tive requirements. The total impact of this study would be a proposed reduction of 40 positions.

Implementation of this staffing plan is anticipated along with other personnel reduction plans and efficiency producing moves. The Department has always been able to use normal attrition to adjust personnel levels in the past. The process is expected to take approximately 1 year to reduce the staff from 344 employees to 304 planned positions for the repair shops. Annual recomputation of the staffing plan by using queuing theory is foreseen as changes occur to replacement funding. If equipment replacement is funded at the optimum level, further reduction of staff requirements may be possible. Unfortunately, Louisiana is currently experiencing a decline in revenue. It is expected that replacement funding in fiscal year 1984 will be significantly below the optimum level.

Although the immediate future appears rather bleak, the Department is currently under a mandate to reduce staffing levels wherever possible. If equipment replacement funds are reduced as expected, the demand for mechanic service will rise. If the optimum staff level cannot be maintained, higher downtime cost will be experienced and a net loss will occur.

Refinements to the cost model may be considered if it becomes apparent that a more precise solution is needed. Simulation will provide for greater precision and the consideration of more options. Measured arrival- and service-rate distributions could be simulated for each shop without the limitations of the Poisson arrival, exponential service distribution assumptions. Although a simulation model will allow many factors to be precisely controlled, including the arrival-rate distribution and the service-rate distribution, simulation is not currently being considered. This degree of precision is not considered necessary, and simulation is much more expensive than the mathematical model used here. If the use of queuing analysis proves successful, the determination of optimum staffing levels will have been performed at least cost. If not, the Department can proceed with the development of a simulation model without having wasted a significant amount of time and effort in the process.

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Arkansas' Equipment Management System

DOUG NIELSEN

ABSTRACT

Arkansas State Highway and Transportation Department (AHTD) personnel have recently completed work on a contract with FHWA to test and evaluate an equipment management system (EMS) using the FHWA EMS manual as a guide. The AHTD EMS consists of four major systems: (a) parts and materials inventory system, (b) equipment maintenance and operations cost system, (c) equipment cost accounting system, and (d) equipment control system. The parts and materials inventory system design specifies on-line computer terminals in each district stockroom to process the normal accounting transactions and provide stock management information. Transactions and adjustments are keyed at the point of origin and subjected to detailed edits to assure data accuracy. The equipment maintenance and operations cost system, equipment cost accounting system, and equipment control system are more interrelated and provide information to better manage the equipment function as a whole. Input data have been consolidated on existing forms to limit paperwork. Reports are primarily batch and produced monthly. Summary and exception reporting are emphasized. Reports to each level of management are limited to only the information needed to make the equipment decisions for which that level is responsible. Reports presently in use deal primarily with management of overall equipment operation and repair functions. Once an adequate amount of data is accumulated under the new EMS, system components dealing with equipment needs, budgeting, replacement, and rental rates will be put into operation.

In recent years there has been a movement among state transportation agencies to develop systematized methods to better manage available resources. Some results of these efforts are the various maintenance management systems and construction management systems. This type of approach can also produce dramatic cost savings in equipment management. Equipment management is the process of managing equipment resources to achieve maximum availability and productivity at the lowest relative overall cost.

Top management of the Arkansas State Highway and Transportation Department (AHTD), cognizant of the potential cost savings in the equipment area, initiated action to develop a comprehensive equipment management system (EMS) in the summer of 1975. Initial emphasis was on formulation of a statewide preventive maintenance (PM) program. A well-functioning PM program is an essential element of sound equipment management.

The PM program that was developed outlines a simple system for planning and scheduling periodic service and reporting equipment deficiencies. The procedures provide a positive means of communication

from the operator to shop personnel and allow for adequate program control. Emphasis is on local responsibility to ensure that recommended service intervals are met and deficiencies corrected. As the PM program became fully operational, attention was turned to other phases of an equipment management system.

During this same time, interest was growing nationwide in formalized equipment management systems to help cope with rising costs. As a result an EMS manual was developed by a consultant under an FHWA contract paid for by 12 states from pooled Highway Planning and Research Program funds.

SYSTEMS

In April 1979 the AHTD entered into a contract with the FHWA to test and evaluate an equipment management system based on the EMS manual. Work has just been completed on this contract. The AHTD EMS is comprised of four interdependent subsystems (Figure 1).

Parts and Materials Inventory System (PMIS)

This system maintains a file of all equipment parts and other materials stocked throughout the department, together with balances on hand at each stocking point. Stockroom personnel have access to on-line computer terminals that provide inventory value and balances, unit prices, and stock locations. All inventory receipts, issues, and adjustments are keyed at the point of origin and subjected to detailed edits to assure data accuracy. PMIS relays parts and materials cost data to two other EMS systems: the equipment maintenance and operations cost system and the equipment cost accounting system.

PMIS design provides critical up-to-date information for stock management on-line at each district. Batch reports provide other stock management information to district stockroom personnel and district bookkeepers, as well as to Fiscal Services and Equipment and Procurement Division personnel. Microfiche catalogs are also provided. Maintenance of the inventory system master file is performed on-line at central headquarters by the inventory coordinator.

As experience with PMIS grows and a reasonable transaction history file is built, parts usage figures will provide guidelines for establishing more precise fill rates, limits on stock level, and replenishment procedures.

Equipment Maintenance and Operations Cost System (EMOCS)

This system collects all direct equipment ownership, maintenance, and operations data and maintains histories of charges to each unit in the equipment inventory. The system generates cost analyses of repair shop resource allocation and provides the means to control scheduled repair and inspections, nonscheduled maintenance, and repair backlogs. It tracks equipment downtime and monitors the various responsibilities related to equipment maintenance. EMOCS draws parts charges from the parts and materials inventory system; collects equipment cost data, such as depreciation, from the equipment cost accounting system; and, in turn, supplies data for allocating indirect and overhead costs to the cost accounting system.

