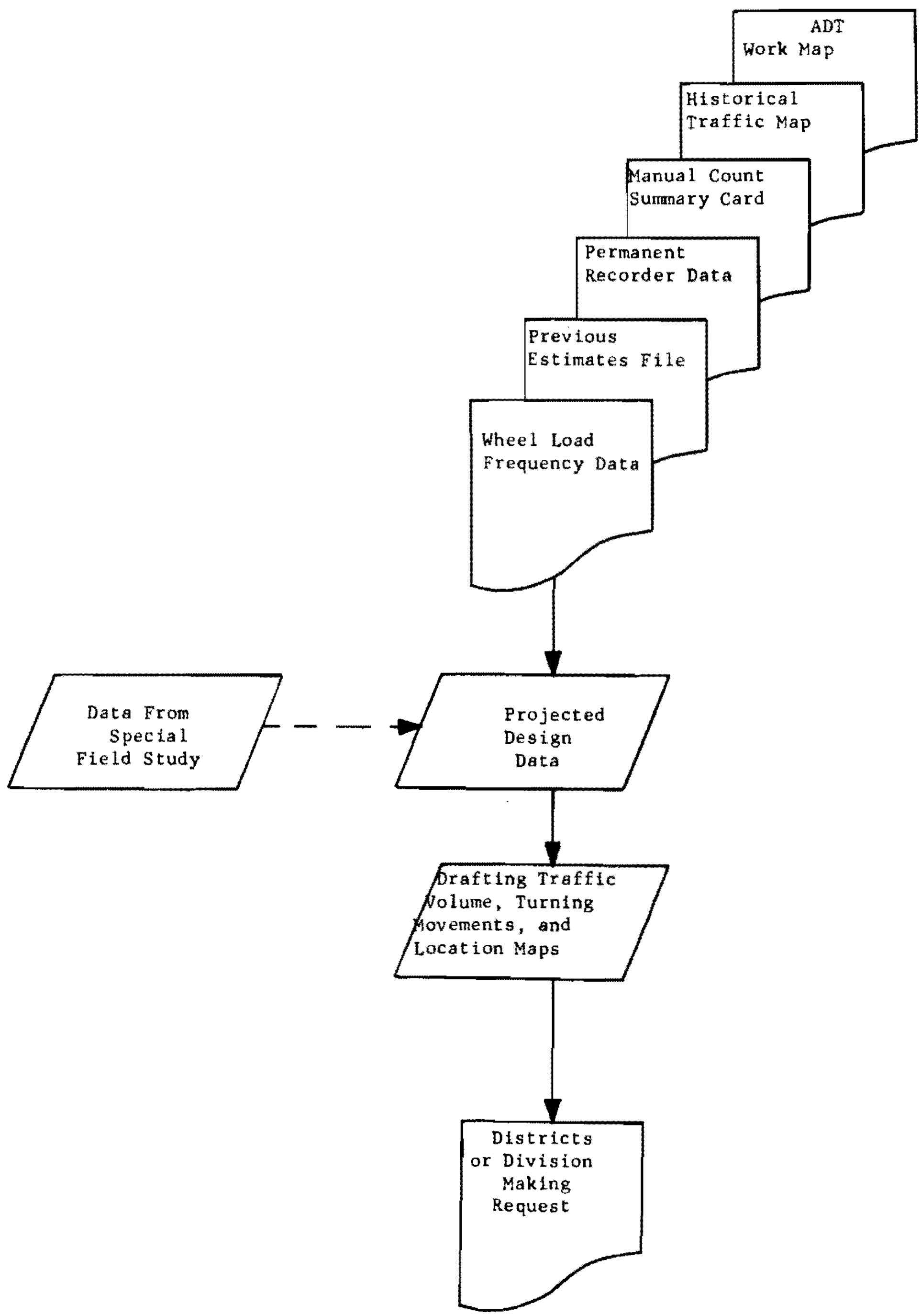

Fig 16. Inputs, operations, and outputs for "Special Data Studies - Traffic Forecasts." (from Ref 3)

CHAPTER 4. FUNCTIONAL REQUIREMENTS FOR PROJECT 123 PAVEMENT DATA SYSTEM

General

The pavement data system was to be developed and implemented as a specific objective of Project 123, as previously noted. This was explicit enough per se but the following basic questions had to be initially faced in the planning phase:

(1) should the data system include the entire paved network, or only those portions designed by the Project 123 system, or

(2) should only certain, selected evaluation segments within these portions be included?

Planning, programming and budgeting would require data on the whole network. However, the availability of resources and the chance for implementation suggested that the second approach was most feasible. Moreover, The Planning and Survey Division (D-10) acquires a variety of data on the highway system for planning purposes. Any widespread collection of information on pavements alone would likely add little to this overall planning function, nor would it likely aid the evaluation of Project 123 models much more than could be done through evaluation segment selection.

Nevertheless, a general requirement of the pavement data system was considered to be flexibility for expansion to include any number of additional portions of the network, the only constraint on this being the resources for collecting and processing data. In this way, a particular district could collect widespread information on one or more specific data items (i.e., skid resistance, present serviceability index, etc.), with no change in use or format of the data system, to aid in planning, programming or budgeting.

The Flexible Pavement System (FPS) and the Rigid Pavement System (RPS) developed in Project 123 use a variety of physical and economic models in order to determine available pavement strategies (and identify the optimal strategy). These models in turn incorporate a large number of factors. Since one of the primary requirements for any data system is to provide a means for updating design and management techniques, it should include the factors in the models.

Finally, a major requirement of the pavement data system should be that provision be made for accessing other data files, such as those previously described. It was pointed out in Chapter 2 that this can be accomplished by proper indexing, control, and coordination.

Figure 17 is a schematic representation or functional format of the foregoing overall requirements for a pavement data system. It points out that there is a supplier of data and a user of data, and in many cases this may be the same person, section, division or district. It also depicts in a general manner the operational requirements of the system. These and other functional requirements are discussed in more detail in the following sections.

Specific Requirements

The successful implementation of a pavement data system depends on prior consideration of several major requirements. These have already been discussed in a general sense but it is useful to consider them in a more specific manner. This may be done by firstly listing the classes in which they fit:

(1) the existing lines or channels of communication in The Highway Department's administrative structure should be used to acquire and transmit data. This includes the use of any equipment or laboratories for testing purposes,

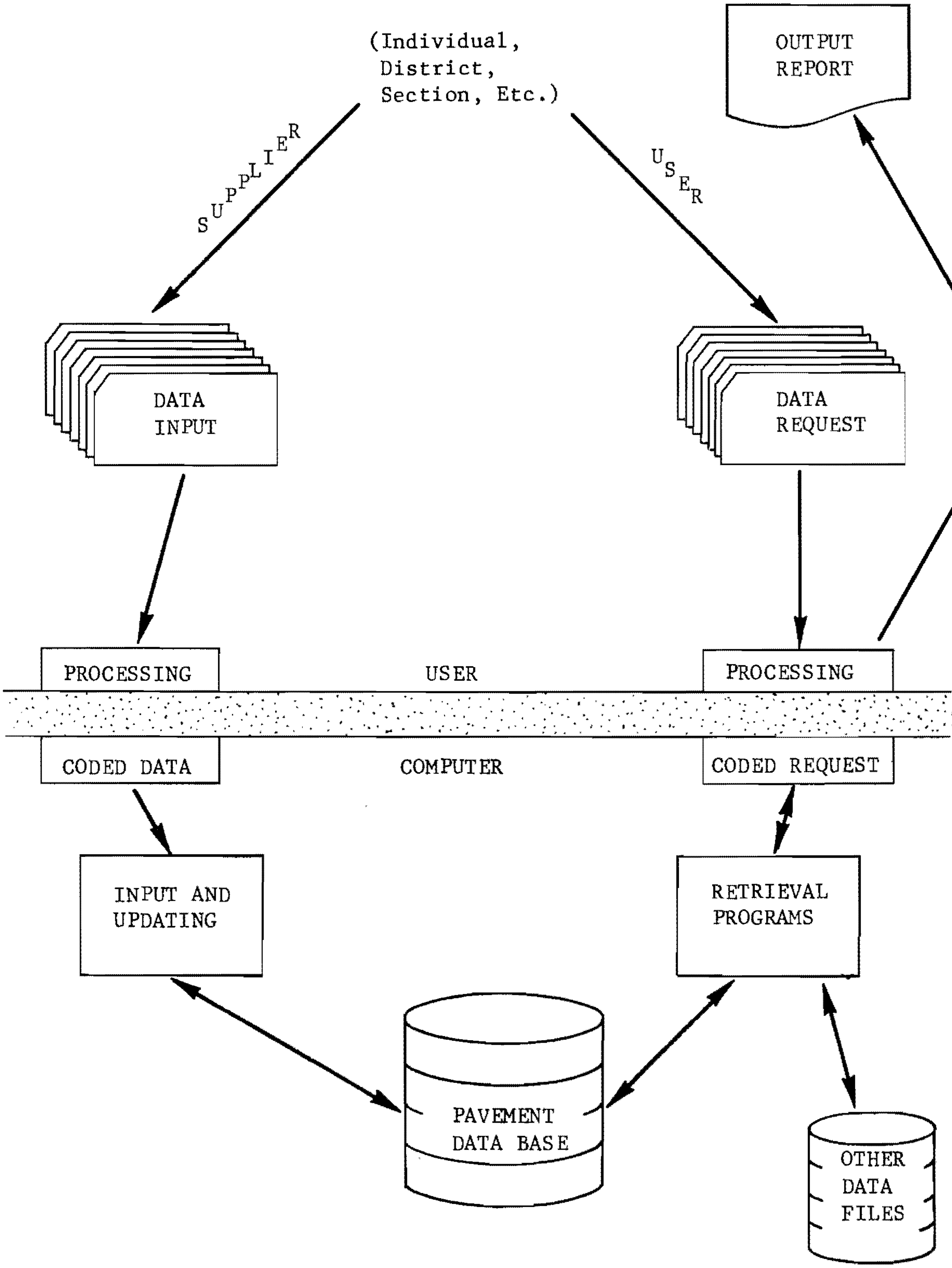

Fig 17. General functional format for a pavement data system.

(2) the data system should be implemented on a progressive or staged basis, including some trial or testing work,

(3) some means should be established for determining the usefulness or value of the data system, during both the testing phase and the subsequent operating state.

Communication of Data

The transmission or communication of data requires the following:

(1) computer programs for processing input data, updating files with new, periodic data, processing output data requests, and retrieving data from the pavement data base and other data files,

(2) availability of equipment (field testing devices such as the Dynaflect and Profilometer, laboratories and their apparatus, computer hardware facilities, etc.),

(3) a delineation of the Highway Department's organizational structure, particularly as it relates to pavement management information flow,

(4) operational guides and sampling plans for field staff engaged in testing and forwarding raw data for editing and processing;

(5) a description, for distribution, of the standard retrieval output reports available,

(6) testing of any new channels of communication required for their feasibility,

(7) absence of any constraints within the data system itself on the amounts of data that can be handled (aside, of course, from availability of manpower and testing facilities).

The foregoing listing could, of course, be subdivided into many more specific items and this, in effect, must be done during the detailed development and implementation of the data system. The actual form of the channels of communication needed to satisfy these requirements is subsequently discussed with regard to implementation.

Progressive Implementation

It has been recognized in Project 123 that to wait for development and implementation of the "ultimate" system is unrealistic and delays the payoff from improvements. A progressive or staged implementation of the data system is more logical and useful and can incorporate improvements on a step wise basis. The requirements for such a staged implementation may be listed as follows:

(1) selection of one or more short representative evaluation segments of each pavement section designed by the Project 123 system. Because annual construction programs are specific, choosing these evaluation segments will inherently provide an orderly annual addition to the total inventory covered by the data system.

(2) output (retrieval) reports of an initial, finite, and standard form. The software development for retrieving data is a major task and it is not initially possible to foresee all possible correlations and analyses that may be performed on the data. Consequently, this development is of a continuing nature and may initially involve only relatively common statistical summary outputs.

(3) the provision for adding new data fields in the future. Initially, only a limited number of data items may be included but it may be foreseen that additions will be needed in the future. For example, the use of layered, structural analyses for predicting stresses and strains must have reliable stiffness parameters. Since the stiffness of the asphalt layers varies greatly with temperature, several data fields relating to temperature measurements may be included in the

system. These may not be used immediately but can be if the need arises in the future.

Determining the Usefulness of the System

Unless some means are established for explicitly and continually evaluating the usefulness of the pavement data system, it could eventually become "static" in nature. It could continue to collect data of questionable value and neglect the additions of new, important data fields. To avoid this, the pavement data system can use the following standards of comparison, which were adopted for the Project 123 Design System (Ref 1):

(1) operationality,

(2) rationality,

(3) acceptability, and

(4) reviseability.

The operational requirement is, of course, partially answered in the actual development and staged implementation of the system. It is also answered by trial use on several initial, evaluation segments, and by the costs and efforts involved (i.e., is it actually possible, as predicted, to make the tests and measurements, record the data, transmit and process them with existing district and headquarters staff and equipment?).

The requirement of rationality may be apparently answered by considering in the system all those factors thought to influence pavement performance. However, sensitivity analyses are required to properly answer this question and these must, of course, be performed on data collected within the system (aside from testing the sensitivity of the design models themselves). Consequently, rationality must be determined on a continuing basis by eliminating unimportant variables and adding new ones of possible importance. The actual analyses and testing for sensitivity involves a major task within itself, including designed experiments, the selection of evaluation segments, varying intensity of data acquisition, etc. The design of the statistical experiments and the analyses are beyond the scope of this report but the latter aspects will subsequently be considered.

The test of acceptability is partially answered when the system is operational and rational. But it must also be answered by feedback from the personnel involved, primarily field staff. While they might be able to meet operational requirements, they may not accept the program of testing and data acquisition for a variety of reasons, including a lack of understanding of its purpose, a commitment of apparently too large a number of resources, and so on. The system must also be acceptable from an administrative standpoint. For example, the operational and rationality requirements may be apparently satisfied but the costs of collecting and processing data have to be justified for administrative acceptance.

Reviseability involves the requirement for adding or deleting data items as the need arises, for altering the output format of standard retrievals of data, for changing the sampling schedule when necessary, and so on. It was pointed out that to be rational, the system must eliminate or add data items on a continuing basis, depending upon their importance. The requirement for reviseability provides the mechanism for doing this.

CHAPTER 5. PLANNING AND INITIAL DEVELOPMENT OF THE PROJECT 123 PAVEMENT DATA SYSTEM

Planned Operating State of the System

The data system proposed would be "integrated" (Ref Fig 1), within the overall development and application scheme of Fig 2, to provide access to other data files (i.e., those that were outlined in Sections 3.1 and 3.2). The planned operating state of such an integrated, computer based system is schematically represented in Fig 18. This diagram is of a general nature and relatively self-explanatory. A more comprehensive, detailed operating state diagram could reflect the software development in terms of the actual output reports or analyses that are generated.

Identification of Factors and Classification for Data Files

Figure 3 has shown that the identification and classification of factors is one of the first major tasks to be done. These are essentially concurrent activities in that a wide variety of factors can first be identified, be grouped according to a trial classification, have new factors added or old ones deleted, have new classes set up or a whole new trial classification attempted, and so on. In other words, a number of cycles, with considerable trial and error, may be involved.

This was certainly the case for the Project 123 data system because of the extremely large variety of possibly relevant factors that have to be considered for pavements. A starting point was the variables used in the Flexible Pavement System (FPS) program and the Rigid Pavement System (RPS) program. However, these do not contain the hundreds of variables that could

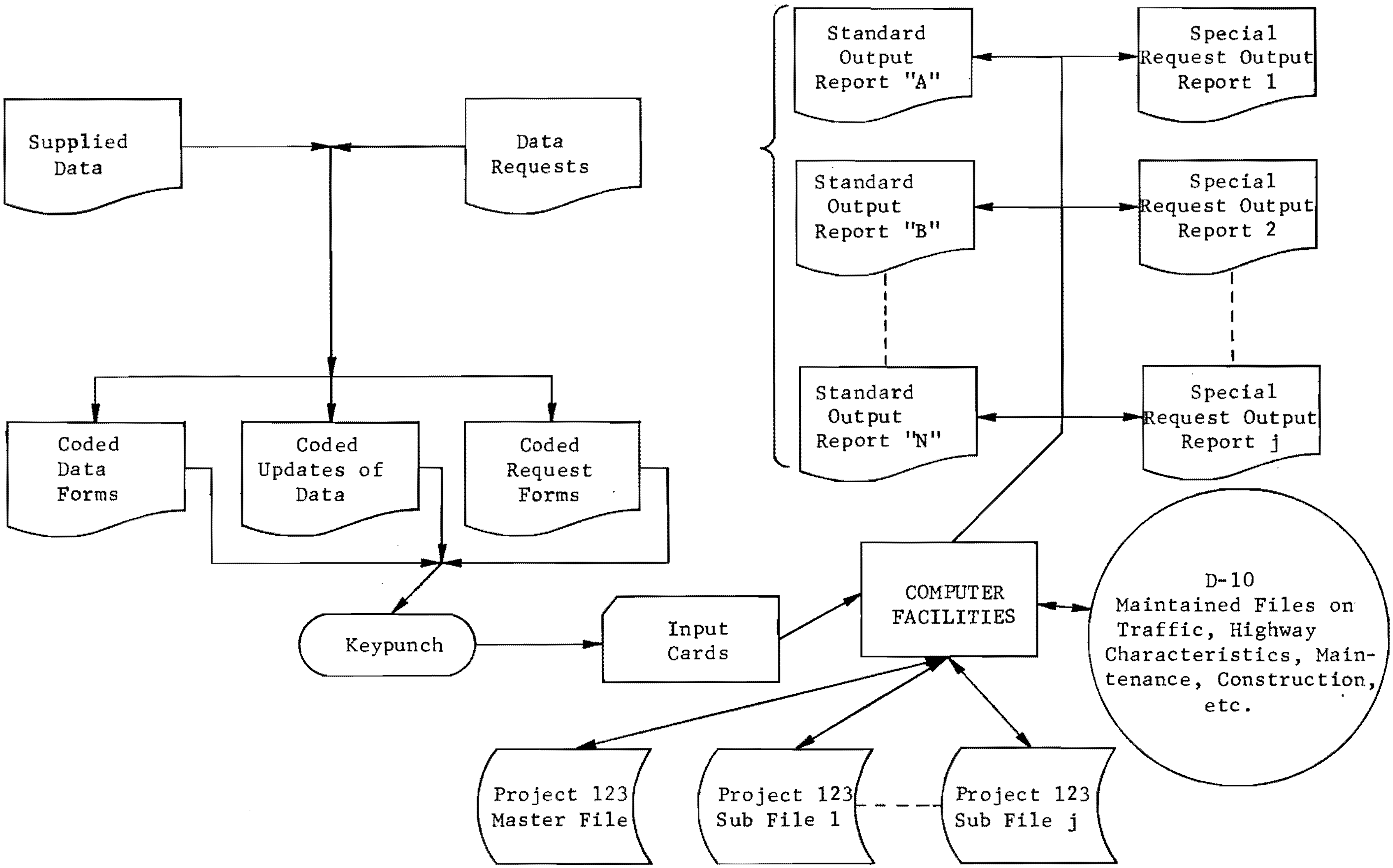

Fig 18. General operating state of an integrated, computer based pavement data system for Project 123.

be involved and which could be incorporated into a data system. Most of these were initially identified but since not all of them could be practically incorporated, a certain number of key factors (those considered to be most important) were selected.

This selection of key factors also required a number of cycles, with considerable questioning and care required in the final examination. The final set, therefore, reflects to some degree the judgment of the data system designer(s). Most of the eliminated factors would likely only be considered in special research studies. Even among the key factors, some would be recorded less frequently and for only a small number of evaluation segments, depending upon the sampling plan and the availability of data collection and processing resources.

A number of classification schemes were considered, along with the many variables. Table 2 shows the final classification scheme that was selected. It is in the form of various data files, similar in concept to the data files used by the Planning and Survey Division (D-10). The identification numbers are also similar, with "123" used to relate to Project 123, and to provide sufficient open numbers for any D-10 increase of their current Road Inventory (RI) files.

A listing of the actual factors in each of the data files of Table 2 is contained in Tables A-1 to A-7 of Appendix A. The forms used have been adapted from similar practice by the Planning and Survey Division (D-10). Details of the files and factors are discussed in the following sections.

<u>Master File (RI-123)</u>

The Master File essentially contains data on the initial as-built pavement, primarily relating to the dimensions of the pavement structure, the materials used, and their costs. It is, therefore, a file of initial information,

TABLE 2. CLASSIFICATION SCHEME FOR PROJECT 123 PAVEMENT DATA FILES

File No.	File Name	Remarks
RI-123	Master File	Contains as-built data on dimensions of pavement structure, construction and materials costs, etc.
RI-123-01	Performance Data Sub File	Contains periodic performance data on roughness, pavement deterioration, skid resistance, etc.
RI-123-02	Structure Capacity Sub File	Contains periodic structural capacity measurements for deflection.
RI-123-03	Maintenance, Resurfacing, and Seal Coats Sub File	Contains periodic data on maintenance, resurfacing and seal coats types and costs.
RI-123-04	Environmental Sub File	Contains periodic data on rainfall, temperature, moisture variations, freezing, etc.
RI-123-05	Materials Data Sub File	Contains as-built and periodic data on physical and chemical properties of pavement component materials.
RI-123-06	Traffic Data Sub File	Contains initial and periodic data on traffic volumes, truck percentages, weights, etc., access to D-10 traffic data file.

as contrasted to the sub files which contain the provision for future changes or additions and periodic data acquisition.

The locational identifiers of the Master File, and all the sub files, correspond to that used by D-10, thereby providing the means for accessing D-10 data files. Also, the pavement data system files provide for a beginning and ending mile point for each evaluation segment, within a Texas Highway Department Section Number. This in effect allows the flexibility for variable length records within each section merely by changing the evaluation segment number and the mile indicator. Consequently, an entire contract or section length could be covered, or only a short, selected segment within it.

The date of acquiring data, date of pavement completion, and date of the pavement being opened to traffic are all shown on separate items. This is simply because they can all be different and thus each can be singularly important.

The dimension data items of the RI-123 file (both geometric and layer thicknesses for the pavement, median, and shoulders) are self-explanatory except where a code rather than a measurement unit is used. These codes are discussed later.

The cost items in RI-123 are not as detailed as a contract unit breakdown. They reflect design system variables (i.e., FPS and RPS variables) and most of the actual data should be available from the D-10 files discussed in Chapter 3.

The subgrade information is only general, to indicate soil type and whether or not lime treatment was used. It is assumed that an evaluation segment would normally only include one soil type (i.e., the segment would be uniform with regard to soil type, drainage conditions, cut or fill section, etc.). If several soil types need to be recorded, say where the segment covers a whole contract or section, a "sub-segment" numbering, within the beginning and ending mile points, could be used.

It has previously been pointed out that the major steps in developing a pavement data system are shown in Fig 3. The next two steps, following the ones already outlined, can be conveniently discussed with regard to the various data files. These involve the selection of measurement units or techniques for the various factors, plus the development of a format or coding scheme.

The units shown beside each of the Master File factors in Table A-1 (as well as those beside the sub file factors of Tables A-2 to A-7) are essentially self-explanatory in that they reflect current practice. Where any differences occur, these are not in measurement technique but are the results of input units required for the design system programs (FPS and RPS). Consequently, only simple conversions are required to or from other units, if desired.

A number of factors in RI-123, and in the sub files, are in coded form for efficiency and convenience. The development of the appropriate codes is facilitated by the design of coding sheets for the factors in Tables A-1 to A-7. While such design is a major task of arrangement, spacing, clarity, etc., a preliminary or draft set of coding sheets is contained in Tables B-1 to B-7 of Appendix B. These correspond to the Table A-1 to A-7 listing and one set-up for direct keypunching from the sheet (as demonstrated schematically in Fig 18). The first two codes encountered in Table B-1, for "Update Class" and "Highway System," are adopted directly from the Planning and Survey Division (D-10) design of their data files.

A listing of all the codes used is contained in Appendix C. Those that are the same as ones used by D-10, such as the two just referred to, are noted but also listed for purposes of a complete set. These codes in Appendix C are designed to reflect all the major possible variations in each factor. Any that are not forseen at this time could be included by simply extending the coding numbers. Most of the codes for the Master File should be relatively self-explanatory, except perhaps for the one referring to the median. Any codes for other files that require explanations are discussed under the appropriate section. Tables A-1 and B-1 show only a median width data item, without a separate item for whether or not a median in fact exists. This is handled by using zero for median width when there is no median, with a corresponding zero for the median type code.

Finally, it may be noted that the coding sheets for the Master File, and for the sub files, in Appendix B use five space or ten space fields for each data item. Considerably less space and fewer punched cards could be used by having only the minimum field width for each data item. However, many programmers find such a spacing scheme far easier and less subject to mistakes. Consequently, because of this and because this data system is not expected to have massive amounts of data, it is considered that the "wasting" of space in coding forms and extra punched cards is justified. Moreover, these extra spaces, especially at the ends of the coding sheets, could be used in the future for convenient addition of new data items.

Performance Data Sub File (RI-123-01)

The Performance Data Sub File has been designed for periodic measurements of the pavement surface, in order to determine the level of service provided by the pavement. The most important of these performance indicators, in terms of present technology, are the Present Serviceability Index (PSI) and the skid resistance. PSI is calculated from roughness, rutting, cracking, and patching data and is an estimate of the mean panel rating of a group of users, according to the concept developed at the AASHO Road Test (Ref 11). This estimate is determined by equations that have been presented in Ref 11 and extensively discussed in the literature. The variables for the equation, as listed in Table A-2, are mean slope variance, cracking, patching, and rut depth. A modification of the original AASHO equations (12) has included a term for surface texture. Consequently, this variable has been added to the listing of Table A-2.