Equipment Cost Accounting System (ECAS)

This system interfaces with existing accounting systems and permits the collection and distribution of all indirect, overhead, and administrative costs related to equipment ownership, operation, and maintenance. The system collects direct costs and other data from the equipment maintenance and operations cost system to allocate indirect overhead costs, and

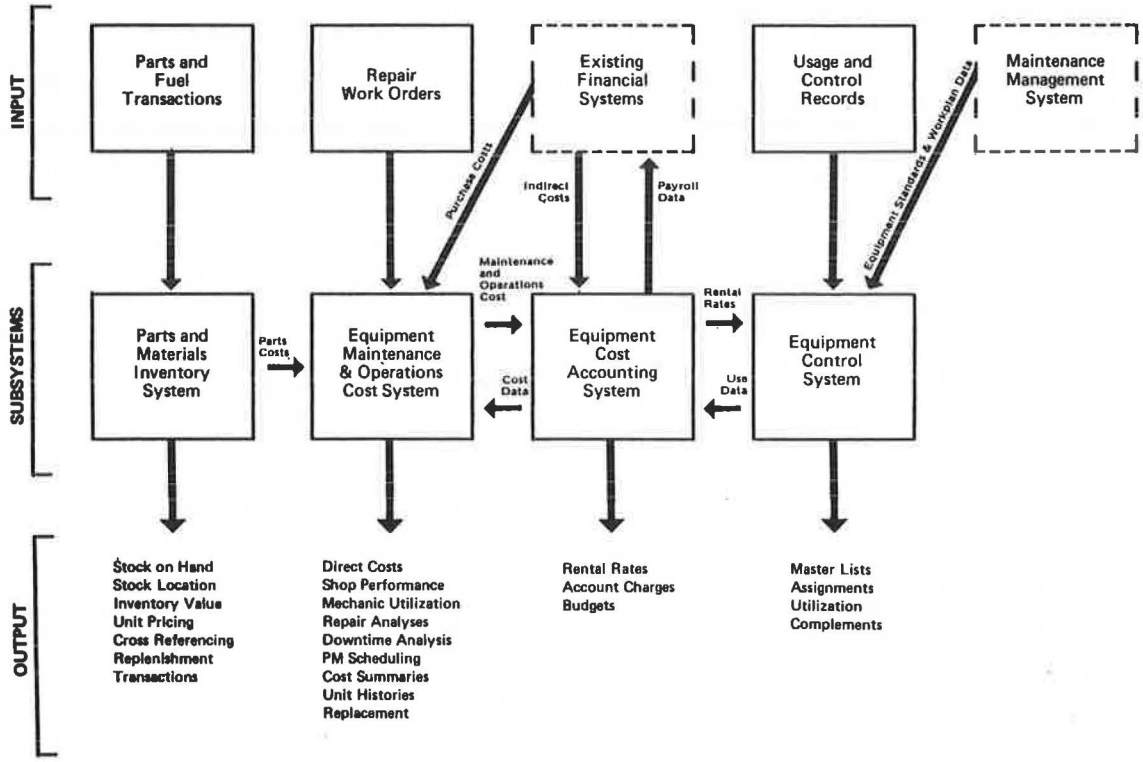


FIGURE 1 General structure of Arkansas EMS.

provides various expenditure information to inventory and depreciation accounts.

Equipment Control System (ECS)

This system maintains a master inventory of all equipment in the fleet, including detailed descriptive data, location and assignment, levels of utilization, and accumulated historical cost information on each unit. Input from the AHTD maintenance management and construction management systems will allow ECS to evaluate equipment needs and help establish complements.

DEVELOPMENT

Development of the parts and materials inventory system (PMIS) is discussed in detail elsewhere (1). Therefore this paper will focus on components of the remaining three systems that deal primarily with management of overall equipment operation and repair functions. When an adequate amount of data is accumulated under the new EMS procedures, system components dealing with equipment needs, budgeting, replacement, and rental rates will be put into operation.

Attempts were made throughout the EMS development process to limit the amount of paperwork necessary to provide adequate information. Four basic field-level data input forms are used to provide EMS information. Three were already in use and required only minor modification to meet EMS needs. For example, the daily fuel station report, used to document the receipt and issue of all fuel and lubricants, was changed to separate "add" oil from "change" oil and add the mileage or hours at oil changes to help keep up with proper service intervals.

Other input changes include using a four-letter code to more precisely classify labor activity of mechanics; putting an individual's Social Security number, for personal vehicle assignment, on the equipment transfer document so an automated individual assignment list can be produced to facilitate more effective equipment control; and adding one-letter coding to certain documents to further clarify data and permit more detailed editing.

Another input change implemented at the district level involved functional changes in the distribution of indirect equipment charges. This revised cost allocation was devised from FHWA Technical Advisory T454.1, dated October 18, 1978, entitled "State Equipment Rental Rate Reimbursement on Federal-Aid Projects," to facilitate more accurate budgeting, indicate the true cost of the various equipment support areas, and obtain the full measure of federal reimbursement of equipment charges. Five equipment overhead functions are now used to distribute equipment-related costs to the areas where they are incurred: (a) shop overhead, (b) storeroom overhead, (c) fuel distribution overhead, (d) district fleet administration, and (e) statewide fleet administration.