A skid resistance data file has been devised by the Research Section of the Design Division (D-8R). Skid data from a number of districts are now being collected, coded, transferred to punched cards, and summarized in various periodic output reports. The RI-123-01 sub file has the same locational identifiers as the Master File and similarly provides control means for accessing the skid data file. Consequently, only summary data items relating to skid resistance are shown in Table A-2.

The Performance Data Sub File also contains data items for panel ratings of the evaluation segment (items 25 to 33 of Table A-2). This is an example of data that may be collected only at infrequent intervals, perhaps only for special studies and only on certain selected evaluation segments. Nevertheless, the whole present serviceability concept has been built from and, of course, is fundamentally related to panel ratings. Therefore, panel rating data items are considered necessary for the sub file.

The draft set of coding sheets for the RI-123-01 sub file is shown in Table B-2 of Appendix B. The items included are those listed in Table A-2. These coding sheets have been designed with the same considerations previously discussed for the Master File coding sheets.

Only one item of the RI-123-01 sub file is in coded form and this is termed "Lane and Wheel Path Designation." It is similarly used for the other sub files and since it provides an important flexibility for the whole data system some discussion of its purpose and use is warranted. Appendix C contains a sketch explanation of the code and some examples. Basically, it permits data to be recorded for a specific wheel path in a specific lane and thereby provides a means for tying this data down to definite location if desired (i.e., roughness measurements, deflection tests, skid tests, etc.). Alternatively, if one only wishes to specify a particular lane (without regard to wheel path), or the set of lanes in one direction of travel, or all the lanes without regard to direction, the coding scheme can provide for this, as shown in Appendix C. For example, traffic may be referenced only as a total (in both directions), or it may have a directional split, or it may be counted in specific lanes (i.e., on heavily travelled, urban freeways or arterials).

Structure Capacity Sub File (RI-123-02)

The sub file for Structure Capacity has also been designed for periodic measurements. While there are many ways in which the response of the pavement structure to load can be measured, the flexible pavement design system of Project 123 (FPS) uses Dynaflect measurement data. Consequently, RI-123-02 has been set up primarily for "raw" Dynaflect data, with the assumption that other in situ structural measurements would be of a research or special study nature.

The listing for the Dynaflect measurements (Table A-3) and the Coding Form (Table B-3) show provision for 15 stations within the evaluation segment. For each set-up of the Dynaflect, at a station, there are five sensors or geophones. This is shown by Item No. 15 of Table A-3, in code form with the label IGEOPH.

The station and geophone code format and the format of the coding sheet of Table B-3 follow the example of NCHRP Project 59 (Ref 11) very closely. In this work, Scrivner and Moore recommended 15 equally spaced stations for Dynaflect measurements per test section.

There were two reasons for recording the Dynaflect data in "raw" form, as in NCHRP Report 59:

(1) the coding sheet can be set up for easy and direct transcribing of the measurements, say at the end of a day,

(2) various types of calculations may be desired on the data. These can be written into the retrieval programs, with only the desired results presented as output.

The structure capacity sub file also contains data items for structural parameters of the layers used in an elastic "n-layer" analysis (i.e., Poisson's ratio, μ , and modulus of elasticity, E). These may only be estimated or determined from laboratory materials tests. But since the future development of Project 123 may include elastic layer analyses, the inclusion of μ and E value data items is warranted.

Maintenance, Resurfacing and Seal Coats

Sub File (RI-123-03)

This is a most important sub file as the data accumulated are not only necessary for modifying the design model per se but also for periodically "re-running" the design to update the original predictions. The data collected primarily relate to periodic costs incurred. Several aspects of these costs and other items in the sub file require further explanation.

Firstly, as shown in the listing of Table A-4 and the coding form of Table B-4, maintenance costs can be recorded between specific dates. This may, of course, be done annually but the provision exists for subdividing into smaller intervals of time, where maintenance activities may be more intense. It also provides for recording maintenance costs just up to the time of a resurfacing or seal coat and then beginning again with the intensity and costs of maintenance now at a reduced level.

The items on Composite Labor Rate, Composite Equipment Rate and Number of Days Temperature Stayed Below 32° F (Nos.16, 17, and 19, respectively, of Table A-4) come from the "maintenance model" of NCHRP Report 42 (Ref 12). This model is currently being incorporated into the Rigid Pavement Design System (RPS) of Project 123.

The Total Cost of Equipment per Lane Mile (No. 27 of Table A-4) is also in RPS and is used to reflect a "fixed" equipment cost for overlaying or seal coating that is relatively independent of the size of the project. In other words, it is a means of recognizing that in-place, unit costs will be greater for smaller jobs than for otherwise comparable larger jobs.

Other variables in Tables A-4 and B-4 relate to traffic costs during overlaying and seal coating. This includes the various distances, numbers of vehicles delayed, and delay times.

Finally, items relating to production rate of material or in-place compacted density are included because of their effects on unit costs, i.e., a higher density requires more rolling, with resulting higher cost of construction.

Environment Sub File (RI-123-04)

The purpose of this sub file is primarily for recording climatic data. It is also designed to include some general topographic and drainage information, as well as temperature and moisture data through the pavement depth.

The general data items for drainage, topography, and weather conditions at time of temperature recording, as shown in the listing of Table A-5 and the coding form of Table B-5, are in coded format. An explanation of the codes used for these items is given in Appendix C.

The climatic data items (i.e., temperature, freezing, frost penetration, and rainfall) are in a form that is thought most suitable for checking or updating models. There are, of course, many variations of the manner in which temperature data could be recorded.

The items for temperature through the pavement depth included are primarily of a research nature, and restricted to a few locations. However, if it is desired to check the estimated stiffness gradient (which depends upon the temperature gradient) through the pavement depth, then temperature data are necessary.

Materials Data Sub File (RI-123-05)

Any data file on pavement materials could be expanded quite easily to include several hundred items. RI-123-05, as shown in the Table A-6 listing, has been held to 122 items, although field space has been left to include several more, if desired.

The sub file has been designed, as reflected by the coding forms of Table B-7, to include the following main categories of materials data:

(1) subgrade,

(2) subbase and subbase aggregates,

(3) base and base aggregates,

(4) portland cement concrete,

(5) aggregates for portland cement and asphalt concretes,

(6) steel for portland cement concrete,

(7) hot mix asphalt concrete,

(8) seal coats.

The subgrade category includes items for strength (i.e., Texas Triaxial Class), lime modification, swelling clay parameter, Atterberg limits, and density. A number of other items could have been included but the foregoing represent the ones on which data can be fairly easily acquired and which will be most useful to the design models.

The variety of items for the other categories listed are for the most part of a "routine" nature and the necessary data are usually acquired during design and construction. Most are self-explanatory except perhaps for the fact that only three data fields for aggregate size are included, rather than the whole range of sieve sizes. The reason is that most design or analysis models usually consider one or two sizes as representative or "critical." Consequently, maximum size, percent passing No. 200, and percent passing No. 4 are used. These could easily be changed, if desired, to say percent passing No. 10 instead of No. 4, and data could be recorded for that size. Space has also been left for one or two extra data fields beside each aggregate type for possible future inclusion of some other parameter.

The number of items for the hot mix asphalt concrete is a bit more extensive than may appear necessary. However, because of the need for safe, durable, and stable surfaces, considerable research attention is usually directed towards this material. Moreover, some apparently minor, within-specification, differences in component properties (i.e., viscosity range of the asphalt cement at 140° F) can markedly affect the behavior and performance of the surface material. Consequently, while many of the items will only be recorded on certain selected evaluation segments, their inclusion in the data bank is thought to be important to an up-to-date materials technology portion of the overall pavement system.

Traffic Sub File (RI-123-06)

The Planning and Survey Division (D-10) collects a large amount of traffic volume and load data. It is not expected that the pavement data system will require anything different from that collected, except perhaps in some future special research study. Consequently, while RI-123-06 is designated as a distinct part of the pavement data system, it will initially at least operate only by accessing D-10's data files. Because of this, coding forms are not required. However, a listing of several of the major data items needed for the design models has been included in Table A-7. It may be considered useful in the future to periodically retrieve such data from D-10 and store them separately in the pavement data system.

Since D-10 has 188 classification stations, 154 continuous coverage stations and 21 loadometer stations, the acquisition of precise RI-123-06 data depends upon the location of the particular evaluation segment. The initial establishment of these segments should therefore carefully consider traffic station location and take advantage where possible of these locations. Otherwise, the estimated traffic and load data for the particular evaluation segment may not be precise enough for checking or updating design models, and special counts may be required.

CHAPTER 6. FURTHER DEVELOPMENT AND IMPLEMENTATION

Sampling Plan and Guides

The sampling plan, and the guides that go with it, comprise a major, forthcoming development task, although sampling and data acquisition were implicitly considered in designing the data files. Since the major amount of data will come from the district staffs, resources available must be carefully considered in selecting the number of evaluation segments and the intensity or frequency of sampling. Moreover, the initial sampling plan must be of a trial nature in one or more selected districts, to test its feasibility.

Communication of Data

Figure 19 is a general outline of the communication and data flow channels needed for the pavement data system. The district resident engineer and pavement design are shown separately, although in some cases they will coincide.

Since the primary purpose of the data system is for checking and updating design models, the Research Section of the Design Division (D-8R) will have responsibility for its maintenance. The Automation Division (D-19) will handle data processing and storage. Figure 19 also shows the link needed between D-8R and the district pavement design. This cooperation and coordination is similar to that underway in the flexible pavement design system (FPS).

Software Development

Another major development task is that of uniting a variety of data

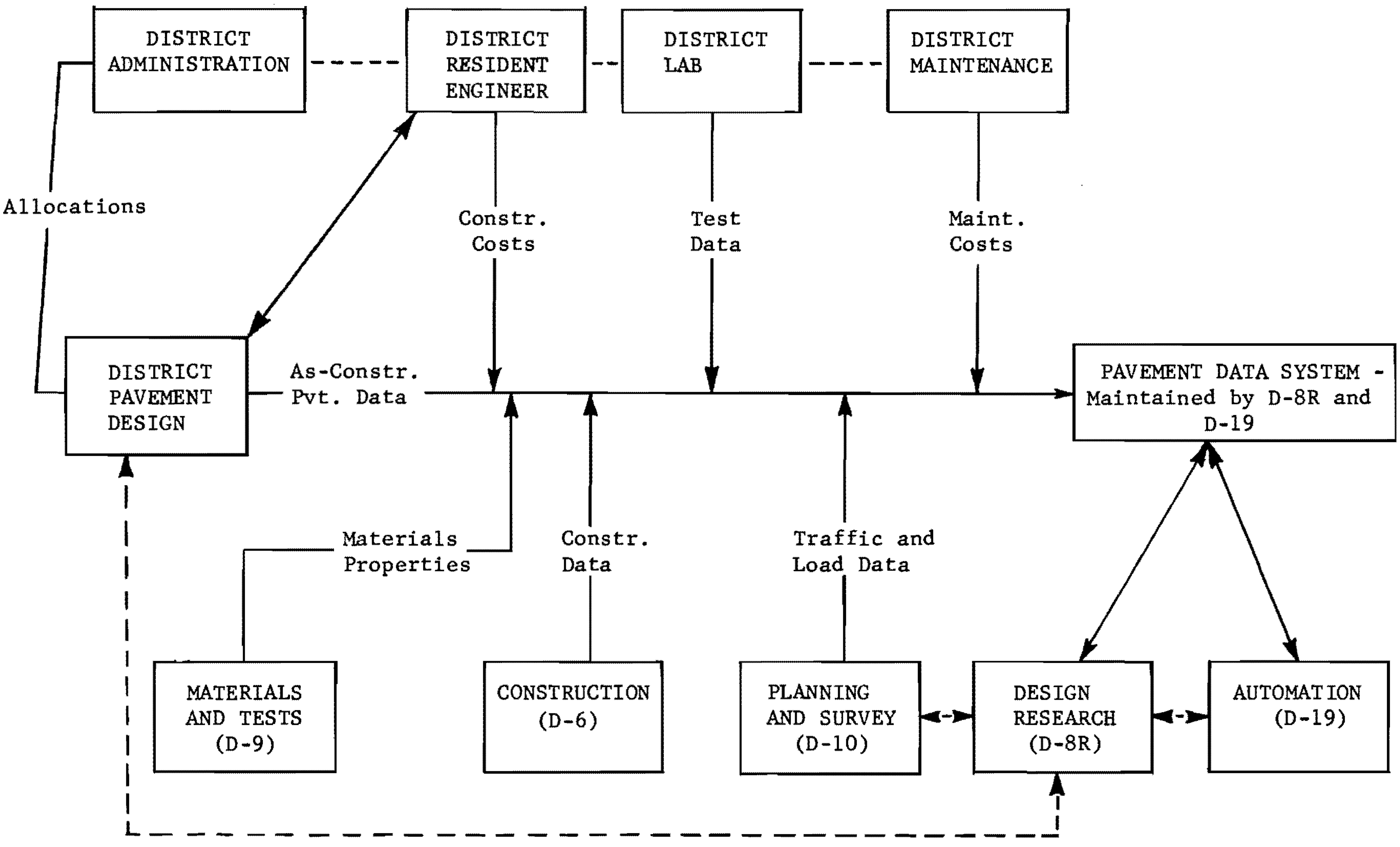

FIGURE 19 - GENERAL COMMUNICATION AND DATA FLOW CHANNELS FOR PROJECT 123 PAVEMENT DATA SYSTEM

retrieval programs. There are a large number of possible types of retrieval that may be desired for analysis. As an example, Figs 20, 21, and 22 show sample retrieval runs from the system using fictitious data. While these show data as it would be directly stored in the system, other forms of output could include varying degrees of analysis and/or correlation.