The approach to EMS development was to give each level of decision making in the department the summary data necessary to make informed equipment decisions at that level of responsibility. For example, first-level supervisors need to know current operating and repair data for their equipment complement, but not necessarily those of other supervisors, so first-level supervisors receive information about their own equipment only. District management needs information about all equipment in that district, but not necessarily about that of other districts, so information is routinely provided concerning that district's equipment only. Though it may be informative for a supervisor or district manager to know about another's equipment, that information is not relevant to the decisions those individuals must make regarding their own equipment, so it is not included in the normal distribution to them. However, summary information on other crews or districts may be provided periodically as a basis for comparison. A list of all current reports, organized by level of management, showing distribution, frequency, and purpose, is given in Table 1.

EMS output data have been consolidated to simplify interpretation. Each first-level supervisor receives only one report presenting operation and repair information for each unit in his complement (Table 2). This report lists all equipment assigned to the supervisor and indicates when any units are overdue for service or due for PM inspections. The report is one to two pages long depending on the number of pieces of equipment in the complement. Even though this information comes from several different sources, it is combined in one report to be convenient and useful to the supervisor.

Information is detailed at lower levels of responsibility and summarized as it progresses to higher levels. The totals, or bottom lines, of reports for one level form the body of the report to the next higher level. This provides a concise view of the data needed at that level without increasing the length of the reports. Lower level details can be consulted if questions arise. For example, first-level supervisors receive a report listing details about each unit in their complements (Table 2) with a total for all categories for their crews. These totals for each crew in each district are listed on a report that goes to the district management (Table 3); then the totals from each of these district reports are listed on a report that goes to fleet management (Table 4). A disparity noted at fleet level in one category for a specific district can be checked down to the crew level by consulting the district-level report, and then down to specific units in the crew by reviewing the crew-level report.

Exception reporting is used to minimize the analysis time required at each level of responsibility; however, sufficiently detailed information is available to support problem evaluation. A monthly report is provided to district management (Table 5), which lists units in the district complement that exceed certain predetermined standards of service, repair, fuel and lubricant consumption, utilization, and various costs. With this report district management can quickly locate problem areas without reviewing detailed information on all units.

Top departmental management periodically receives a one-page report (Table 6), composed from the bottom lines of several lower level reports, that gives a comprehensive view of the entire fleet for the period by district. Major categories summarized on the report are (a) equipment inventory with number of pieces in major classes and changes during the period; (b) equipment operation showing total miles and hours operated and gallons of fuels consumed; (c) maintenance program breaking down labor hours of mechanics expended on various functions as well as number of mechanics and their utilization percentage; (d) fleet costs listing expenditures for operations, labor, parts, and indirect expense and showing the percentage of these costs billed to other districts; and (e) fleet earnings giving total acquisition cost, book value, rental earned, and a ratio to indicate the relationship of rental earned to cost.

Another one-page report (Table 7) compares the totals of the current fleet summary with the totals of the same report for a previous time period and shows the percentage change in each item. Reports

TABLE 1 Current Equipment Management Reports

FLEET LEVEL

1. Fleet Summary (Department Top Management-Annually). This report contains summarized statistics of all aspects of Departmental equipment operation by District for the past year.

2. Fleet Summary Comparison (Department Top Management-Annually). This report compares the change between the overall totals of the current Fleet Summary report and the same report from the previous year.

3. Mileage and Fuel Consumption (Department Fleet Management-Annually and Quarterly). This report details the fuel and lubricant consumption and miles/hours operated fleetwide quarterly and annually.

4. Fleet Distribution (Department Fleet Management-Quarterly). This report shows the distribution of major classes of equipment among the Districts.

5. Accumulated Active Equipment Cost Details (Department Fleet Management-Quarterly). This report presents accumulated cost details for each active unit in the fleet.

6. Personally Assigned Vehicles (Department Fleet Management-Quarterly). This report lists certain personnel data on individuals (primarily administrative personnel) who are personally assigned a specific vehicle.

7. Statewide Mechanic Utilization (Department Fleet Management-Monthly). This report compares the relative efficiency of all District repair facilities.

8. Equipment Cost Summary by Budget (Department Fleet Management-Monthly). This report summarizes overall equipment costs for the month for each District.

DISTRICT LEVEL

1. District Fleet Summary (District Top Management-Annually). This report presents summary statistics concerning the overall fleet management program for each individual District by crew for the past year.

2. District Fleet Summary Comparison (District Top Management-Annually). This report documents the change in totals between current and previous periods of the District Fleet Summary report.

3. District Fleet Distribution (District Fleet Management-Quarterly). This report shows the distribution of major classes of equipment among crews in each District.

4. Mileage and Fuel Consumption (District Fleet Management-Quarterly and Monthly). This report details the fuel and lubricant consumption and miles/hours operated Districtwide each month and provides averages quarterly.

5. Exceptional Equipment (District Fleet Management-Monthly). This report highlights units which exceed or fall short of certain predetermined standards and exception criteria.

6. Equipment Cost Summary by Crew (District Fleet Management-Monthly). This report summarizes overall equipment costs for the month for each crew in each District.

DISTRICT LEVEL

7. Indirect Charges (District Fleet Management-Monthly). This report presents the indirect costs incurred and distributed monthly for each District, by Accounting Object, within the five indirect cost classifications.

8. District Equipment Downtime Summary (District Shop Management-Quarterly). This report presents equipment downtime summaries, by Shop Status Code, in terms of number of days down. This report may also be produced annually for each individual District, as well as with all Districts combined, to evaluate relative downtime.