The retrieval programs needed will basically involve two types:

(1) periodic outputs, primarily for trend analyses,

(2) special outputs for special research analyses.

For the second type of retrieval, the program generator being used in the Wisconsin Highway Network Data System (Ref 2) may be of some value. It avoids being dependent upon the availability of a programmer each time a retrieval is desired.

TEXAS HIGHWAY DEPARTMENT

PAVEMENT DATA SYSTEM - DATA RETRIEVAL

INVENTORY OF PAVEMENT EVALUATION SEGMENTS DESIGNED BY FPS AND RPS

FILES ACCESSED= RT-123
RT-123-01
RT-123-06

HWY	CONTL	SEC NO	EVAL SEG NO	BEG MI PT	END MI PT	DATE PVT COMPL	PVT SURF TYPE	BASE TYPE	SUBB TYPE	SUBGR SOIL TYPE	TOT PVT DEPTH	INITIAL PSI	INITIAL ADT
IH35	15	7	3	24.610	25.083	30AUG68	2	0	1	A-7-5	9	4.5	25000
IH35	15	8	3	34.700	35.173	11SEP68	2	0	1	A-7-5	9	4.5	25000
IH35	15	9	3	43.240	43.713	01OCT68	2	0	1	A-7-5	9	4.5	25000
IH35	15	10	4	52.115	52.588	17OCT68	2	0	1	A-7-6	9	4.5	25000
US77	371	3	1	18.210	18.683	10FEB69	1	2	1	A-2-7	12	4.3	15000
US77	371	4	2	22.450	22.923	12FEB69	1	2	1	A-2-7	12	4.4	15000
SH103	336	5	1	15.335	15.808	25APR69	1	2	4	A-4	13	4.2	12000
SH103	336	6	2	25.650	26.123	30APR69	1	2	4	A-5	13	4.2	12000
SH103	336	7	3	33.825	34.298	02MAY69	1	2	4	A-3	13	4.0	12000
SH103	336	8	4	41.220	41.693	05MAY69	1	2	4	A-4	13	4.4	12000
US377	80	2	1	40.400	40.873	01JUN70	1	2	1	A-7-5	12	4.4	16000
US377	80	3	2	45.265	45.738	06JUN70	1	2	1	A-7-6	12	4.5	16000

Fig 20. Example retrieval from project 123 Pavement Data System.

TEXAS HIGHWAY DEPARTMENT

PAVEMENT DATA SYSTEM - DATA RETRIEVAL

INITIAL SERVICEABILITY AND SKID CONDITIONS

FILES ACCESSED- RT-123
RT-123-01

HWY	CONTL	SEC NO	EVAL SEG NO	BEG MI PT	END MI PT	DATE PVT COMPL	PVT SURF TYPE	INITIAL PSI	MEAN SKID NO	MEAN PSR
IH35	15	7	1	24.610	25.083	30AUG68	2	4.5	.59	4.2
IH35	15	8	2	34.700	35.173	11SEP68	2	4.5	.62	4.1
IH35	15	9	3	43.240	43.713	01OCT68	2	4.5	.65	4.1
IH35	15	10	4	52.115	52.588	17OCT68	2	4.5	.62	4.3
US77	371	3	1	18.210	18.683	10FEB69	1	4.5	.65	4.3
US77	371	4	2	22.450	22.923	12FEB69	1	4.3	.56	4.2
SH103	336	5	1	15.335	15.808	25APR69	1	4.4	.52	4.5
SH103	336	6	2	25.650	26.123	30APR69	1	4.2	.49	4.0
SH103	336	7	3	33.825	34.298	02MAY69	1	4.2	.50	4.0
SH103	336	8	4	41.220	41.693	05MAY69	1	4.0	.52	4.3
US377	80	2	1	40.400	40.873	01JUN70	1	4.4	.55	4.2
US377	80	3	2	45.265	45.738	06JUN70	1	4.5	.55	4.1

Fig 21. Example retrieval from project 123 Pavement Data System.

TEXAS HIGHWAY DEPARTMENT

PAVEMENT DATA SYSTEM - DATA RETRIEVAL

TOTAL CONSTRUCTION AND MAINTENANCE COSTS PER LANE-MILE

FILES ACCESSED- RI-123
RI-123-01
RI-123-06
RI-123-03

THE AGE OF ALL SECTIONS IS 4.5 TO 5.0 YEARS AS OF 01 JULY 1970.

HWY	CONTL	SEC NO	EVAL SEG NO	BEG MI PT	END MI PT	DATE PVT COMPL	PVT SURF TYPE	CURR PSI	CURR ADT	INITIAL COST PER LANE-MI	MAINT COST PER LANE-MI
FM1911	1150	5	1	3.500	3.973	03JUL65	1	3.5	2500	18830.00	0.00
FM1911	1150	5	2	5.610	6.083	03JUL65	1	3.5	2500	18830.00	0.00
FM1911	1150	5	3	8.215	8.688	03JUL65	1	3.6	2500	18830.00	0.00
US181	101	2	1	3.750	4.223	10NOV65	1	4.0	9000	117400.00	70.00
US181	101	2	2	5.750	6.223	10NOV65	1	3.9	9000	117400.00	70.00
US181	101	3	3	10.370	10.843	30NOV65	1	3.9	9000	117400.00	70.00
US181	101	3	4	14.260	14.733	30NOV65	1	3.9	9000	117400.00	70.00
FM1323	1056	4	1	2.500	2.973	15SEP65	1	3.7	2200	16700.00	100.00
FM1323	1056	4	2	4.500	4.973	15SEP65	1	3.8	2200	16700.00	100.00
FM1323	1056	5	3	8.200	8.673	21SEP65	1	3.8	2200	16700.00	100.00
FM1323	1056	5	4	15.450	15.923	20SEP65	1	3.8	2200	16700.00	100.00
US285	139	5	1	8.000	8.473	16AUG65	1	3.1	5000	101550.00	450.00
US285	139	6	2	5.250	5.723	26AUG65	1	3.2	5000	101550.00	450.00
US285	139	6	3	10.650	11.123	26AUG65	1	3.2	5000	101550.00	450.00

Fig 22. Example retrieval from project 123 Pavement Data System.

CHAPTER 7. SUMMARY AND RECOMMENDATIONS

This report has described the planning and initial development of a pavement feedback data system, which is a part of Project 123, "A System Analysis of Pavement Design and Research Implementation." The principal points of the report may be summarized as follows:

(1) The existing state of technology in the pavement field is imperfect and design and management models require upgrading on a continuing basis. This can best be accomplished by collecting feedback information on pavements in service.

(2) The general principles underlying the development of a data system are described in the report. These relate to its scope, to its integration with other functions and data files of the particular agency, and to general types of data systems available. In addition, the major phases in developing and implementing a data system have been described.

(3) The Texas Highway Department currently acquires and processes a large amount of data on its highway network. Much of this is relevant to the pavement data system and examples are contained in the report.

(4) The functional requirements for the pavement data system have been discussed in the report in terms of (1) acquisition and communication of data, (2) staged implementation, and (3) methods for determining the usefulness of the system.

(5) The initial development of the pavement data system has been

described in detail in the report. The various factors in the system have been listed and categorized in the following data files:

(i) Master File,

(ii) Performance Data Sub File,

(iii) Structure Capacity Sub File,

(iv) Maintenance, Resurfacing, and Seal Coats Sub File,

(v) Environment Sub File,

(vi) Materials Data Sub File, and

(vii) Traffic Data Sub File.

Each file has been described in detail, including the coding of factors. Coding forms have been prepared, using groupings of various factors. These have also been described.

(6) Further development needs and implementation of the data system have been discussed briefly in the report. Several sets of example retrieval data have been presented to illustrate the software development.

The major recommendations derived from the work to date on the data system are that a sampling plan and guides should be prepared and that the software development should be continued, as discussed briefly in the report. Trial implementation should also be started using the pavement sections constructed using the Project 123 design system. In this way, assumptions of the sampling plan as to resources required for data acquisition and processing can be evaluated quickly and accurately. Similarly, payoffs from the research effort will be realized much earlier by following the Project 123 principle of immediate implementation followed by progressive improvements.

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APPENDIX A

LISTINGS OF FACTORS IN PAVEMENT DATA SYSTEM

APPENDIX A-1. FACTORS FOR RI 123/MASTER FILE

Job Number	File Name RI 123 Master File		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 1 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page of 1 5
Remarks RI 123 Sheet 1, Sheet 2				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
1	1-5	5			NCARD	Card No.
2	6-10	5			IUPCL	Update Class, Code
3	11-15	5			DIST	District No.
4	16-20	5			CONTY	County No.
5	21-25	5			SYST2	Highway System, Code
6	26-30	5			HWY	Highway No.
7	31-35	5			CONTL	SHD Control No.
8	36-40	5			SHD	SHD Section No.
9	41-45	5			IEVAL	Evaluation Segment No.
10	46-55	10	3		BEGMI	Begin Mile Point of Evaluation Segment
11	56-65	10	3		ENDMI	End Mile Point of Evaluation Segment
12	1-5	5			NCARD	Card No.
13	6-15	10			IDATE1	Date of Acquiring Inventory Data
14	6-15	10			IDATE2	Date Pavement Completed
15	26-35	10			IDATE3	Date Pavement Opened to Traffic
16	36-41	5			KOC37	Number of Lanes

TABLE A-1. (Continued)

Job Number	File Name RI 123 Master File		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 1 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 2 of 5
Remarks RI 123 Sheet 2, Sheet 3				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
17	41-45	5			LANEW	Lane Width, ft.
18	46-50	5			MEDW	Median Width, ft.
19	51-55	5			MEDTYP	Median Type, Code
20	56-60	5			CONJT	Contraction Joint Spacing, ft.
21	61-65	5			EXPJT	Expansion Joint Spacing, ft.
22	66-70	5			NJM	Number of Transverse Joints per mile for CRCP
23	1-5	5			NCARD	Card No.
24	6-10	5	1		PVTD	As-Built Total Pavement Depth, In.
25	11-15	5			ISURF	As-Built Surface Type, Code
26	16-20	5	1		SURFD	As-Built Surface Depth, In.
27	21-25	5	1		BINDD	As-Built Asphalt Binder Course Depth, In.
28	26-30	5			IBASE	As-Built Base Type, Code
29	31-35	5	1		BASED	As-Built Base Depth, In.
30	26-40	5			ISUBB	As-Built Subbase Type, Code
31	41-45	5	1		SUBBD	As-Built Subbase Depth, In.

Job Number	File Name RI 123 Master File		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 1 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page of 3 5
Remarks RI 123 Sheet 3, Sheet 4				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
32	46-55	10			ISUBGR	Subgrade Soil Type (AASHO Classification)
33	56-60	5			SUBTRD	Depth of Lime Treatment of Subgrade
34	1-5	5			NCARD	Card No.
35	6-15	10	2		TOTCOS	Total As-Built Pavement Cost per Lane-Mile
36	16-20	5	2		SYCOC	Total As-Built Pavement Cost per Sq. Yd.
37	21-25	5	2		TONCOS	Total As-Built Cost of Surface and Binder per Ton
38	26-30	5	2		CYCOS	Total As-Built Cost of Surface per Comp. Cu. Yd.
39	31-35	5	2		BASEC	Total As-Built Cost of Base per Compacted Cu. Yd.
40	36-40	5	2		SUBBC	Total As-Built Cost of Subbase per Comp. Cu. Yd.
41	41-45	5	2		SUBTRC	Total As-Built Cost of Subgrade Treatment per Sq. Yd.
42	46-50	5	2		BARCOS	Cost per Pound of Bar Steel (Transv. and Long.)
43	51-55	5	2		TIECOS	Cost per Pound of Tie Bar Steel
44	56-60	5	2		WIREC	Cost per Pound of Wire Mesh Reinforcement
45	61-65	5	2		SAWTC	Cost per Foot of Transverse Sawing and/or Sealing
46	66-70	5	2		SAWLC	Cost per Foot of Longitudinal Sawing and/or Sealing

TABLE A-1. (Continued)

Job Number	File Name RI 123 Master File		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 1 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 4 of 5
Remarks RI 123 Sheet 5, Sheet 6				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
47	1-5	5			NCARD	Card No.
48	6-10	5			SALVAL	Material Salvage Value as a Percent of Original Cost
49	11-20	10	2		EQCOS1	Initial Fixed Cost of Equip. per Lane-Mile for Pouring Conc. Slab
50	21-25	5	2		CONCYC	Cost per Cubic Yard of Concrete in Place
51	26-35	10	2		CONLMC	Cost per Lane-Mile of Finished Concrete
52	36-45	10	2		SUBPRC	Cost per Lane-Mile of Subgrade Preparation
53	46-55	10	2		EQCOS2	Cost per Lane-Mile of Equip. for Constructing Subbase
54	56-60	5	2		SUBBCR	Cost per Cu. Yd. of Compacted Subbase for Rigid Pvt.
55	1-5	5			NCARD	Card No.
56	6-10	5			INST	Inner Shoulder Surface Type, Code
57	11-15	5	1		SINSD	Inner Shoulder Surface Depth, Inches
58	16-20	5			INBT	Inner Shoulder Base Type, Code
59	21-25	5	1		SINBD	Inner Shoulder Base Depth, Inches
60	26-30	5			INSBT	Inner Shoulder Subbase Type, Code
61	31-35	5	1		SINSBD	Inner Shoulder Subbase Depth, Inches

Job Number	File Name RI 123 Master File		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 1 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page of 5 5
Remarks RI 123 Sheet 6				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
62	36-40	5			IOUTST	Outer Shoulder Surface Type, Code
63	41-45	5	1		SOUTSD	Outer Shoulder Surface Depth, In.
64	46-50	5			IOUTBT	Outer Shoulder Base Type, Code
65	51-55	5	1		SOUTBD	Outer Shoulder Base Depth, In.
66	56-60	5			IOUTSB	Outer Shoulder Subbase Type, Code
67	61-65	5	1		SOUTSB	Outer Shoulder Subbase Depth, In.