9. District Equipment Repair Analysis by Cause (District Shop Management-Quarterly). This report lists shop repair activity by Task Code Cause and points out the cause of repair problems.

10. District Equipment Repair Analysis by System (District Shop Management-Monthly). This report details the shop repair distribution by Task Code System and indicates cost areas in the repair facility.

    (Reports 9 and 10 may also be produced periodically for Statewide equipment repair to analyze the relative performance of all District repair facilities).

11. PM Schedule (District Shop Management-Monthly). This report schedules various levels of Preventive Maintenance activity in advance.

12. District Mechanic Utilization (District Shop Management-Monthly). This report lists all mechanic hours by Function and Task Code System for the month to determine labor distribution and utilization. It reveals how efficiently District equipment repair labor is being utilized.

13. Task Code Display - On-Line Screen (District Mechanics-On Demand). This is a complete labor history for each unit, available on request at the computer terminal in each District. A printed copy of any unit history can be obtained at the terminal in seconds for review. This enables a mechanic to review recent repair history of a unit and avoid duplication of effort and unnecessary parts changing.

14. Equipment Transactions - Microfiche (Various District Personnel-Monthly). This microfiche report details all direct transactions to each equipment unit for the month and constitutes a complete repair and operation cost history for the unit.

CREW LEVEL

1. Equipment Cost Summary by Tag (Line Supervisors-Monthly). This report presents operational and repair information for the month for each unit in each District crew. It includes miscellaneous minor equipment and serves as an assignment list. This is the only EMS report which goes to first level supervisors.

TABLE 2 Equipment Cost Summary by Tag

PGM=AD145B1A ARKANSAS HIGHWAY AND TRANSPORTATION DEPARTMENT PAGE 001
REPORT DATE 05/24/84
PERIOD APRIL 1984 CREW NO. 01541 DISTRICT ONE

TAG	S PV MC	MAKE	MODEL	MODEL YR	OPER COST	PM COST	--REPAIR COSTS-- PARTS	LABOR	TOTAL DIRECT COSTS	MILES	HOURS	MPG/ GPH	DIRECT COST MI/HR	UTIL
01458		CHAUSSE MDT170	ASPHALT KETTLE	74	27.19	.00	.00	.00	27.19		58	.00	.47	.00
01675		GALION 4-6 T	PORTABLE ROLLER	75	15.31	.00	.00	.00	15.31		13	1.23	1.18	.00
01901		WOODS D315T2	PULL TYPE MOWER	74	.00	.00	82.49	.00	82.49		0	.00	.00	.00
01902		WOODS D315T2	PULL TYPE MOWER	74	.00	.00	19.16	31.65	50.81		24	.00	2.12	.00
01919		JOHN DEERE 301A	W/5 FT ROT MOWE	80	30.53	.00	47.00	.00	77.53		30	.97	2.58	.00
02025		JOHN DEERE 401	WHEEL TRACTOR	75	11.09	.00	340.26	79.09	430.44		0	.00	.00	.00
02170		JOHN DEERE 301A	W/5 FT ROT MOWE	74	33.81	.00	51.57	.00	85.38		23	1.17	3.71	.00
02179		TERRAIN KING 15	PULL TYPE MOWER	80	.00	.00	184.92	.00	184.92		0	.00	.00	.00
02841		FORD 51024C	WHEEL TRACTOR	67	17.08	.00	11.06	39.57	67.71		0	.00	.00	.00
03171		LE ROI 0160FG	AIR COMPRESSOR	78	50.74	.00	.00	.00	50.74		10	5.30	5.07	.00
03189		FORD 3600	W/6 FT SKL MOWE	78	16.72	.00	103.14	33.76	153.62		0	.00	.00	.00
03578		JOHN BEAN 200HW	POWER SPRAYER	78	32.55	.00	.00	.00	32.55		22	1.55	1.48	.00
03813		M-B 53T	PL TYPE SWEEPER	74	.00	.00	.00	.00	.00		0	.00	.00	.00
04389		MSSY FRGSN 4F31	WHEEL TRACTOR	75	30.53	.00	3.39	.00	33.92		24	1.21	1.41	.00
04390		MSSY FRGSN 4F31	WHEEL TRACTOR	75	.00	.00	12.55	.00	12.55		0	.00	.00	.00
04452		MILLER DT16	TILT TRAILER	66	.00	.00	94.43	.00	94.43	299		.00	.32	.00
04500		MOBIL 2TE4	SP PU SWEEPER	68	51.94	.00	.00	.00	51.94		7	7.14	7.42	.00
04592		GALION T600B	MOTOR GRADER	74	110.21	.00	151.46	39.56	301.23		17	4.24	17.72	.00
04719		JOHN DEERE 544B	FRT END LOADER	74	93.49	.00	263.52	23.74	380.75		25	2.76	15.23	.00
04755		WHITE 2-63-15	WHL TRTR W/PKUP	75	80.40	.00	105.92	39.56	225.88		54	1.06	4.18	.00
04902		FORD 31023C	W/6 FT FL MOWER	71	.00	.00	.00	.00	.00		0	.00	.00	.00
04933		FORD 3000	W/5 FT ROT MOWE	72	.00	.00	.00	.00	.00		0	.00	.00	.00
04937		FORD 3000	W/5 FT ROT MOWE	72	20.37	.00	193.26	64.16	277.79		42	.48	6.61	.00
05871		DODGE D100	1/2T PICKUP	77	90.04	.00	7.37	.00	97.41	843		10.28	.12	.00
06137		CHEV C10	1/2 T PICKUP	83	115.74	.00	5.82	.00	121.56	2122		18.78	.06	.00
06908		CHEV C20	3/4 T CR CB PU	82	125.60	.00	7.17	.00	132.77	1105		8.99	.12	.00
08694		IHC 1700	STD DSTR 345 CI	66	196.33	.00	1.34	.00	197.67		44	3.14	4.49	.00
09245		FORD F600	FB DT 361 CID	74	269.54	.00	.00	.00	269.54	922		3.01	.33	.00
09345		FORD F750	4CY DT 389 CID	75	136.75	.00	28.22	73.77	238.74	686		4.83	.35	.00
09349		FORD F750	4CY DT 389 CID	75	139.24	.00	3.10	63.30	205.64	507		3.70	.41	.00
09506		IHC 1700	4CY DT 404 CID	77	53.46	.00	.00	.00	53.46	394		7.16	.14	.00
09507		IHC 1700	4CY DT 404 CID	77	180.96	.00	.00	.00	180.96	862		4.71	.21	.00
09828		IHC 1724	4CY DT 392 CID	79	199.60	.00	37.78	47.49	284.87	892		4.46	.32	.00
09845		IHC 1854 DIESEL	4CY DT 636 CID	79	200.61	.00	182.95	.00	383.56	1226		5.42	.31	.00
TOTAL		0034	AVG AGE(YRS)	9.09	2329.83	.00	1937.78	535.65	4803.26	9758	393			.00

TABLE 3 Equipment Cost Summary by Crew

PGM=AD145B1B ARKANSAS HIGHWAY AND TRANSPORTATION DEPARTMENT PAGE 001
REPORT DATE 05/24/84
PERIOD APRIL 1984 DISTRICT ONE

CREW NO/NO	TOT EQP	IDLE EQP	OPER COST	PM COST	---REPAIR COSTS--- PARTS	LABOR	TOTAL DIRECT COSTS	ACCUM FISCAL COSTS	AVG AGE (YRS)	MILES	HOURS
0100A	6	0	610.68	.00	276.33	79.41	966.42		3.17	14233	0
0100B	11	10	122.72	.00	330.28	41.66	494.66		7.64	2144	0
0100C	16	5	924.16	.00	607.06	209.68	1,740.90		12.81	10127	34
0100D	6	4	101.92	.00	7.54	.00	109.46		11.17	1946	1
01001	22	3	1,651.58	.00	2,433.65	1,013.88	5,099.41		12.68	13456	241
01002	2	0	519.82	.00	10.96	28.84	559.62		4.50	3070	30
01004	39	14	4,138.57	.00	2,171.13	432.86	6,742.56		8.69	36616	173
01006	28	4	1,882.48	.00	2,685.99	540.78	5,109.25		9.43	12242	289
01007	37	9	3,037.14	.00	5,498.10	1,781.72	10,316.96		9.84	13864	441
01181	54	26	2,757.14	.00	4,963.91	1,357.99	9,079.04		8.67	12616	270
01191	31	12	2,310.05	.00	1,269.76	414.89	3,994.70		10.39	12780	197
01391	30	13	2,284.99	.00	1,544.34	1,181.80	5,011.17		9.30	13954	149
01481	38	17	1,767.20	.00	1,856.03	715.24	4,338.47		9.42	10338	261
01541	34	9	2,329.83	.00	1,937.78	535.65	4,803.26		9.09	9758	393
01681	54	24	2,965.02	.00	4,552.78	1,934.78	9,452.58		8.96	14896	435
01741	31	12	1,764.70	.00	1,151.43	235.77	3,151.90		10.03	10911	170
11	13	0	1,071.10	.00	288.29	20.88	1,380.27		4.77	18656	0
13	15	2	992.11	.00	449.17	163.92	1,505.20		5.20	14294	0
14	12	0	806.25	.00	143.31	41.89	991.45		5.83	10573	0
TOTAL	479	169	31,937.46	.00	32,178.18	10,731.64	74,847.28		9.13	236374	3084

TABLE 4 Equipment Cost Summary by Budget

PGM=AD145B1C — ARKANSAS HIGHWAY AND TRANSPORTATION DEPARTMENT — PAGE 001
REPORT DATE 05/24/84
PERIOD APRIL 1984

BUD	TOT EQP	IDLE EQP	OPER COST	PM COST	---REPAIR COSTS--- PARTS	LABOR	TOTAL DIRECT COSTS	ACCUM FISCAL COSTS	AVG AGE (YRS)	MILES	HOURS
D-01	479	169	31,937.46	.00	32,178.18	10,731.64	74,847.28		9.13	236374	3084
D-02	423	144	29,366.95	.00	31,336.87	13,630.40	74,334.22		9.68	234763	3633
D-03	450	153	34,130.06	.00	30,637.80	10,297.71	75,065.57		8.52	242639	2561
D-04	516	201	30,910.06	.00	35,360.31	14,627.96	80,898.33		9.36	249267	2690
D-05	427	132	34,670.13	.00	22,262.62	7,933.03	64,865.78		7.67	258307	2464
D-06	573	211	42,013.17	.00	40,428.63	15,926.36	98,368.16		9.03	323227	2789
D-07	417	144	29,995.96	.00	29,648.84	10,424.23	69,059.03		8.46	243388	3186
D-08	482	210	40,069.58	.00	28,168.03	10,466.15	78,703.76		9.09	259739	3052
D-09	498	191	31,856.40	.00	23,368.38	8,422.73	63,647.51		9.09	192152	3694
D-10	477	172	32,397.96	.00	29,711.33	12,073.36	74,182.65		9.19	221558	2672
G/A	417	61	39,093.18	.00	16,775.72	7,616.00	63,484.90		5.37	660153	3111
TOT	5159	1788	375,430.91	.00	319,876.71	122,149.57	817,457.19		8.65	3120567	32944