TABLE A-2. FACTORS FOR RI 123-01/PERFORMANCE DATA SUBFILE

Job Number	File Name RI 123-01 Performance Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 3 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 1 of 3
Remarks RI 123-01 Sheet 1, Sheet 2 (Part)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
1	1-5	5			NCARD	Card No.
2	6-10	5			IUPCL	Update Class, Code
3	11-20	10			INDATE	Time of Acquiring Inventory Data
4	21-25	5			DIST	District No.
5	26-30	5			CONTY	County No.
6	31-35	5			CONTL	SHD Control No.
7	36-40	5			SHD	SHD Section No.
8	41-45	5			IEVAL	Evaluation Segment No.
9	46-55	10	3		BEGMI	Begin Mile Point of Evaluation Segment
10	56-65	10	3		ENDMI	End Mile Point of Evaluation Segment
11	66-70	5			LANE	Lane and Wheel Path Designation, Code
12	1-5	5			NCARD	Card No.
13	6-10	5			SLOPE	Mean Slope Variance, $\overline{sv}$
14	11-15	5			METHOD	Method of Obtaining Slope Variance, Code
15	16-20	5			CRACK	Cracking, Sq. Ft. per 1000 Sq. Ft.
16	21-25	5			PATCH	Patching, Sq. Ft. per 1000 Sq. Ft.

Job Number	File Name RI 123-01 Performance Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 3 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 2 of 3
Remarks RI 123-01 Sheet 2 (cont.), Sheet 3 (Part)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
17	26-30	5	1		RUT	Mean Rut Depth, In.
18	31-35	5	1		TEXT	Mean Pavement Texture
19	36-40	5	1		PSI	Present Serviceability Index, Calc.
20	41-45	5			ITEMP	Air Temperature at Time of Test, °F
21	46-50	5			NSKID	Number of Skid Tests
22	51-55	5			SKIDM	Mean Skid No.
23	56-60	5			SKIDS	Std. Dev. of Skid No.
24	1-5	5			NCARD	Card No.
25	6-10	5	1		PSR	Mean Panel Present Serviceability Rating
26	11-15	5			NPSR	Number of People on Panel
27	16-20	5	1		PSRDEV	Std. Dev. of Panel Rating
28	21-25	5			IYESIS	No. Accepted for Interstate System
29	26-30	5			IUNIS	No. Undecided for Interstate System
30	31-35	5			IREJIS	No. Rejected for Interstate System

TABLE A-2. (Continued)

Job Number	File Name RI 123-01 Performance Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 3 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 3 of 3
Remarks RI 123-01 Sheet 3 (Cont.) * Items 34-38 not listed on coding sheets				

	Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
	31	36-40	5			IYESSS	No. Accepted for Secondary System
	32	41-45	5			IUNSS	No. Undecided for Secondary System
	33	46-50	5			IREJSS	No. Rejected for Secondary System
*	34		5	1		RIBPR	Roughness Index by BPR Roughometer
	35		5	1		RISDP	Roughness Index by SD Profilometer
	36		5	1		RIMAYS	Roughness Index by Mays Meter
	37		5			PCASUM	Roughness Index by PCA Meter (Σ count)
	38		5			PCADEV	Roughness Index by PCA Meter (ΣD^2)

TABLE A-3. FACTORS FOR RI 123-02/STRUCTURE CAPACITY SUBFILE

Job Number	File Name RI 123-02 Structure Capacity Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 14 Jul 1970
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page of 1 of 3
Remarks RI 123-02 Sheet 1, Sheet 2 (Part)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
1	1-5	5			NCARD	Card No.
2	6-10	5			IUPCL	Update Class, Code
3	11-12	10			INDATE	Time of Acquiring Inventory Data
4	21-25	5			DIST	District No.
5	26-30	5			CONTY	County No.
6	31-35	5			CONTL	SHD Control No.
7	36-40	5			SHD	SHD Section No.
8	41-45	5			IEVAL	Evaluation Segment No.
9	46-55	10	3		BEGMI	Begin Mile Point of Evaluation Segment
10	56-65	10	3		ENDMI	End Mile Point of Evaluation Segment
11	66-70	5			LANE	Lane and Wheel Path Designation
12	1-5	5			NCARD	Card No.
13	6-10	5			ITEMP	Air Temperature at Time of Tests, °F
14	11-15	5			JTEMP	Pavement Surface Temperature at Time of Tests, °F
15	16-20	5			IGEOPH	Geophone Code
16	21-23	3			DYNS1	Deflection at Station 1, milli-in.

TABLE A-3. (Continued)

Job Number	File Name RI 123-02 Structure Capacity Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 14 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 2 of 3
Remarks RI 123-02 Sheet 2 (cont.), Sheet 3 (Poisson's Ratio, E Value) (Part)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
17	24-26	3			DYNS2	Deflection at Station 2, milli-in.
18	27-29	3			DYNS3	Deflection at Station 3, milli-in.
19	33-35	3			DYNS4	Deflection at Station 4, milli-in.
20	33-35	3			DYNS5	Deflection at Station 5, milli-in.
21	36-38	3			DYNS6	Deflection at Station 6, milli-in.
22	39-41	3			DYNS7	Deflection at Station 7, milli-in.
23	42-44	3			DYNS8	Deflection at Station 8, milli-in.
24	45-47	3			DYNS9	Deflection at Station 9, milli-in.
25	48-50	3			DYNS10	Deflection at Station 10, milli-in.
26	51-53	3			DYNS11	Deflection at Station 11, milli-in.
27	54-56	3			DYNS12	Deflection at Station 12, milli-in.
28	57-59	3			DYNS13	Deflection at Station 13, milli-in.
29	60-62	3			DYNS14	Deflection at Station 14, milli-in.
30	63-65	3			DYNS15	Deflection at Station 15, milli-in.
31	1-5	5			NCARD	Card No.
32	6-10	5	2		USUBGR	Poisson's Ratio for Subgrade

TABLE A-3. (Continued)

Job Number	File Name RI 123-02 Structure Capacity Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 14 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 3 of 3
Remarks RI 123-02 Sheet 3 (Cont.) (Poisson's Ratio, E Value)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
33	11-15	5	2		USUBB	Poisson's Ratio for Subbase
34	16-20	5	2		UBASE	Poisson's Ratio for Base
35	21-25	5	2		USURF	Poisson's Ratio for Surface
36	26-30	5	2		UOVER	Poisson's Ratio for Overlay
37	31-40	10			ESUBGR	E Value for Subgrade, psi
38	41-50	10			ESUBB	E Value of Subbase, psi
39	51-60	10			EBASE	E Value for Base, psi
40	61-70	10			ESURF	E Value for Surface, psi
41	71-80	10			EOVER	E Value for Overlay, psi

TABLE A-4. FACTORS FOR RI 123-03/MAINTENANCE, RESURFACING, AND SEAL COAT SUBFILE

Job Number	File Name RI 123-03 Maintenance, Resurfacing, and Seal Coat Subfile		Storage Medium		
Avg. No. Records	Fields	Characters	How current	Date Prepared 16 July 70	
File Sequence			Prepared by DPS	Reviewed by RCGH	
Labels				Record Source	
Retention Characteristics				Page 1 of 3	
Remarks Sheet 1 (Locational Identification), Sheet 2 (Maintenance)					

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
1	1-5	5			NCARD	Card No.
2	6-10	5			IUPCL	Update Class, Code
3	11-20	10			INDATE	Time of Acquiring Inventory Data
4	21-25	5			DIST	District No.
5	26-30	5			CONTY	County No.
6	31-35	5			CONTL	SHD Control No.
7	36-40	5			SHD	SHD Section No.
8	41-45	5			IEVAL	Evaluation Segment No.
9	46-55	10	3		BEGMI	Begin Mile Point of Evaluation Segment
10	56-65	10	3		ENDMI	End Mile Point of Evaluation Segment
11	66-70	5			LANE	Lane and Wheel Path Designation, Code
12	1-5	5			NCARD	Card No.
13	6-15	10			ISMAIN	Start Date of Maintenance Cost
14	16-25	10			IEMAIN	End Date of Maintenance Cost
15	26-35	10	2		COMAIN	Total Maint. Cost for Pvt. and Shldr. Incurred Between Dates
16	36-40	5	2		COSLAB	Composite Labor Rate Between Dates, $ per hr.

Job Number	File Name RI 123-03 Maintenance, Resurfacing, and Seal Coat Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 16 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 2 of 3

Remarks

Sheet 2 (Maintenance), Sheet 3 (Overlays and Seal Coats)

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
17	41-45	5	2		EORATE	Composite Equip. Rental Rate Between Dates, $ per hr.
18	46-55	10	2		COMAT	Maint. Matl. Cost between Dates, $ per hr.
19	56-60	5			NFREEZ	No. of Days Temp. Stayed Below 32°F Between Dates
20	1-5	5			NCARD	Card No.
21	6-15	10			ICONST	Start Date
22	16-25	10			ICONEN	Completion Date
23	26-30	5			NCONDA	Number of Actual Construction Days
24	31-35	5			IOVTYP	Type of Overlay or Seal Coat, Code
25	36-40	5	1		OVTHIC	Thickness, in.
26	41-45	5	2		OVCOSY	Total Cost per Square Yard
27	46-55	10	2		EQCOS	Total Cost of Equipment per lane-mile
28	56-60	5	2		OVRATE	Production Rate of Overlay Material, tons per hr.
29	61-65	5	2		COSACY	In-place Cost of Asphalt Concrete per cubic yd.
30	66-75	10	2		COMPAC	Compacted Density of Overlay, tons per cubic yd.

TABLE A-4. (Continued)

Job Number	File Name RI 123-03 Maintenance, Resurfacing, and Seal Coat Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 16 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 3 of 3
Remarks Sheet 4 (Traffic Through Overlay Zone)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
31	1-5	5			NCARD	Card No.
32	6-10	5	3		DTSO	Dist. over which Traffic is Slowed in Ov. Dir., miles
33	11-15	5	3		DTSN	Dist. over which Traffic is Slowed in Non-Ov. Dir., miles
34	16-20	5	3		DDOZ	Dist. Meas. along Detour around Ov. Zone, miles
35	21-25	5	2		HPDC	No. of hrs. per day of Overlay or Seal Coat Constr.
36	26-30	5			NVEHO	No. of Vehicles Arriving During hrs. of Constr.
37	31-35	5			NOLO	No. of Open Lanes in Restricted Zone, Ov. Dir.
38	36-40	5			NOLN	No. of Open Lanes in Restricted Zone, Non-Ov. Dir.
39	41-45	5			PVSO	Vehicles Stopped by Road Equip. in Ov. Dir., %
40	46-50	5			PVSN	Vehicles Stopped by Road Equip. in Non-Ov. Dir., %
41	56-55	5	2		DEQO	Avg. Delay per Vehicle Stopped in Restricted Zone in Ov. Dir., hours
42	56-60	5	2		DEQN	Avg. Delay per Vehicle stopped in Restricted Zone in Non-Ov. Dir., hours
43	61-65	5			AAS	Avg. Approach Speed to Overlay Zone, mph.
44	66-70	5			ASOD	Avg. Speed Through Restricted Zone in Ov. Dir., mph
45	71-75	5			ASND	Avg. Speed Through Restricted Zone in Non-Ov. Dir., mph.