TABLE 5 Exceptional Equipment

B145B02 — ARKANSAS HIGHWAY AND TRANSPORTATION DEPARTMENT — PAGE 0001
REPORT DATE 01/13/8
PERIOD DECEMBER 198
DISTRICT SEVEN

TAG	DESCRIPTION	PM/SERV OVERDUE	MI/HR AT LAST PM	DATE AT LAST PM	HI/LO MPG/ GPH	HI/LO UTIL	EXCESS IDLE TOME	EXCESS DOWN TIME	HIGH OIL CONSUMP MI/HR QT	HIGH NUM REPAIR ORDERS	EXCESS REPAIR COSTS	REPAIR COST/ MILE	EXCESS OPERATING COST	OPERATING COST/ MILE
00257	DODGE MONACO				36.01									
02068	JOHN DEERE 401	PM	3,680	11/14/8										
02280	JOHN DEERE 301A	PM	2,775	11/13/8										
02532	INGRAM 3-WHEEL							20						
02935	GALION 160	PM	16,107	10/29/8										
03770	OLIVER 2-78	SERVICE	4,820	09/21/8										
04322	FORD 45011F	PM	1,265	11/04/8										
04325	FORD 45011F				.42									
04486	CASE CW10B	PM	10,462	11/10/8	.39									
04549	GALION T600B	SERVICE	1,824	09/10/8										
04594	GALION T600B				.97									
04911	FORD 31023C	PM	1,385	11/12/8										
05065	CHEV SUBURBAN				45.20									
05423	DODGE D200	SERVICE	135,684	10/20/8						115				
05459	CHEV C20									199				
05468	CHEV C20	SERVICE	68,946	10/12/8										
05747	DODGE D100					288								
05750	DODGE D100				9.70	136								
05821	DODGE D100					70								
05976	DODGE D100	SERVICE	87,223	11/04/8										
05984	DODGE D100									438				
06799	CHEV C10	SERVICE	66,894	11/23/8		4211								
06802	CHEV C10									443				
06839	CHEV C10							22						
06966	CHEV C20									185				
07353	IHC R195A									94				
09061	FORD LT 800					8								
09092	FORD F600									90				
09099	FORD F600									65				
09175	FORD F600									78				
09304	FORD F600 CR CB									75				
09307	FORD F600 CR CB									107				
09310	FORD F600 CR CB				1.93									
09401	FORD F750	SERVICE	120,012	09/16/8										
09537	IHC 1700									53				
09539	IHC 1700	SERVICE	87,643	10/27/8										
09543	IHC 1700									129				
09732	FORD F800				12.49									
09734	FORD F800									110				
09737	FORD F800				1.15	45								
09810	IHC 1800							21						
09853	IHC 1854 DIESEL				23.54									
09962	CHEV C701 DIES	SERVICE	46,062	11/02/8										

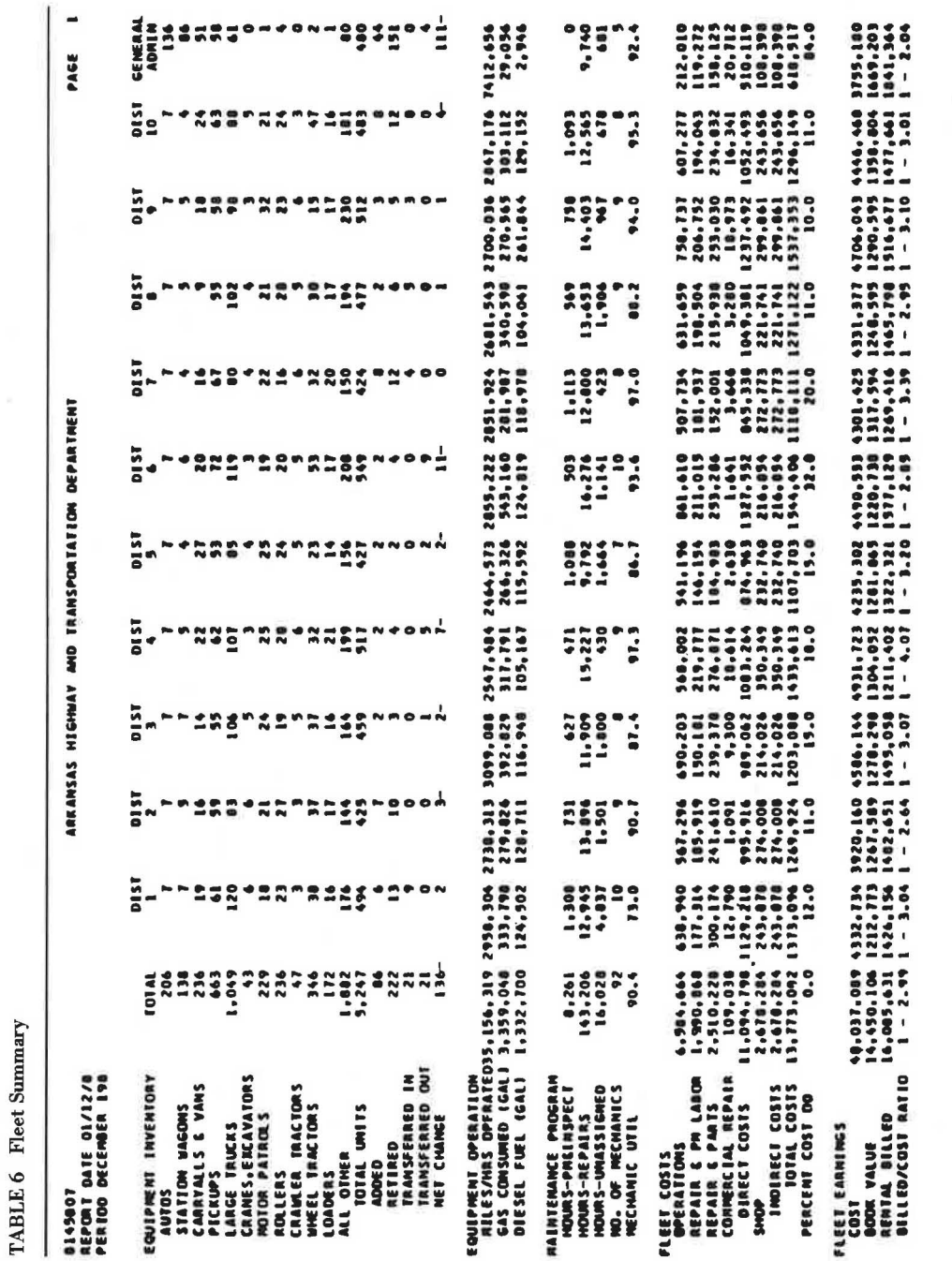
formatted similarly to these two are provided to district management with a breakdown of the major categories by crew within each district in lieu of the breakdown by district that is provided to top management.