TABLE A-5. FACTORS FOR RI 123-04/ENVIRONMENT SUBFILE

Job Number	File Name RI 123-04 Environment Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 17 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 1 of 3

Remarks
Sheet 1 (Locational Identification), Sheet 2 (Temperature, Frost and Rain Data)

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
1	1-5	5			NCARD	Card No.
2	6-10	5			IUPCL	Update Class, Code
3	11-20	10			INDATE	Time of Acquiring Inventory Data
4	21-25	5			DIST	District No.
5	26-30	5			CONTY	County No.
6	31-35	5			CONTL	SHD Control No.
7	36-40	5			SHD	SHD Section No.
8	41-45	5			IEVAL	Evaluation Segment No.
9	46-55	10	3		BEGMI	Begin Mile Point of Evaluation Segment
10	56-65	10	3		ENDMI	End Mile Point of Evaluation Segment
11	66-70	5			LANE	Lane and Wheel Path Designation, Code
12	1-5	5			NCARD	Card No.
13	6-10	5			IDRAIN	General Drainage Conditions, Code
14	11-15	5			ITOPOG	Topography, Code
15	21-30	10			IBEDA	Begin Date of Temp., Frost or Rain Data
16	31-40	10			IENDA	End Date of Temp., Frost or Rain Data
17	41-45	5			MAXTEM	Mean Max. Daily Temperature, ^{o}F

TABLE A-5. (Continued)

Job Number	File Name RI 123-04 Environment Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 17 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 2 of 3

Remarks Sheet 2 (Temperature, Frost and Rain Data),
Sheet 3 (Temperature and Moisture Through Pavement Depth)

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
18	46-50	5			MINTEM	Mean Min. Daily Temperature, °F
19	51-55	5	1		FROST	Mean Depth of Frost Pen. Below Pvt. Surf., in.
20	56-60	5			INDEX	Freezing Index, Degree-Days
21	61-65	5	1		RAIN	Total Rainfall, in.
22	1-5	5			NCARD	Card No.
23	6-10	5			IAIR	Air Temperature, °F
24	11-15	5			ISKY	Weather Conditions, Code
25	16-20	5			IWIND	Wind Speed, mph.
26	21-25	5			ISTEMP	Pavement Surface Temperature, °F
27	26-29	4	1		DE1	Depth Below Surface, in. (Point 1)
28	30-32	3			IT1	Temperature, °F
29	33-35	3			MO1	Moisture Content, %
30	36-39	4	1		DE2	Depth Below Surface, in (Point 2)
31	40-42	3			IT2	Temperature, °F
32	43-45	3			MO2	Moisture Content, %
33	46-49	4	1		DE3	Depth Below Surface, in. (Point 3)
34	50-52	3			IT3	Temperature, °F

TABLE A-5. (Continued)

Job Number	File Name RI 123-04 Environment Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 17 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page of 3 3
Remarks Sheet 3 (Temperature and Moisture Through Pavement Depth)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
35	53-55	3			MO3	Moisture Content, %
36	56-59	4	1		DE4	Depth Below Surface, in. (Point 4)
37	60-62	3			IT4	Temperature, ^{o}F
38	63-65	3			MO4	Moisture Content, %

TABLE A-6. FACTORS FOR RI 123-05/MATERIALS DATA SUBFILE

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 17 July 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 1 of 8

Remarks

Sheet 1 (Locational Identification), Sheet 2 (Subgrade)

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
1	1-5	5			NCARD	Card No.
2	6-10	5			IUPCL	Update Class, Code
3	11-20	10			INDATE	Time of Acquiring Inventory Data
4	21-25	5			DIST	District No.
5	26-30	5			CONTY	County No.
6	31-35	5			CONTL	SHD Control No.
7	36-40	5			SHD	SHD Section No.
8	41-45	5			IEVAL	Evaluation Segment No.
9	46-55	10	3		BEGMI	Begin Mile Point of Evaluation Segment
10	56-65	10	3		ENDMI	End Mile Point of Evaluation Segment
11	66-70	5			LANE	Lane and Wheel Path Designation, Code
12	1-5	5			NCARD	Card No.
13	6-10	5	1		SGRLM	Mean Lime Content, %
14	11-15	5	1		SGRLSD	Std. Dev. of Lime Content, %
15	16-20	5			SGKM	Mean K Value, pci
16	21-25	5			SGKSD	Std. Dev. of K Value

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 17 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 2 of 8
Remarks Sheet 2 (Subgrade), Sheet 3 (Subbase)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
17	26-30	5	1		SGRDEN	Mean Compacted Density, lbs/cu. ft.
18	31-35	5	1		SGRSD	Std. Dev. of Compacted Density, lbs/ cu. ft.
19	36-40	5			TTCSGR	Texas Triaxial Class
20	41-45	5			FFSG	Friction Factor
21	46-50	5			PTWD	Swelling Clay Parameter, P_2
22	51-55	5			BONE	Swelling Clay Parameter, b_1
23	56-60	5			LIQLIM	Liquid Limit, %
24	61-65	5			PLIND	Plasticity Index
25	1-5	5			NCARD	Card No.
26	6-10	5			EF	Erodability Factor
27	11-15	5			FFSB	Friction Factor
28	16-20	5			TTCSBB	Texas Triaxial Class
29	21-25	5	1		SBBDEN	Mean Compacted Density, lb./cu. ft.
30	26-30	5	1		SBBSD	Std. Dev. of Compacted Density, lb./cu.ft.
31	31-35	5	1		SBBLM	Mean Lime Content (field), %
32	36-40	5	1		SBBLSD	Std. Dev. of Lime Content (field), %

TABLE A-6. (Continued)

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 20 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 3 of 8
Remarks Sheet 3 (cont.) (Subbase), Sheet 4 (Base)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
33	41-45	5	1		SBBCM	Mean Cement Content (field), %
34	46-50	5			SBBCSD	Std. Dev. of Cement Content (field), %
35	51-55	5			SBBASP	Asphalt Type for Treated Subbase, Code
36	56-60	5	1		SBBAM	Mean Residual Asphalt Content (field), %
37	61-65	5	1		SBBASD	Std. Dev. of Residual Asphalt Content (field), %
38	1-5	5			NCARD	Card No.
39	6-10	5			TTCB	Texas Triaxial Class
40	11-15	5	1		BSDEN	Mean Compacted Density, lb./cu. ft.
41	16-20	5	1		BSSD	Std. Dev. of Compacted Density, lb./cu. ft.
42	21-25	5	1		BSLM	Mean Lime Content (field), %
43	26-30	5	1		BSLSD	Std. Dev. of Lime Content, %
44	31-35	5	1		BSCM	Mean Cement Content (field), %
45	36-40	5	1		BSCSD	Std. Dev. of Cement Content (field), %
46	41-45	5			BSASP	Asphalt Type for Treated Base, Code
47	46-50	5	1		BSAM	Mean Residual Asphalt Content (field), %
48	51-55	5	1		BSASD	Std. Dev. of Residual Asphalt Content (field), %

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 20 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 4 of 8
Remarks Sheet 5 (aggregates), Sheet 6 (concrete)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
49	1-5	5			NCARD	Card No.
50	6-10	5			IBSAG	Base Aggregate Type, Code
51	11-15	5	2		BSAGS	Maximum Size of Base Aggregate, in.
52	16-20	5			BSA4	Percent of Base Aggregate Passing No.4 Sieve
53	21-25	5			BSA200	Percent of Base Aggregate Passing No. 200 Sieve
54	36-40	5			ISBBAG	Subbase Aggregate Type
55	41-45	5	2		SBBAGS	Maximum Size of Aggregate, in.
56	46-50	5			SBA4	Percent of Aggregate Passing No. 4 Sieve
57	51-65	5			SBA200	Percent of Aggregate Passing No. 200 Sieve
58	1-5	5			NCARD	Card No.
59	6-10	5			ICONC	Concrete Type, Code
60	11-15	5			ND	No. of Days at which Strength was Measured
61	16-20	5			SX	Mean Value of Flexural Strength, psi
62	21-25	5			SXSD	Std. Dev. of Flexural Strength, psi
63	26-30	5			CCSM	Mean Value of Compressive Strength, lbs.
64	31-35	5			CCSSD	Std. Dev. of Compressive Strength, lbs.

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 20 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 5 of 8
Remarks Sheet 6 (concrete), Sheet 7 (Asphalt or Concrete Aggregates)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
65	36-45	10			ECONC	Modulus of Elasticity-28 Days, psi
66	46-50	5			CONWT	Weight, lb./cu. ft.
67	51-55	5			CONTS	Tensile Strength, psi
68	56-60	5			IADMIX	Admixture Type, Code
69	61-65	5	1		CEMCON	Cement Content, %
70	66-70	5			ICEM	Cement Type, Code
71	1-5	5			NCARD	Card No.
72	6-10	5			IAORC	Type Referred to (HMAC or PCC)
73	11-15	5			IFILL	Mineral Filler Type, Code
74	16-20	5			ICAG	Coarse Aggregate Type, Code
75	21-25	5	2		CAGS	Maximum Size, in.
76	26-30	5			CAG4	Percent Passing No. 4 Sieve
77	31-35	5			CAG200	Percent Passing No. 200 Sieve
78	41-45	5			IFAG	Fine Aggregate Type
79	46-50	5	2		FAGS	Maximum Size, in.
80	51-55	5			FAG4	Percent Passing No. 4 Sieve

TABLE A-6. (Continued)

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 20 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 6 of 8
Remarks Sheet 7 (cont.) (Asphalt or Concrete Aggregates), Sheet 8 (Steel), Sheet 9 (HMAC (I))				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
81	56-60	5			FAG200	Percent Passing No. 200 Sieve
82	1-5	5			NCARD	Card No.
83	6-10	5			IBARS	Bar Steel Type, Code
84	11-15	5			IWIRE	Wire Mesh Steel Type, Code
85	16-25	10			YPLONG	Longitudinal Bars
86	26-35	10			YPTRAN	Transverse Bars
87	36-45	10			YPTIE	Tie-Bars
88	46-55	10			YPWIRE	Wire Mesh
89	1-5	5			NCARD	Card No.
90	6-10	5			IHMAC	HMAC Type, Code
91	11-15	5	2		HMRATE	Production Rate, tons/hr.
92	16-20	5	2		HMDM	Mean In-Place Compacted Density, tons/cu.yd.
93	21-25	5	1		HMDSD	Std. Dev. of In-Place Compacted Density, tons/cu. yd.
94	26-30	5	1		HMVM	Mean In-Place Voids Content, %
95	31-35	5	1		HMVSD	Std. Dev. of In-Place Voids Content,%

TABLE A-6. (Continued)

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 20 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 7 of 8
Remarks Sheet 9 (HMAC(I)) (cont.), Sheet 10 (HMAC(II))				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
96	36-40	5	1		HVMAM	Mean In-Place VMA, %
97	41-45	5	1		HVMASD	Std. Dev. of In-Place VMA, %
98	46-50	5	1		HSTABM	Marshall Stability (Design), lbs.
99	51-55	5			HSTABS	Marshall Stability (Field), lbs.
100	56-60	5			HFLOWD	Marshall Flow Value (Design), lbs.
101	61-65	5			HFLOWF	Marshall Flow Value (Field), lbs.
102	66-70	5			IMARSH	Compaction, Code
103	1-5	5			NCARD	Card No.
104	6-10	5	1		HACD	Asphalt Content (Design), %
105	11-15	5	1		HACF	Mean Asphalt Content (Field), %
106	16-20	5			HACSD	Std. Dev. of Asphalt Content (field),%
107	21-25	5			ACOPEN	Penetration of Original Asphalt Cement at 77° F, mm.
108	26-30	5			ACAPEN	Penetration of Oven-Aged Asphalt Cement at 77° F, mm.
109	31-35	5			AOV77	Viscosity of Original Asphalt Cement at 77° F, C.P.
110	36-40	5			AAV77	Viscosity of Oven-Aged Asphalt Cement at 77° F, C.P.
111	41-45	5			AOV140	Viscosity of Original Asphalt Cement at 140° F, Poise

TABLE A-6. (Continued)

Job Number	File Name RI 123-05 Materials Data Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 17 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 8 of 8
Remarks Sheet 10 (cont.) (HMAC(II)), Sheet 11 (Seal Coats)				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
112	46-50	5			AAV140	Viscosity of Oven-Aged Asphalt Cement at 140° F, Poise
113	51-55	5			AOV275	Viscosity of Original Asphalt Cement at 275° F, Stokes
114	56-60	5			AAV275	Viscosity of Oven-Aged Asphalt Cement at 275° F, Stokes
115	61-65	5			AOD77	Ductility of Original Asphalt Cement at 77° F, cm.
116	1-5	5			NCARD	Card No.
117	6-10	5			IASEAL	Asphalt Type, Code
118	11-15	5	1		GALSY	Asphalt Rate, gals./sq. yd.
119	16-20	5	1		RGALSY	Residual Asphalt Content, Gals./sq. yd
120	21-25	5			ISCAG	Aggregate Type, Code
121	26-30	5	2		SCAGS	Maximum Size of Aggregate, in.
122	31-35	5			SCAGR	Aggregate Rate, lbs./sq. yd.