SUMMARY

The key to the AHTD EMS is simplicity of input and output, although the programming is complicated. Consolidating data and presenting summarized and exceptioned information greatly reduced the number and volume of reports necessary to provide adequate equipment information to each level of responsibility. The information must be useful and presented in an easily assimilated form or the people for whom it is intended will not use it.

The level of information initially being sought

TABLE 6 Fleet Summary



0145007 ARKANSAS HIGHWAY AND TRANSPORTATION DEPARTMENT PAGE 1
REPORT DATE 01/12/8
PERIOD DECEMBER 198

	TOTAL	DIST 1	DIST 2	DIST 3	DIST 4	DIST 5	DIST 6	DIST 7	DIST 8	DIST 9	DIST 10	GENERAL ADMIN
EQUIPMENT INVENTORY												
AUTOS	206	7	7	7	7	7	7	7	7	7	7	136
STATION WAGONS	138	7	5	7	5	4	4	5	5	5	4	86
CARRYALLS & VANS	236	19	16	14	22	27	20	9	10	10	24	51
PICKUPS	663	61	59	55	62	53	72	67	55	58	63	58
LARGE TRUCKS	1,049	120	83	106	107	85	119	80	102	98	88	61
CRANES,EXCAVATORS	43	6	6	5	3	4	3	4	4	3	5	0
MOTOR PATROLS	229	18	21	24	25	25	19	22	21	32	21	1
ROLLERS	236	23	21	19	28	24	20	16	28	23	24	4
CRAWLER TRACTORS	47	3	3	5	6	5	5	6	5	6	3	0
WHEEL TRACTORS	346	38	37	37	32	23	53	32	30	15	47	2
LOADERS	172	16	17	16	21	14	17	20	17	17	16	1
ALL OTHER	1,882	176	146	164	199	156	208	150	194	230	181	80
TOTAL UNITS	5,267	494	425	459	517	427	549	424	477	512	483	480
ADDED	86	6	7	2	2	2	2	8	2	3	8	44
RETIRED	222	13	10	3	4	2	4	12	4	5	12	151
TRANSFERRED IN	21	9	0	0	0	0	0	4	9	3	0	0
TRANSFERRED OUT	21	0	0	1	5	2	9	0	0	0	0	4
NET CHANGE	136-	2	3-	2-	7-	2-	11-	0	1	1	4-	111-
EQUIPMENT OPERATION												
MILES/HRS OPERATED	35,156,319	2930,304	2738,313	3099,088	2547,484	2444,573	2855,222	2851,924	2681,543	2700,036	2847,176	7412,656
GAS CONSUMED (GAL)	3,359,048	333,798	279,026	392,629	317,791	266,326	543,160	281,987	340,598	270,565	303,112	29,056
DIESEL FUEL (GAL)	1,332,700	124,502	128,711	116,948	105,167	115,592	124,819	118,978	104,041	261,844	189,152	2,946
MAINTENANCE PROGRAM												
HOURS-PRELINSPECT	8,261	1,308	731	627	471	1,088	503	1,113	569	758	1,093	0
HOURS-REPAIRS	163,206	12,945	13,896	11,909	15,227	9,792	16,276	12,000	13,653	14,403	12,565	9,740
HOURS-UNASSIGNED	16,028	4,837	1,501	1,800	430	1,644	1,141	423	1,904	947	678	681
NO. OF MECHANICS	92	10	9	8	9	7	10	8	9	9	8	5
MECHANIC UTIL	90.4	73.0	90.7	87.4	91.3	86.7	93.6	97.0	88.2	94.0	95.3	92.4
FLEET COSTS												
OPERATIONS	6,984,664	638,940	567,296	650,203	560,002	541,196	661,610	587,734	631,659	758,737	607,277	212,010
REPAIR & PM LABOR	1,980,868	177,314	185,919	150,181	219,777	146,154	211,019	181,937	198,504	206,732	194,043	119,272
REPAIR & PARTS	2,510,228	300,174	241,610	239,378	276,871	184,985	259,286	192,001	215,938	293,030	234,032	158,125
COMMERCIAL REPAIR	109,038	12,790	1,091	9,300	18,614	2,030	1,641	3,646	3,280	18,973	16,341	20,712
DIRECT COSTS	11,084,798	1129,218	995,916	989,062	1083,264	874,963	1327,552	965,338	1049,381	1237,492	1052,493	510,119
SHOP	2,678,284	243,878	274,006	214,026	350,349	232,740	216,854	272,773	221,741	299,861	243,656	108,399
INDIRECT COSTS	2,678,284	243,878	274,006	214,026	350,349	232,740	216,854	272,773	221,741	299,861	243,656	108,399
TOTAL COSTS	13,763,082	1373,096	1269,924	1203,088	1433,613	1107,703	1544,406	1238,111	1271,122	1537,353	1296,149	618,517
PERCENT COST OO	0.0	12.0	11.0	15.0	10.0	15.0	32.0	20.0	11.0	10.0	11.0	84.0
FLEET EARNINGS												
COST	48,037,089	4332,734	3920,160	4586,144	4931,723	4235,382	4490,533	4301,425	4331,377	4704,043	4446,448	3755,180
BOOK VALUE	14,490,106	1212,773	1267,589	1278,290	1304,052	1281,865	1220,738	1317,594	1248,595	1290,595	1358,804	1669,203
RENTAL BILLED	16,005,631	1424,156	1402,651	1495,058	1211,402	1322,321	1577,129	1269,416	1465,798	1510,477	1477,641	1841,364
BILLED/COST RATIO	1 - 2.99	1 - 3.04	1 - 2.64	1 - 3.07	1 - 4.07	1 - 3.20	1 - 2.85	1 - 3.39	1 - 2.95	1 - 3.10	1 - 3.01	1 - 2.04