TABLE A-7. FACTORS FOR RI 123-06/TRAFFIC SUBFILE

Job Number	File Name RI 123-06 Traffic Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 13 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 1 of 2
Remarks				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
1	1-5	5			NCARD	Card No.
2	6-10	5			IUPCL	Update Class
3	11-20	10			INDATE	Time of Acquiring Inventory Data
4	21-25	5			DIST	District No.
5	26-30	5			CONTY	County No.
6	31-35	5			CONTL	SHD Control No.
7	36-40	5			SHD	SHD Section No.
8	41-45	5			IEVAL	Evaluation Segment No.
9	46-55	10	3		BEGMI	Begin Mile Point of Evaluation Segment
10	56-65	10	3		ENDMI	End Mile Point of Evaluation Segment
11	66-70	5			LANE	Lane and Wheel Path Designation
12					NOWADT	Current ADT at Time of Acquiring Inv. Data
13					TRUCKS	Percent Trucks in ADT
14					NAXLES	Number of Axle Load Groups
15					NRANGE	Range of Axle Loads

TABLE A-7. (Continued)

Job Number	File Name RI 123-06 Traffic Subfile		Storage Medium	
Avg. No. Records	Fields	Characters	How current	Date Prepared 13 Jul 70
File Sequence			Prepared by DPS	Reviewed by RCGH
Labels				Record Source
Retention Characteristics				Page 2 of 2
Remarks Continued				

Item No.	From To	Size	No. of Dec. Pos.	Field Char.	Label	Item Name
16					NTOTAX	Total No. of Axle Applications Since
						Previous Time of Acquiring Inventory
17						Data No. of NTOTAX in Axle Load Group 1
						No. of NTOTAX in Axle Load Group j

APPENDIX B

CODING FORMS FOR PAVEMENT DATA SYSTEM

RI 123

Sheet 1

TEXAS HIGHWAY DEPARTMENT

Pavement Data System

TABLE B-1. DRAFT CODING SHEET FOR RI 123/MASTER FILE

		LOCATIONAL IDENTIFICATION								
Card No.	Update Class, Code	District No.	County No.	Highway System, Code	Highway No.	SHD Control No.	SHD Section No.	Evaluation Segment No.	Begin Mile Point of Evaluation Segment	End Mile Point of Evaluation Segment

TABLE B-1. (Continued)

	DATES									GEOMETRIC DIMENSIONS				JOINTS			
Card No.	Date of Acquiring Inventory Data			Date Pavement Completed						Number of Lanes	Lane Width, Feet	Median Width, Feet	Median Type, Code	Contraction Joint Spacing, Feet	Expansion Joint Spacing, Feet	Number of Transv. Joints Per Mile for CRCP	
	Day	Mo.	Yr.	Day	Mo.	Yr.	Day	Mo.	Yr.								

Sheet 3

TABLE B-1. (Continued)

	LAYER DEPTH AND TYPE								SUBGRADE		
Card No.	As-Built Total Pavement Depth, In.	As-Built Surface Type, Code	As-Built Surface Depth, In.	As-Built Asphalt Binder Course Depth, In.	As-Built Base Type, Code	As-Built Base Depth, In.	As-Built Subbase Type, Code	As-Built Subbase Depth, In.	Subgrade Soil Type, Code (AASHO Classification)	Depth of Lime Treatment of Subgrade, In.	

TABLE B-1. (Continued)

	COSTS (I)										
Card No.	Total As-Built PVT Cost Per Lane-Mile	Total As-Built PVT Cost Per Square Yard	Total As-Built Cost of Surface Binder Per Ton	Total As-Built Cost of Surface Binder Per Compacted Cubic Yard	Total As-Built Cost of Base Per Compacted Cubic Yard	Total As-Built Cost of Subbase Per Compacted Cubic Yard	Total As-Built Cost of Subgrade Treatment Per Square Yard	Cost Per Pound of Bar Steel (Transverse and Longitudinal)	Cost Per Pound of Tie Bar Steel	Cost Per Pound of Wire Mesh Reinforcement	Cost Per Foot of Transverse Joint Sawing and/or Sealing	Cost Per Foot of Long. Joint Sawing and/or Sealing

TABLE B-1. (Continued)

	COSTS (II)							
Card No.	Material Salvage Value as a Percent of Original Cost	Initial Fixed Cost of Equipment Per Lane-Mile for Pouring Concrete Slab	Cost Per Cubic Yard of Concrete in Place	Cost Per Lane-Mile of Finished Concrete	Cost Per Lane-Mile of Subgrade Preparation	Cost Per Lane-Mile of Equipment for Constructing Subbase	Cost Per Cubic Yard of Compacted Subbase for Rigid Pvt.	

Sheet 6

TABLE B-1. (Continued)

	SHOULDERS											
	INNER						OUTER					
Card No.	Surface Type, Code	Surface Depth, Inches	Base Type, Code	Base Depth, Inches	Subbase Type, Code	Subbase Depth, Inches	Surface Type, Code	Surface Depth, Inches	Base Type, Code	Base Depth, Inches	Subbase Type, Code	Subbase Depth, Inches

RI 123-01

Sheet 1

TEXAS HIGHWAY DEPARTMENT

Pavement Data System

TABLE B-2. DRAFT CODING SHEET FOR RI 123-01/PERFORMANCE DATA SUBFILE

						LOCATIONAL IDENTIFICATION							
Card No.	Update Class	Time of Acquiring Inventory Data				District No.	County No.	SHD Control No.	SHD Section No.	Evaluation Segment No.	Begin Mile Point of Evaluation Segment	End Mile Point of Evaluation Segment	Lane and Wheel Path Designation, Code
		Hr.	Day	Mo.	Yr.								

TABLE B-2. (Continued)

	PRESENT SERVICEABILITY INDEX							SKID				
Card No.	Mean Slope Variance, $\overline{SV}$	Method of Obtaining Slope Variance, Code	Cracking, Square Feet Per 1000 Square Feet	Patching, Square Feet	Mean Rut Depth, Inches	Mean Pavement Texture	Present Serviceability Index, Calc.	Air Temperature at Time of Test, °F	Number of Skid Tests	Mean Skid No.	Std. Dev. of Skid No.	

TABLE B-2. (Continued)

	PANEL RATINGS			PANEL ACCEPTANCES						
				FOR INTERSTATE SYSTEM			FOR SECONDARY SYSTEM			
Card No.	Mean Panel Present Serviceability Rating	Number of People on Panel	Std. Dev. of Panel Rating	Yes	Undecided	No	Yes	Undecided	No	

RI 123-02

Sheet 1

TEXAS HIGHWAY DEPARTMENT

Pavement Data System

TABLE B-3. DRAFT CODING SHEET FOR RI 123-02/STRUCTURE CAPACITY SUBFILE

						LOCATIONAL IDENTIFICATION							
Card No.	Update Class	Time of Acquiring Inventory Data: Hr.	Day	Mo.	Yr.	District No.	County No.	SHD Control No.	SHD Section No.	Evaluation Segment No.	Begin Mile Point of Evaluation Segment	End Mile Point of Evaluation Segment	Lane and Wheel Path Designation, Code

TABLE B-3. (Continued)

				DEFLECTION IN MILLI-INCHES AT STATION INDICATED														
Card No.	Air Temperature at Time of Tests, °F	Pavement Surface Temperature at Time of Tests, °F	Geophone Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

TABLE B-3. (Continued)

	POISSON'S RATIO					E VALUE, PSI				
Card No.	Subgrade	Subbase	Base	Surface	Overlay	Subgrade	Subbase	Base	Surface	Overlay

RI 123-03

Sheet 1

TEXAS HIGHWAY DEPARTMENT

Pavement Data System

TABLE B-4. DRAFT CODING SHEET FOR RI 123-03/MAINTENANCE, RESURFACING, AND SEAL COAT SUBFILE.

						LOCATIONAL IDENTIFICATION								
Card No.	Update Class	Time of Acquiring Inventory Data				District No.	County No.	SHD Control No.	SHD Section No.	Evaluation Segment No.	Begin Mile Point of Evaluation Segment	End Mile Point of Evaluation Segment	Lane and Wheel Path Designation, Code	
		Hr.	Day	Mo.	Yr.									

TABLE B-4. (Continued)

Card No.													
	MAINTENANCE												
	Start Date of Maintenance Cost			End Date of Maintenance Cost			Total Maintenance Cost for Pavement and Shoulder Incurred Between Dates	Composite Labor Rate Between Dates, $ per hour	Composite Equipment Rental Rate Between Dates, $ per hour	Maintenance Material Cost Between Dates, $	Number of Days Temperature Stayed Below 32^{o}F Between Dates		
	Day	Mo.	Yr.	Day	Mo.	Yr.							

TABLE B-4. (Continued)

	OVERLAYS AND SEAL COATS									
Card No.	Start Date	Completion Date	Number of Actual Construction Days	Type of Overlay or Seal Coat, Code	Thickness, Inches	Total Cost per Square Yard	Total Cost of Equipment per Lane-Mile	Production Rate of Overlay Material, Tons per Hour	In-Place Cost of Asphalt Concrete per Cubic Yard	Compacted Density of Overlay, Tons per Cubic Yard

TABLE B-4. (Continued)

	TRAFFIC THROUGH OVERLAY ZONE													
Card No.	Distance Over Which Traffic is Slowed in Overlay Direction, Miles	Distance Over Which Traffic is Slowed in Non-Overlay Direction, Miles	Distance Measured Along Detour Around Overlay Zone, Miles	Number of Hours per Day of Overlay or Seal Coat Construction	Number of Vehicles Arriving During Hours of Construction	Number of Open Lanes in Restricted Zone, Overlay Dir.	Number of Open Lanes in Restricted Zone, Non-Overlay Dir.	Vehicles Stopped by Road Equipment in Overlay Direction, %	Vehicles Stopped by Road Equipment in Non-Overlay Direction, %	Average Delay per Vehicle Stopped in Restricted Zone in Overlay Direction, Hours	Average Delay per Vehicle Stopped in Restricted Zone in Non-Overlay Direction, Hours	Average Approach Speed to Overlay Zone, mph	Average Speed Through Restricted Zone in Overlay Direction, mph	Average Speed Thru Restricted Zone in Non-Overlay Dir., mph

RI 123-04 TEXAS HIGHWAY DEPARTMENT

Sheet 1 Pavement Data System

TABLE B-5. DRAFT CODING SHEET FOR RI 123-04/ENVIRONMENT SUBFILE

						LOCATIONAL IDENTIFICATION							
Card No.	Update Class	Time of Acquiring Inventory Data				District No.	County No.	SHD Control No.	SHD Section No.	Evaluation Segment No.	Begin Mile Point of Evaluation Segment	End Mile Point of Evaluation Segment	Lane and Wheel Path Designation, Code
		Hr.	Day	Mo.	Yr.								

Sheet 2

TABLE B-5. (Continued)

			TEMPERATURE, FROST, AND RAIN DATA										
Card No.	General Drainage Conditions, Code	Topography, Code	Begin Date of Temperature, Frost, or Rain Record			End Date of Temperature, Frost, or Rain Record			Mean Max. Daily Temperature, °F	Mean Min. Daily Temperature, °F	Mean Depth of Frost Penetration Below Pavement Surface, inches	Freezing Index, Degree-Days	Total Rainfall, inches
			Day	Mo.	Yr.	Day	Mo.	Yr.					

Sheet 3

TABLE B-5. (Continued)

	TEMPERATURE AND MOISTURE THROUGH PAVEMENT DEPTH				Point 1			Point 2			Point 3			Point 4		
Card No.	Air Temperature, °F	Weather Conditions, Code	Wind Speed, MPH	Pavement Surface Temperature, °F	Depth Below Surface, inches	Temperature, °F	Moisture Content, %	Depth Below Surface, Inches	Temperature, °F	Moisture Content, %	Depth Below Surface, Inches	Temperature, °F	Moisture Content, %	Depth Below Surface, Inches	Temperature, °F	Moisture Content, %

TABLE B-6. DRAFT CODING SHEET FOR RI 123-05/MATERIALS DATA SUBFILE.

							LOCATIONAL IDENTIFICATION								
Card No.	Update Class	Time of Acquiring Inventory Data				District No.	County No.	SHD Control No.	SHD Section No.	Evaluation Segment No.	Begin Mile Point of Evaluation Segment	End Mile Point of Evaluation Segment	Lane and Wheel Path Designation, Code		
		Hr.	Day	Mo.	Yr.										

Sheet 2

TABLE B-6. (Continued)

	SUBGRADE												
Card No.	Mean Lime Content, %	Std. Dev. of Lime Content, %	Mean K Value, pci	Std. Dev. of K Value	Mean Compacted Density, lbs/cu.ft.	Std. Dev. of Compacted Density, lbs./cu. ft.	Texas Triaxial Class	Friction Factor	Swelling Clay Parameter, P_2	Swelling Clay Parameter, b_1	Liquid Limit, %	Plasticity Index	

Sheet 3

TABLE B-6. (Continued)

	SUBBASE												
Card No.	Erodability Factor	Friction Factor	Texas Triaxial Class	Mean Compacted Density, lb/cu ft	Std. Dev. of Compacted Density, lb/cu ft.	Mean Lime Content (field), %	Std. Dev. of Lime Content (field),%	Mean Cement Content (field), %	Std. Dev. of Cement Content (field), %	Asphalt Type for Treated Subbase, Code	Mean Residual Asphalt Content, (field), %	Std. Dev. of Residual Asphalt Content (field), %	

RI 123-05

Sheet 4

TABLE B-6. (Continued)

	BASE												
Card No.	Texas Triaxial Class	Mean Compacted Density, lb/cu ft	Std. Dev. of Compacted Density, lb/cu ft	Mean Lime Content (field), %	Std. Dev. of Lime Content, %	Mean Cement Content (field), %	Std. Dev. of Cement Content (field), %	Asphalt Type for Treated Base, Code	Mean Residual Asphalt Content (field), %	Std. Dev. of Residual Asphalt Content (field), %			

Sheet 5

TABLE B-6. (Continued)

	BASE AGGREGATES						SUBBASE AGGREGATES						
Card No.	Aggregate Type, Code	Maximum Size of Aggregate, in.	Percent of Aggregate Passing No. 4 Sieve	Percent of Aggregate Passing No. 200 Sieve			Aggregate Type	Maximum Size of Aggregate, in.	Percent of Aggregate Passing No. 200 Sieve	Percent of Aggregate Passing No. 200 Sieve	Liquid Limit, %	Plasticity Index	

Sheet 6 TABLE B-6. (Continued)

	CONCRETE											
Card No.	Concrete Type, Code	No. of Days at Which Strength was Measured	Mean Value of Flexural Strength, psi	Std. Dev. of Flexural Strength, psi	Mean Value of Compressive Strength, lbs.	Std. Dev. of Compressive Strength, lbs.	Modulus of Elasticity-28 Days, psi	Weight, lb/cu ft	Tensile Strength, psi	Admixture Type, Code	Cement Content, %	Cement Type, Code

TABLE B-6. (Continued)

		ASPHALT OR PORTLAND CEMENT CONCRETE AGGREGATES												
			Coarse Aggregate					Fine Aggregate						
Card No.	Type Referred to (HMAC or PCC)	Mineral Filler Type, Code	Aggregate Type, Code	Maximum Size, in.	Percent Passing No. 4 Sieve	Percent Passing No. 200 Sieve		Aggregate Type, Code	Maximum Size, in.	Percent Passing No. 4 Sieve	Percent Passing No. 200 Sieve			

Sheet 8

TABLE B-6. (Continued)

	STEEL							
			Tensile Yield Point Strength, psi					
Card No.	Bar Steel Type, Code	Wire Mesh Steel Type, Code	Longitudinal Bars	Transverse Bars	Tie-Bars	Wire Mesh		

Sheet 9

TABLE B-6. (Continued)

	HMAC (I)												
Card No.	HMAC Type, Code	Production Rate, tons/hr.	Mean In-Place Compacted Density, tons/cu yd	Std. Dev. of In-Place Compacted Density, tons/cu yd	Mean In-Place Voids, Content, %	Std. Dev. of In-Place Voids Content, %	Mean In-Place VMA, %	Std. Dev. of In-Place VMA, %	Marshall Stability, lbs		Marshall Flow Value, lbs.		Compaction, Code
									Design	Field	Design	Field	

TABLE B-6. (Continued)

		HMAC (II)										
Card No.	Asphalt Content (Design), %	Mean Asphalt Content (Field), %	Std. Dev. of Asphalt Content (Field), %	Penetration of Asphalt Cement at 77° F, mm		Viscosity of Asphalt Cement at 77° F, C.P.		Viscosity of Asphalt Cement at 140° F, Poise		Viscosity of Asphalt Cement at 275° F, Stokes		Ductility of Original Asphalt Cement at 77° F, cm
				Original	Oven-aged	Original	Over-aged	Original	Oven-aged	Original	Oven-aged	

TABLE B-6. (Continued)

	SEAL COATS									
Card No.	Asphalt Type, Code	Asphalt Rate, gals/sq yd	Residual Asphalt Content, gals/sq yd	Aggregate Type, Code	Max. Size of Aggregate, in.	Aggregate Rate, lbs/sq yd				

APPENDIX C

CODES FOR PAVEMENT DATA SYSTEM

EXPLANATION OF LANE AND WHEEL PATH DESIGNATION CODES

The data field for the lane and wheel path designation consists of five spaces. When properly filled in, these items will correctly identify the particular wheel path and lane and the total number of lanes. Alternatively, as shown in the examples, the data can refer to all the lanes in general, if desired.

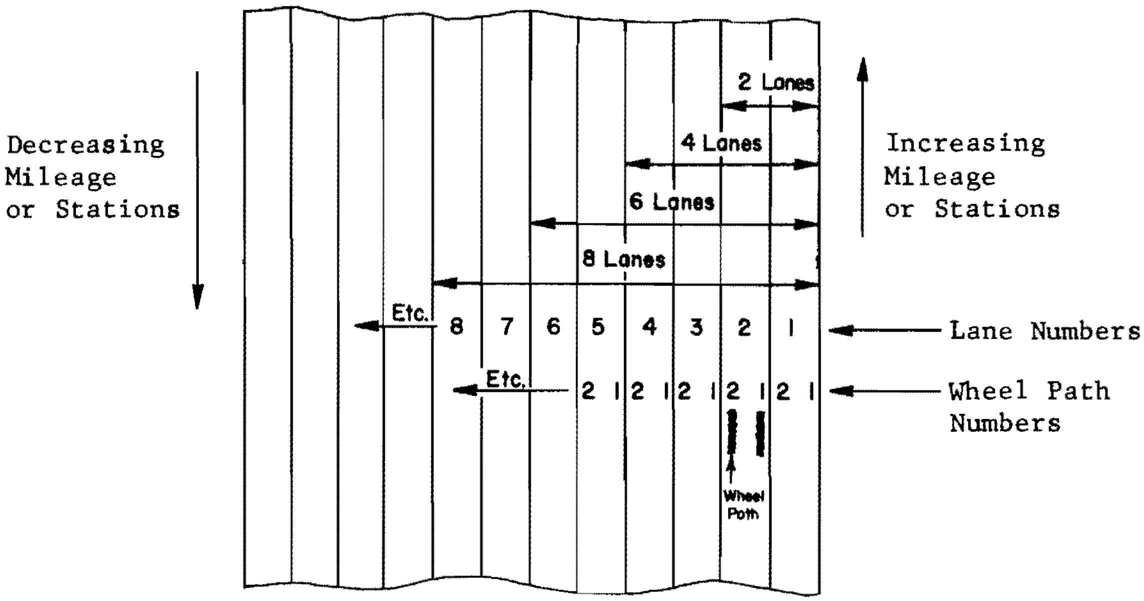
To understand the code, one must consider the relation of the diagram to the actual segment of highway being evaluated. The operator must be certain to orient himself on the chart with reference to the numbering of mile-points, which increase toward the top of the sheet. In some cases the operator might be facing in the direction of decreasing mileage; thus, he should imagine his car to be heading in the direction of the leftmost arrow, toward the bottom of the sheet.

Note that the lanes are numbered sequentially from RIGHT to LEFT. Within each lane, the wheel paths are numbered 1 and 2, also from RIGHT to LEFT.

The actual number placement within the lane and wheel path designation data field may be seen on the accompanying diagram.

LANE AND WHEEL PATH DESIGNATION

Travel Lanes - Both Directions
(Median Not Shown)



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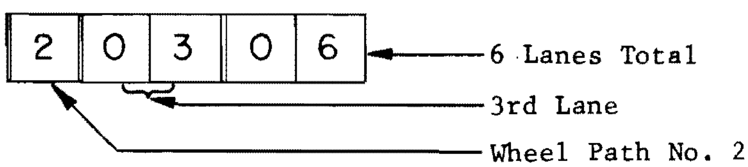

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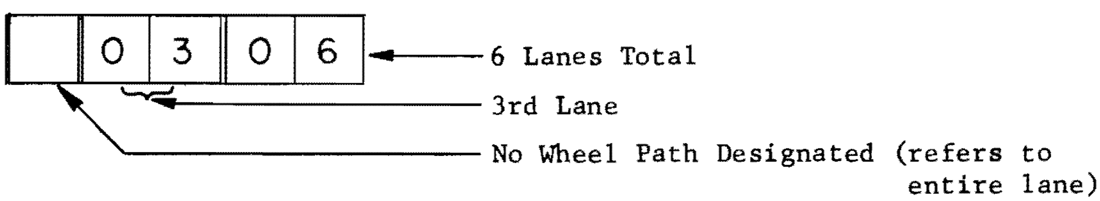

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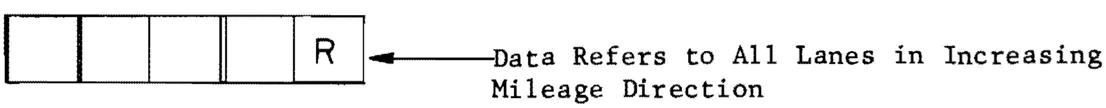

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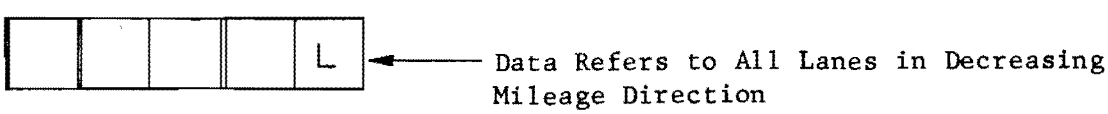

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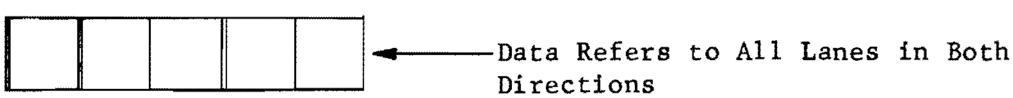

PAVEMENT DATA SYSTEM

CODE INDEX

UPDATE CLASS
1. Delete
2. Add
3. Change

HIGHWAY SYSTEM
01. U. S. Highway
02. State Highway
03. State Loop or Spur
04. Park Roads
05. Farm or Ranch to Market
06. U. S. Alternate
07. State Alternate or Temporary Route
08. Interstate Highway
09. Farm or Ranch to Market Spur
00. U. S. Highway Spur

MEDIAN TYPE
0. No Median
1. Depressed-Paved
2. Raised-Paved
3. Raised-Paved, No Curb
4. Raised-Grassed, Curb
5. Raised-Grassed, No Curb
6. Flat-Paved
7. Flat-Grassed

SURFACE TYPE
1. Asphalt Concrete
2. Portland Cement Concrete
3. Surface Treatment
4. Gravel

BASE TYPE
0. No Base
1. Granular, Untreated
2. Portland Cement Treated
3. Asphalt Treated
4. Lime Treated

SUBBASE TYPE
0. No Subbase
1. Granular, Untreated
2. Portland Cement Treated
3. Asphalt Treated
4. Lime Treated

SUBGRADE SOIL TYPE

(AASHO Classification Numbers Used)

METHOD OF OBTAINING SLOPE VARIANCE
1. By CHLOE Profilometer
2. By Surface Dynamics Profilometer
3. By PCA Road Meter

GEOPHONE CODE
1. First Sensor From Load Wheel
2. Second Sensor From Load Wheel
3. Third Sensor From Load Wheel
4. Fourth Sensor From Load Wheel
5. Fifth Sensor From Load Wheel

TYPE OF OVERLAY OR SEAL COAT
0. HMAC Overlay
1. Seal Coat
2. Two Course Surface Treatment
3. Three Course Surface Treatment
4. CRCP Overlay

GENERAL DRAINAGE
0. Poor
1. Fair
2. Good

TOPOGRAPHY

0. Flat
1. Rolling
2. Hilly
3. Mountainous

WEATHER CONDITIONS

0. Clear
1. Partly Cloudy
2. Overcast
3. Rain

ASPHALT TYPE

01. AC-5
02. AC-10
03. AC-20
04. AC-40
05. OA-30
06. OA-400
07. RC-1
08. RC-2
09. RC-3
10. RC-4
11. RC-5
12. MC-1
13. MC-2
14. MC-3
15. MC-5
16. RO-3
17. RO-4
18. RO-95
19. RO-Special
20. Cracked Fuel Oil
21. Crude Oil
22. EA-10S
23. EA-11M
24. EA-HVRS
25. EA-HVMS
26. Cat. Blown Asph.
27. Special Precoat Material

AGGREGATE TYPE

CONCRETE TYPE

ADMIXTURE TYPE

1. Air Entraining Agent
2.
3.

CEMENT TYPE

MINERAL FILLER TYPE

1. Portland Cement
2. Limestone
3.
4.

MARSHALL COMPACTION

BAR STEEL TYPE

(AASHO Classification Numbers Used)

WIRE MESH STEEL TYPE

AASHO Classification Numbers Used)

HMAC TYPE

THE AUTHOR

R. C. G. Haas has been Visiting Associate Professor of Civil Engineering at The University of Texas at Austin on leave from The University of Waterloo, in Canada, where he is Associate Professor of Civil Engineering.

He is active in a number of professional capacities, including Chairman of the Transportation Education Committee of the Canadian Good Roads Association. He is on two Highway Research Board Committees, with Subcommittee Chairmanship in each.

His research activities are primarily in the transportation field, with emphasis on pavement systems, and he has authored about thirty-five technical papers.

His experience includes twelve years with the Alberta Highway Department and Research Council, three years with Carleton University as a Lecturer and Assistant Professor, and two years with the University of Waterloo as an Associate Professor. He is a Registered Professional Engineer in the Province of Ontario and a Member of the Engineering Institute of Canada.