TABLE 7 Fleet Summary Comparison

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REPORT DATE 01/12/8
PERIOD DECEMBER 198 STATEWIDE

EQUIPMENT INVENTORY	CURRENT PERIOD	PREVIOUS PERIOD	PERCENT CHANGE	SAME PERIOD LAST YEAR	PERCENT CHANGE
AUTOS	206			264	22.0-
STATION WAGONS	138			167	17.4-
CARRYALLS & VANS	236			237	0.4-
PICKUPS	663			664	0.2-
LARGE TRUCKS	1,049			1,056	0.7-
CRANES,EXCAVATORS	43			45	4.4-
MOTOR PATROLS	229			232	1.3-
ROLLERS	236			240	1.7-
CRAWLER TRACTORS	47			48	2.1-
WHEEL TRACTORS	346			347	0.3-
LOADERS	172			174	0.0
ALL OTHER	1,882			1,909	1.1-
TOTAL UNITS	5,247			5,383	2.5-
ADDED	86			114	24.6-
RETIRED	222			234	5.1-
TRANSFERRED IN	21			18	16.7
TRANSFERRED OUT	21			18	16.7
EQUIPMENT OPERATION					
MILES/HRS OPERATED	35,156,319			37,325,750	5.8-
GAS CONSUMED (GAL)	3,359,048			4,336,688	22.5-
DIESEL FUEL (GAL)	1,332,700			1,122,606	18.7
MAINTENANCE PROJECTS					
HOURS-PM&INSPECT	8,261			6,844	20.7
HOURS-REPAIRS	143,206			151,707	5.6-
HOURS-UNASSIGNED	16,028			18,529	13.5-
MECHANIC UTIL	90.4			89.5	1.0
FLEET COSTS					
OPERATIONS	6,584,664.45			7,187,432.64	8.4-
REPAIR & PM LABOR	1,990,867.95			2,100,087.59	5.2-
REPAIR & PARTS	2,510,228.02			2,600,302.37	3.5-
COMMERCIAL REPAIR	109,038.05			119,882.22	9.1-
DIRECT COSTS	11,094,798.47			12,007,704.82	7.6-
SHOP	2,678,284.08			2,588,417.32	3.5
INDIRECT COSTS	2,678,284.08			2,588,417.32	3.5
TOTAL COSTS	13,773,082.55			14,596,122.14	5.6-
FLEET EARNINGS					
COST	48,037,088.50			49,237,770.39	2.4-
BOOK VALUE	14,450,105.71			19,388,626.92	25.5-
RENTAL BILLED	16,085,631.30			16,567,481.83	2.9-
BILLED/COST RATIO	1 - 2.99			1 - 2.97	0.70

is, in some cases, rather general. When that level is being reported reliably, a more exact level will be sought. For example, before the establishment of the EMS there was no procedure to capture downtime; the system is now set up to capture downtime in days. When the input and analysis mechanisms for dealing with downtime in days are functioning adequately downtime will be captured in hours. As another example, thorough, in-shop PM inspections of each piece of equipment are now conducted once a year; when the shops are able to adequately handle the work at this level, these inspections will be conducted on a mileage or hourly basis.

This is part of the continual updating required to keep the EMS current with changes in the activities for which it provides management information. New equipment designs, operating procedures, and repair methods must be compensated for in the EMS if the management information generated is to remain valid and useful. Chemical mowing, alternate fuels, on-board electronics that diagnose problems and indicate service needs, and maintenance-free components are some technological changes that affect EMS procedures. By changing to meet these needs as they arise, the AHTD EMS will continue to be a viable tool for managing the department's equipment and allied resources.

REFERENCE

1. D. Nielsen. Development of Parts and Materials Inventory System. In Transportation Research Record 864, TRB, National Research Council, Washington, D.C., 1982, pp. 33-37.

Publication of this paper sponsored by Committee on Maintenance Equipment.